Natural Refrigerant Training Summit

Building a Sustainable Workforce

CO2 Climate Study, TCO Study, ESG Goals and Controls Transition Plans for Food Retailers.

Andre Patenaude, Mike Hill

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NORTH AMERICAN Sustainable Refrigeration Council

Natural Refrigerant Training Summit

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Who We Are

A 501c3 nonprofit working to create a sustainable future for supermarket refrigeration by removing barriers to natural refrigerant adoption.

160+
member companies

55K+
food retail locations

Goals

- Build a sustainable technician workforce
- Increase funding for natural refrigerant equipment
- Improve technology options, education, and awareness

What are Natural Refrigerants?

CO_2	C_3H_8	NH_3
R744 Carbon Dioxide	**R290** Propane	**R717** Ammonia

NORTH AMERICAN
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CO2 Climate Study – High Ambient Strategies

Total Cost of Ownership Study - 8 Ref. Architectures

Copeland ESG Goals and Objectives

NASRC – Natural Refrigerant Training Summit
Pittsburgh, PA

March 19-21, 2024
Andre Patenaude

Impact of Ambient on CO_2 System Selection

FGN
FUTURE GREEN NOW

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CO_2 With Confidence
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Overview

- Selected 13 climate zones
  - ASHRAE and IECC
- Determine cities
- Compile ambient bin data
  - S.C. & T.C. hours for each
  - Dry and adiabatic hours
- Identify key strategies
- Build energy comparison
- Additional technologies
- External variables

Desired Outcome of Study

To provide a guideline on comparing high ambient strategies for CO_2 transcritical booster systems for the Americas

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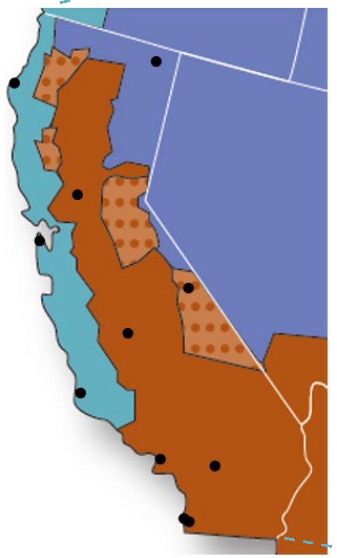
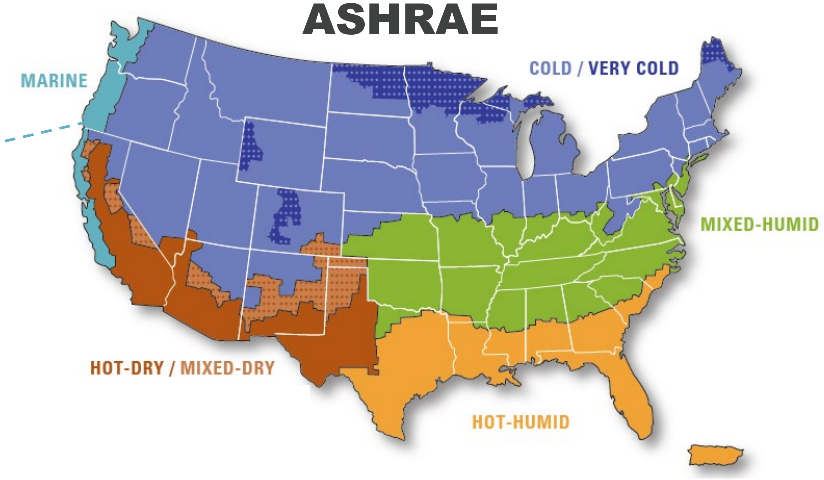
Weather Data: NREL TMY3 data, EES Software, 400MBH MT +18SST, 100MBH LT -20F

Climate Zone Categories

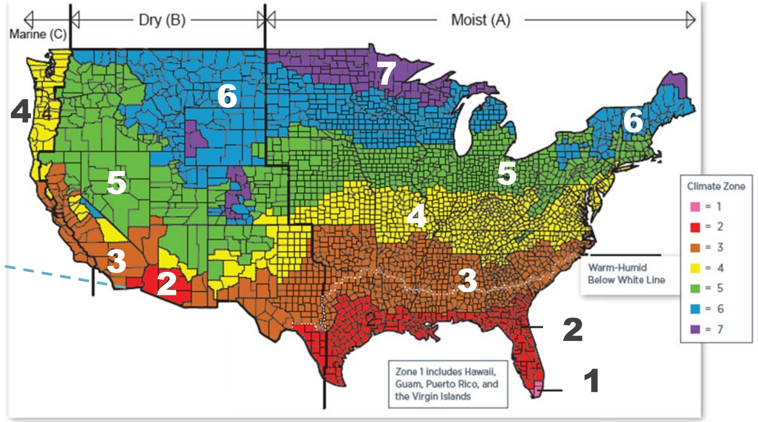
California
5 Zones



ASHRAE



IECC

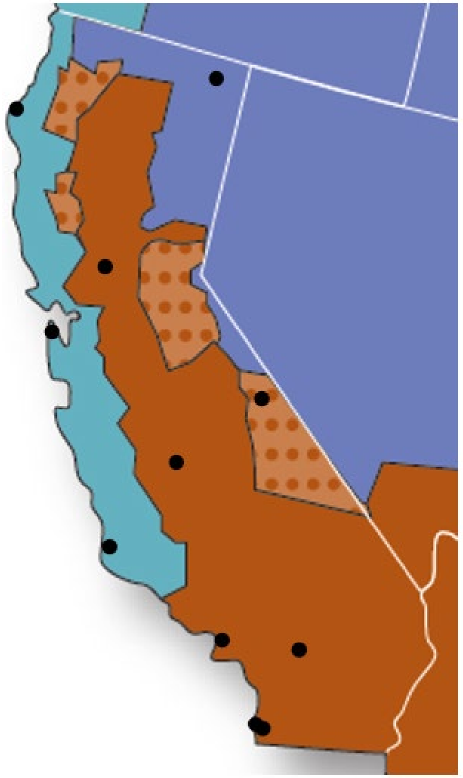


Select Climate Classifications

- California; 5 zones
  - 10 cities identified
  - San Francisco is in climate zone category Marine 3C
    - ASHRAE (Marine), IECC = 3C

% Time Operating in Transcritical Mode (Supercritical Operation)

California
5 Zones



City	ASHRAE	IECC	%TC Dry GC	%TC Adi GC
San Diego	Hot Dry	3B	10%	0.5%
Sacramento	Hot Dry	3B	22%	0%
Los Angeles	Hot Dry	3B	5%	0%
Palm Springs	Hot Dry	3B	54%	6.5%
Fresno Yosemite	Hot Dry	3B	30%	0%
San Francisco	Marine	3C	2%	0%
Santa Maria	Marine	3C	4%	0%
Bishop	Mixed Dry	4B	25%	0%
Arcata	Marine	4C	0.1%	0%
Alturas	Cold	5B	13%	0%

Assumptions: ≥ 75 °F Ambient = Supercritical operation dry gas cooler
≥ 72 °F Ambient = Water flow adiabatic gas cooler

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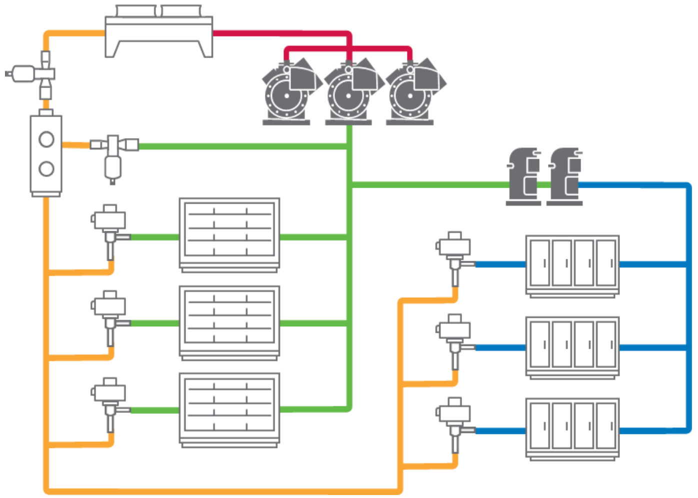
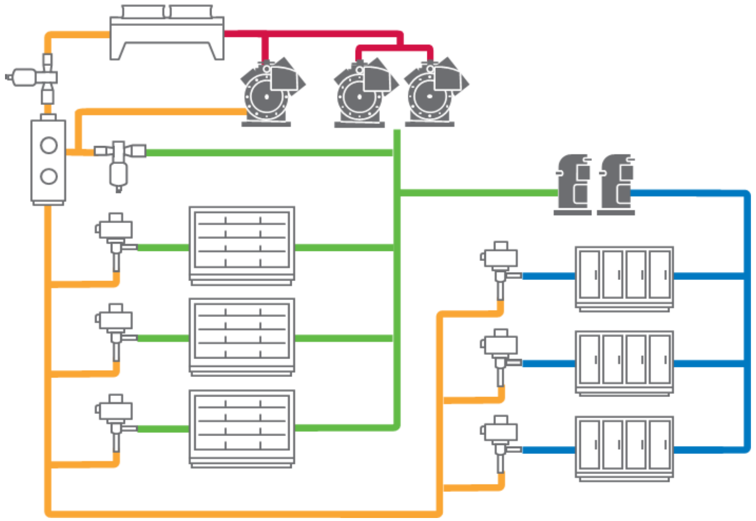
Strategies Evaluated

Dry Gas Cooler + Parallel	Adiabatic Gas Cooler + Parallel	Dry Gas Cooler + Parallel + HP Ejector	Adiabatic Gas Cooler + Parallel + HP Ejector

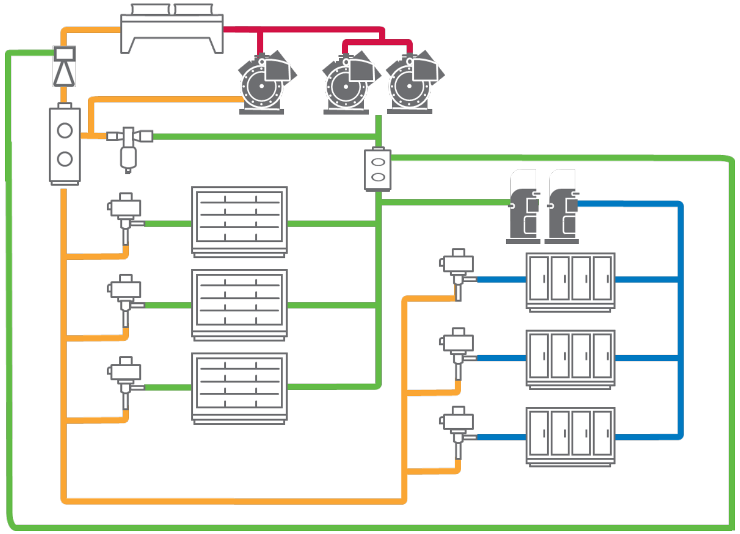
Dry Gas Cooler



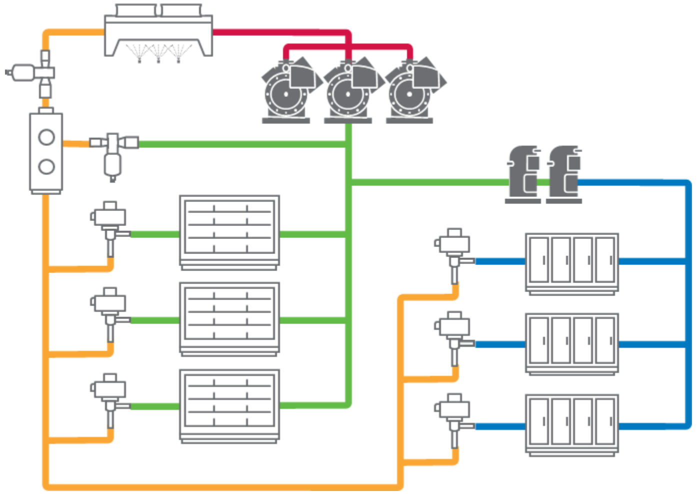
Dry Gas Cooler + Parallel



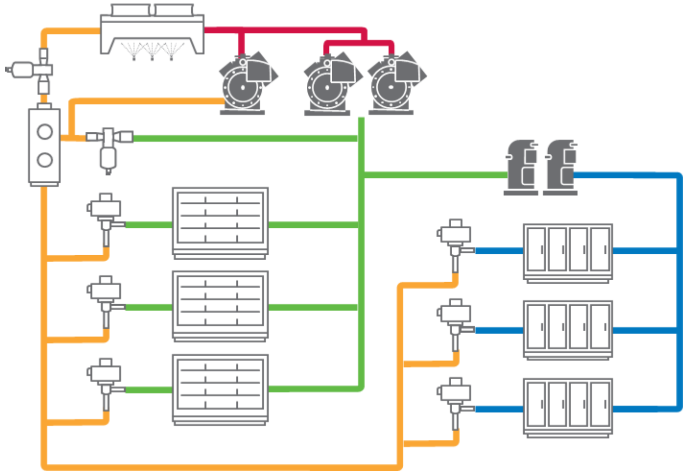
Dry + Parallel + HP Ejector



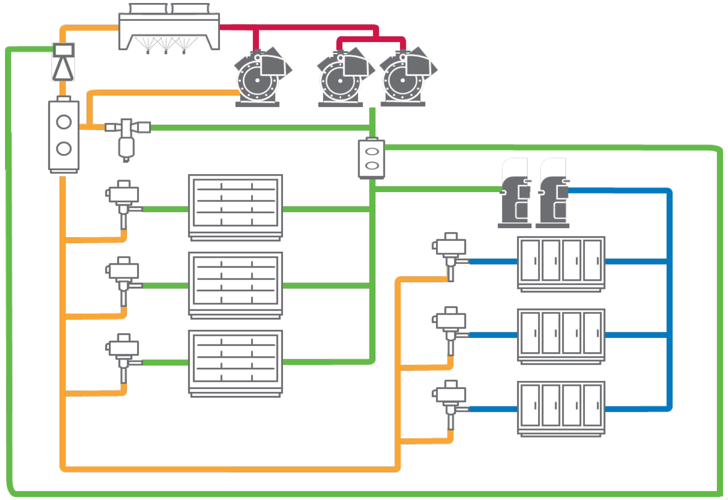
Adiabatic Gas Cooler



Adiabatic + Parallel

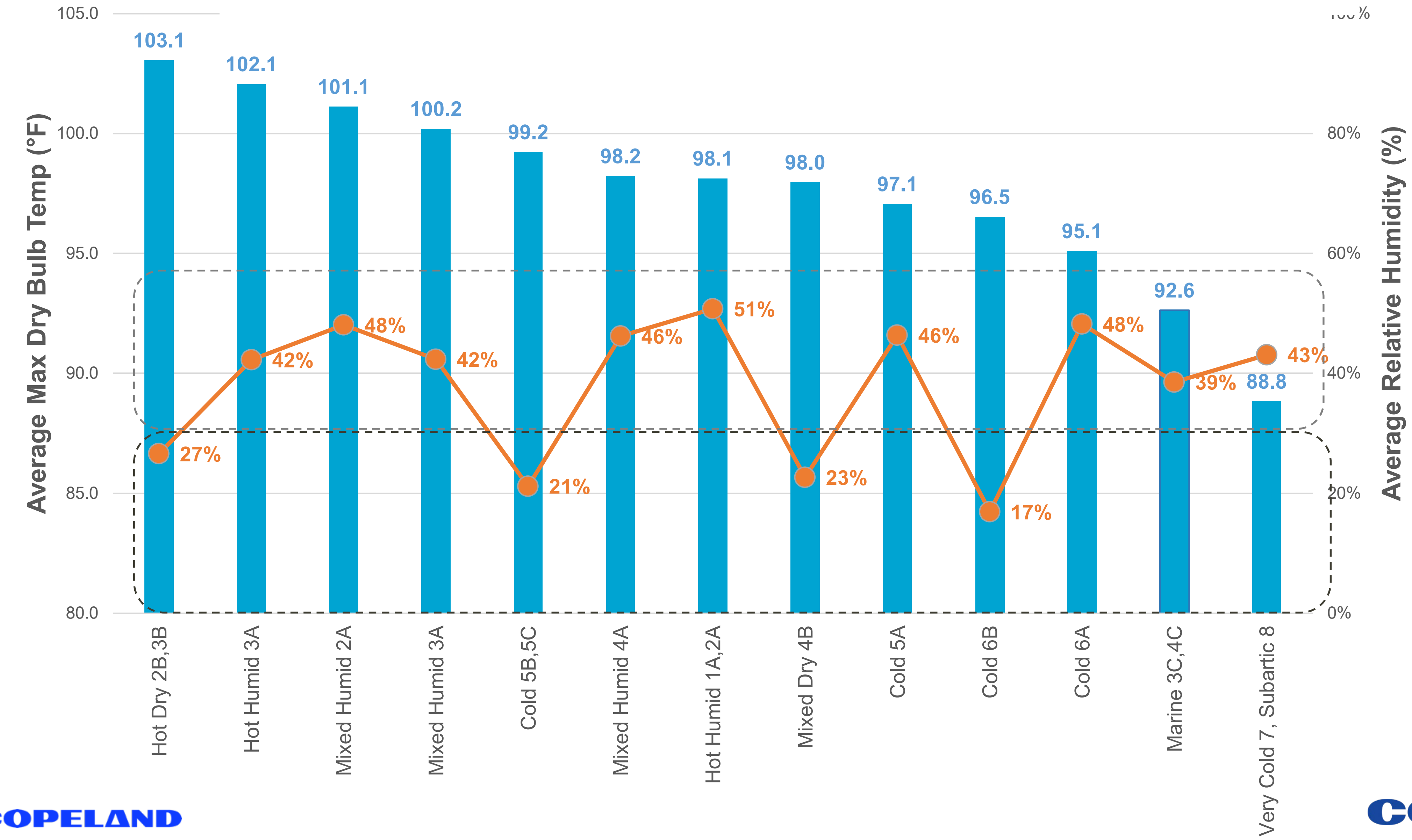


Adiabatic + Parallel + HP Ejector



Mechanical sub-cooling evaluated & Zero MT S.H. and liquid ejectors being evaluated in CO2 Climate Study v2.0

Ave Max Dry Bulb and RH% Per Climate Zone



Parallel Compression Advantage over Adiabatic

Adiabatic Advantage Over Parallel Compression

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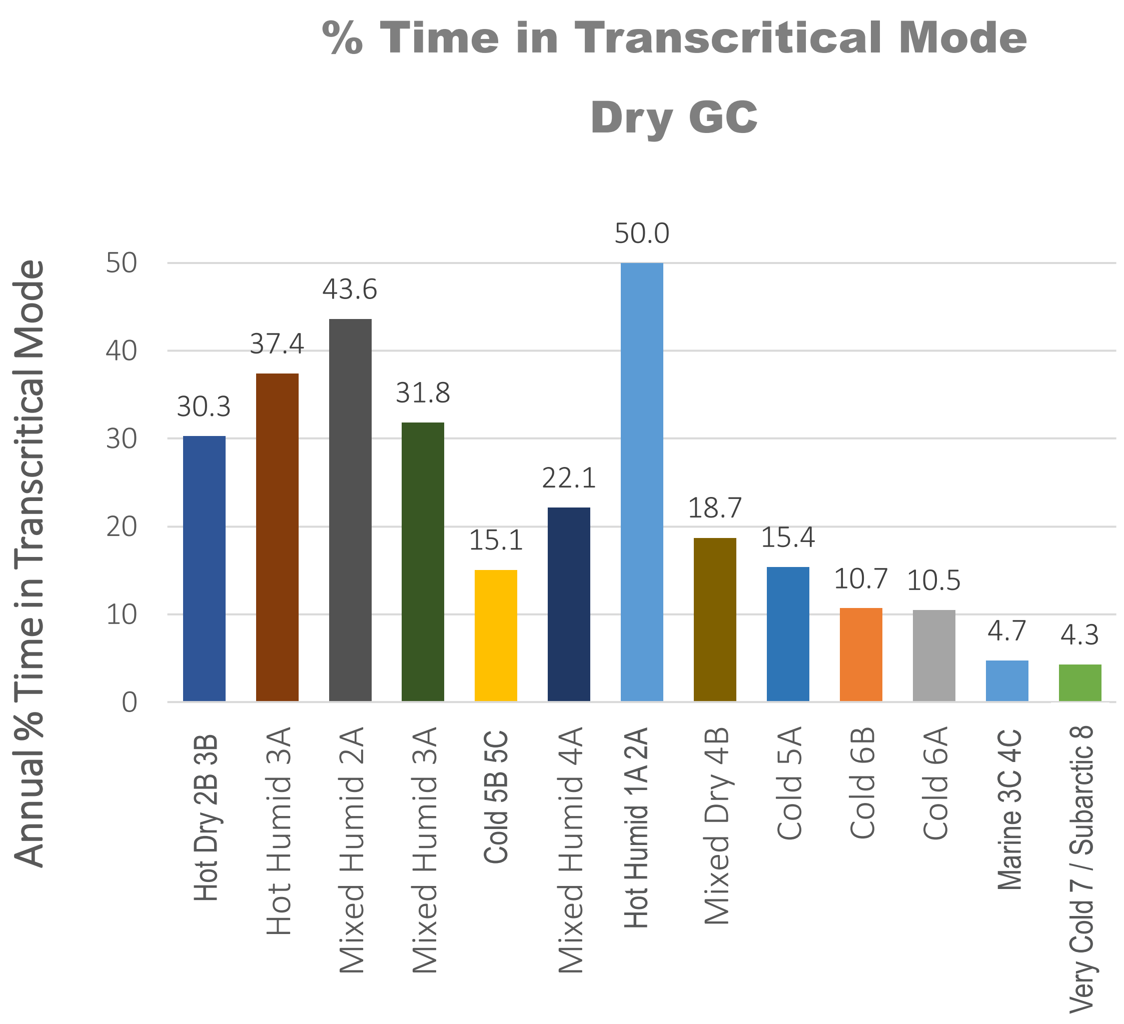
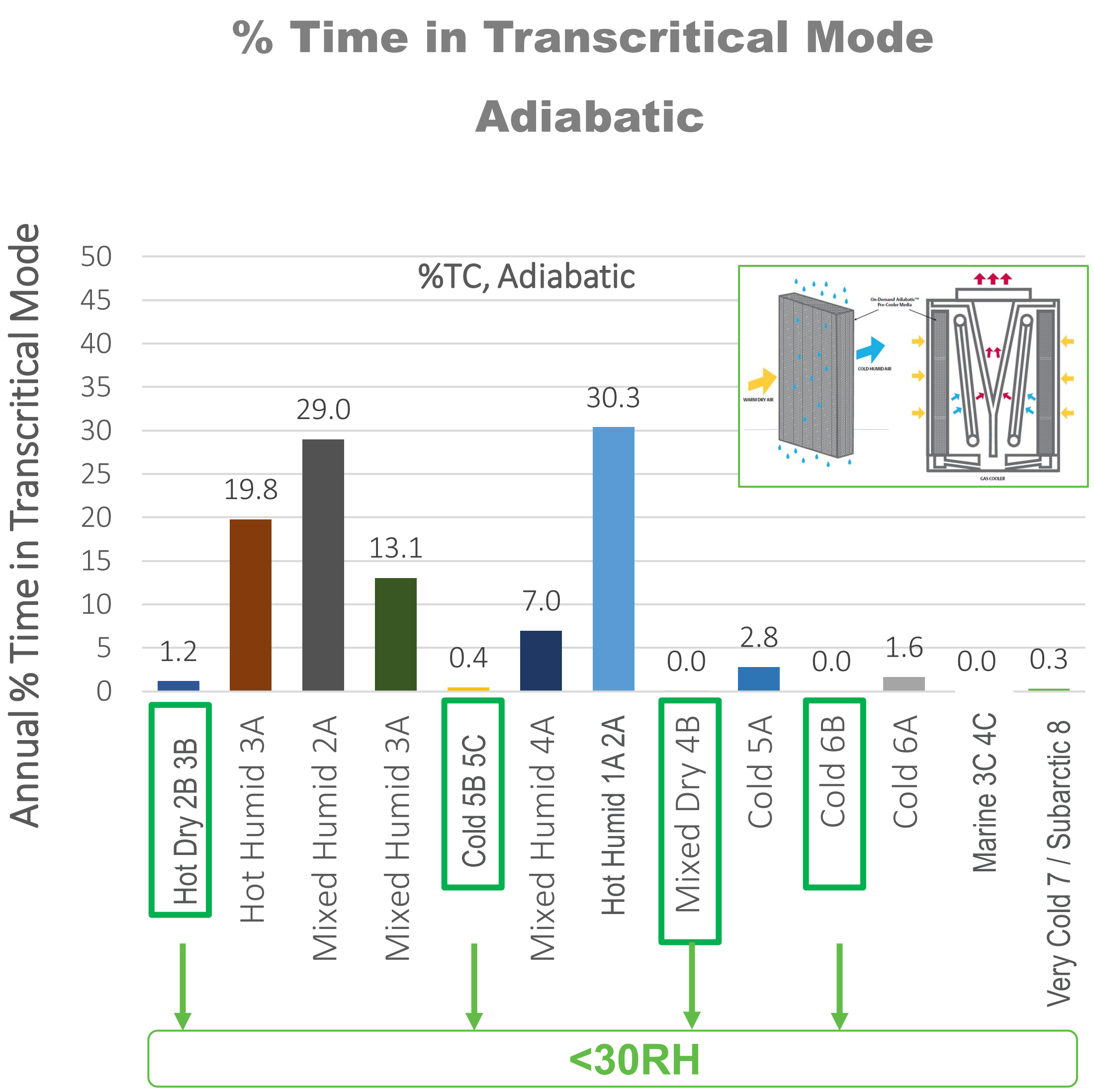
Basic Transcritical CO2 Booster Annual % Runtime Above Critical Point*





- *Assumptions: ≥ 75 °F Ambient = Supercritical operation dry gas cooler
- ≥ 72 °F Ambient = Water flow adiabatic gas cooler

Climate Zones with Lower Relative Humidity have the Most Significant Reduction in % Transcritical Time When Adiabatic Gas Coolers are Applied.

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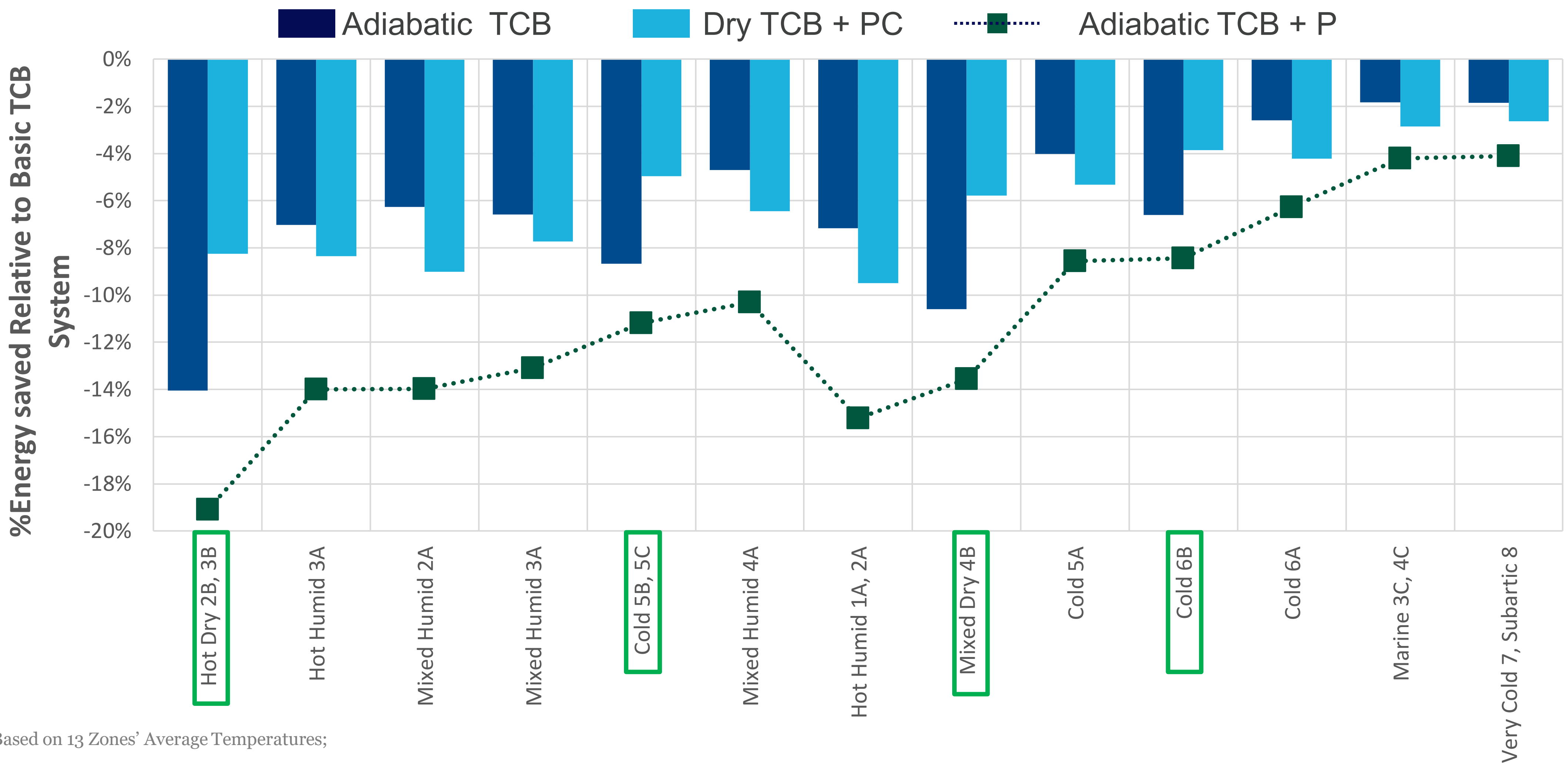
Percent of Energy Saved vs. Basic TCB Systems

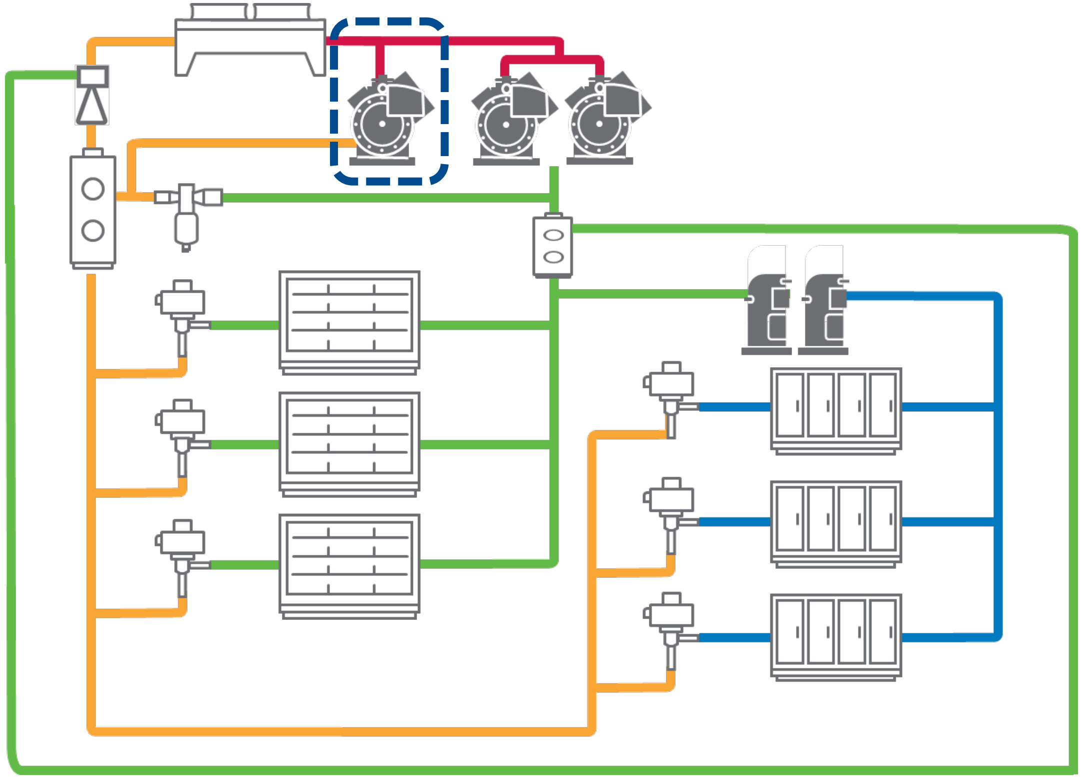


- Charts Based on 13 Zones' Average Temperatures;
- Weather Data: NREL TMY3 data, EES Software, 400MBH MT +18SST, 100MBH LT -20F

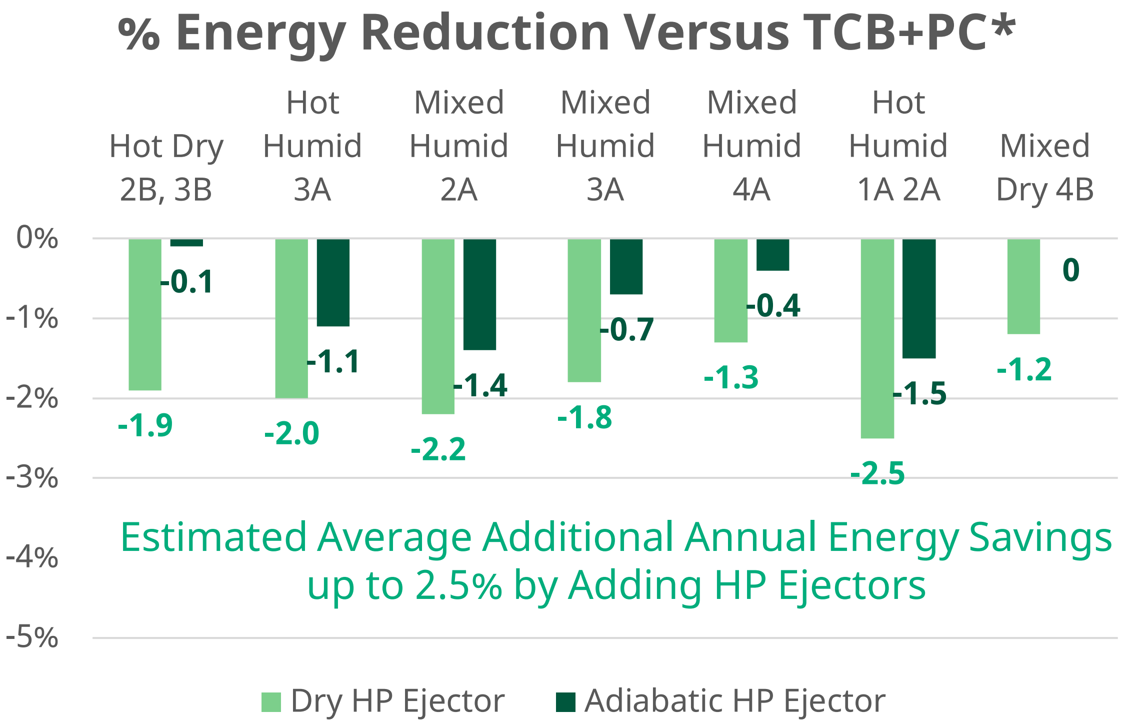
Climate Zones with Lower Average Relative Humidity Show Better Energy Reduction With Adiabatic Gas Coolers than with Parallel Compression…

High Pressure Ejectors?   Result from Emerson CO2 High Ambient Study

High Pressure Ejector System Requires Parallel Compression By Default



Energy Benefit of Adding Ejectors For Only The Warmest Climate Zones (%Time Dry Cooler TC >18%)



High Pressure Ejectors Add An Estimated 1-3% Annual Energy Reduction Over and Beyond a Transcritical CO2 Booster System with Parallel Compression…

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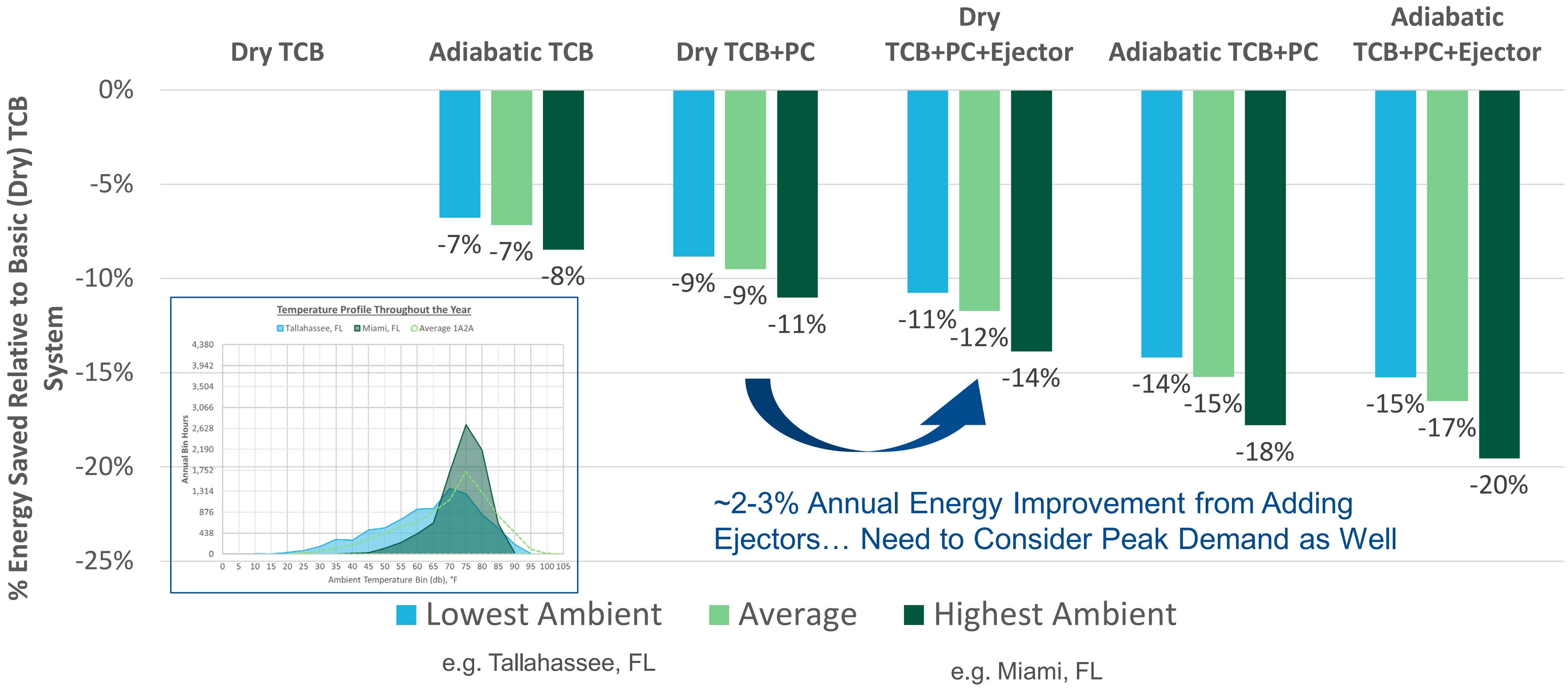
*Comparison is Normalized By Gas Cooler Type;
Dry Gas Cooler + Parallel Compression Vs Adiabatic Gas Cooler + Parallel Compression

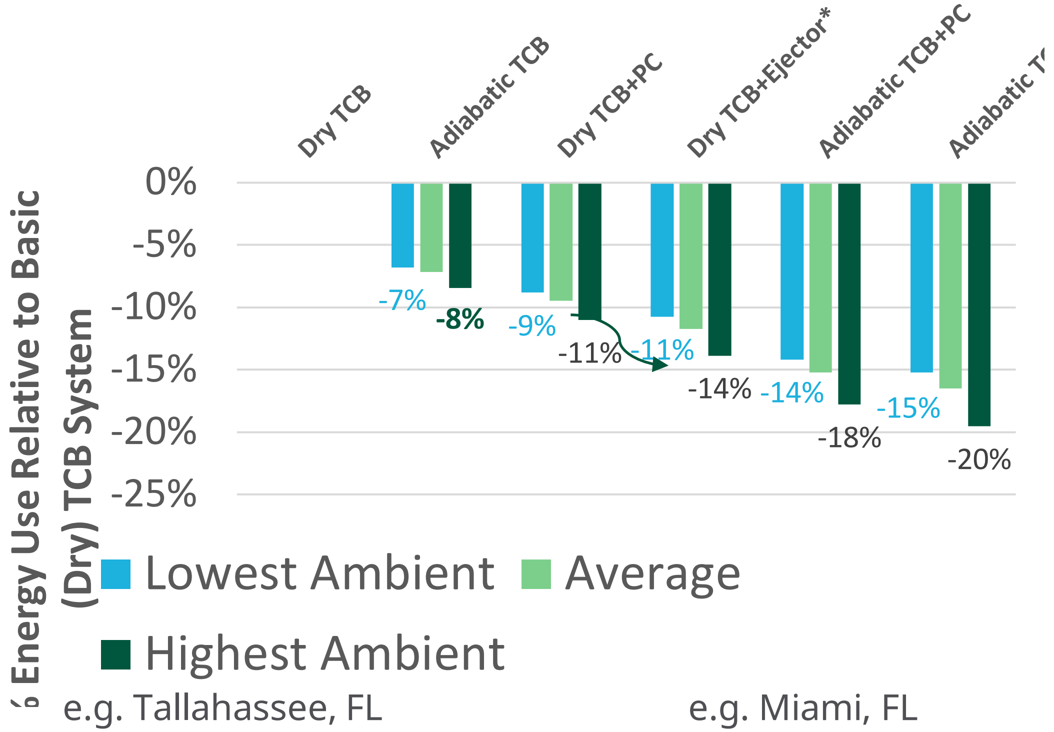
Percent Energy Saved vs. Basic TCB Systems;
Climate Zone – Hot Humid 1A 2A – 10 Cities



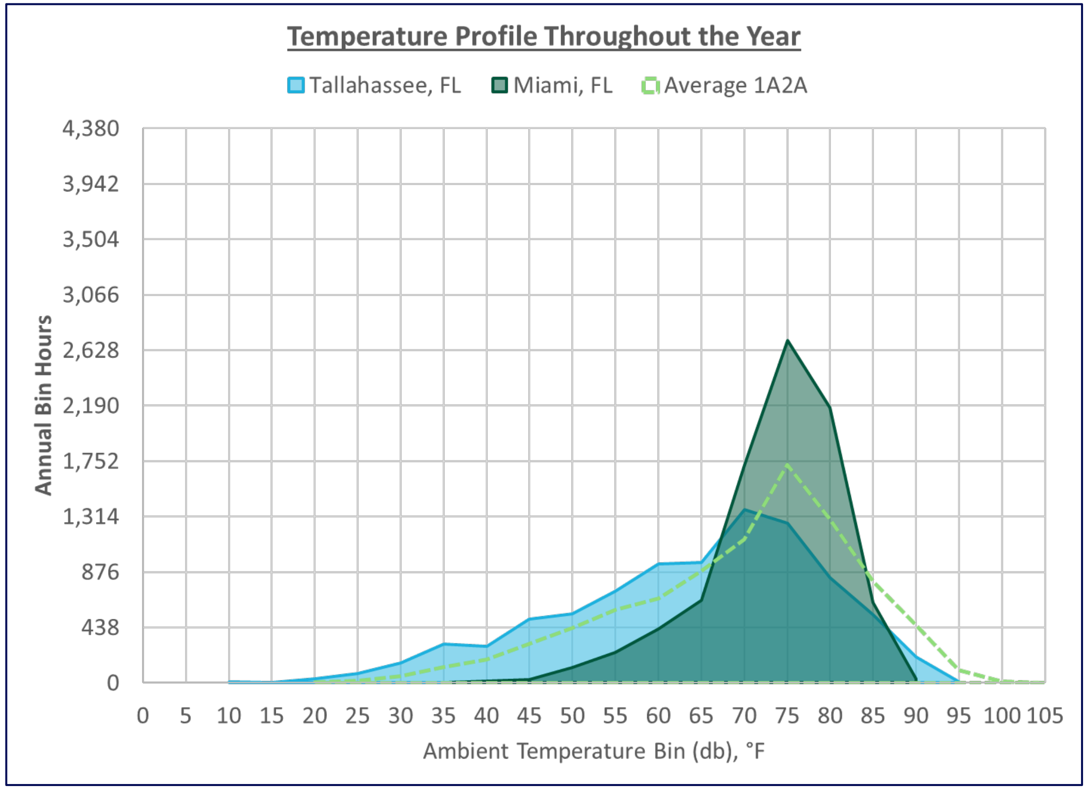
Systems with HP Ejectors also use Parallel Compression

Percent Energy Saving vs. Basic TCB Systems; Climate Zone – Hot Humid 1A 2A – 10 Cities

Parallel Compression for Hot Humid Climate Provides Best Efficiency Improvement; High Pressure Ejector Adds ~2 to 3% More Annual Energy Savings



Temperature Profile For Hot Humid 1A/2A Climate Zone



* Systems with HP Ejectors also use Parallel Compression

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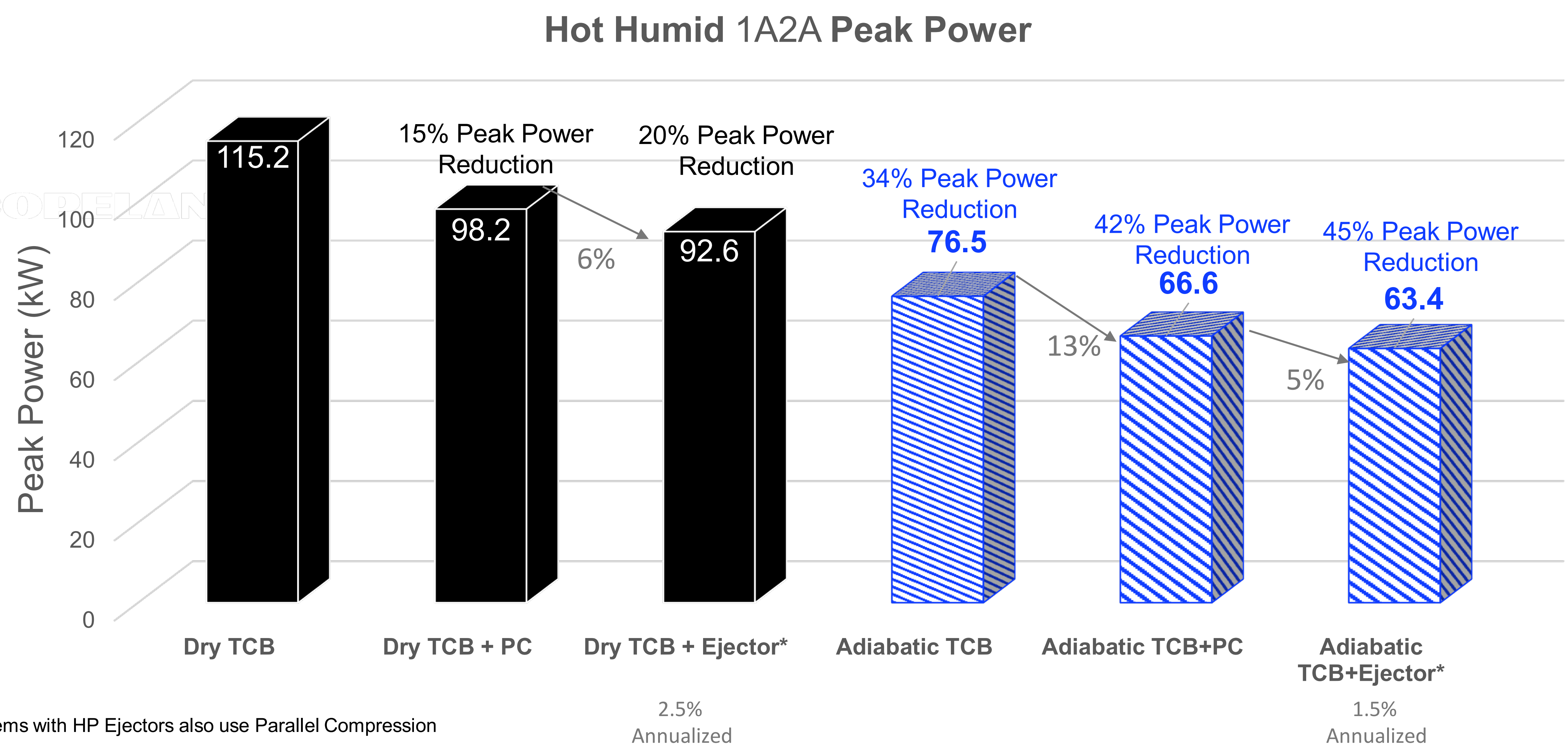
Example of Peak Power Usage Depending on Refrigeration Strategy

Hot Humid 1A 2A (Florida)



* Systems with HP Ejectors also use Parallel Compression

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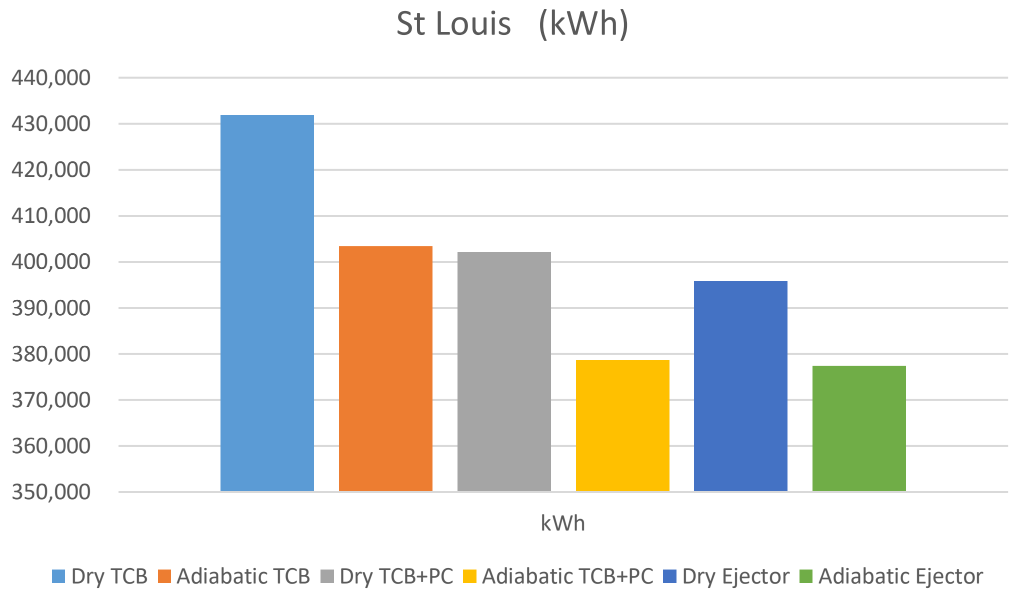
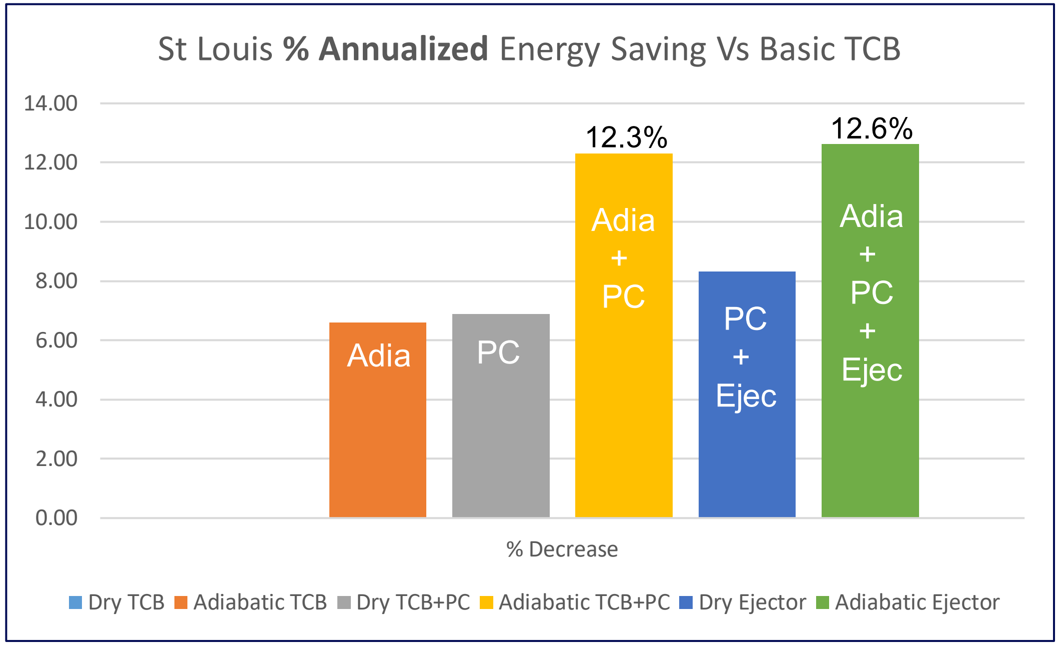
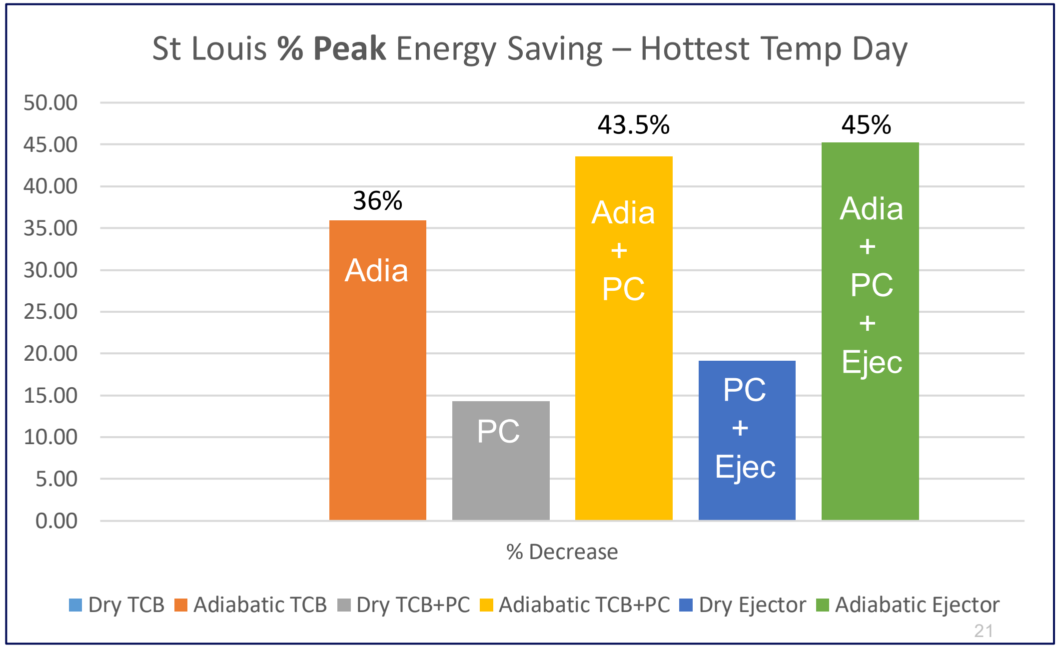
Peak power consumed when system running in maximum ambient temperature bin. For this climate zone , on average , the dry cooler system may see less than an hour at 105°F ambient and at least one hour at 85°F when using an adiabatic gas cooler. *HP Ejectors can reduce peak power an additional 3-5% over parallel compression.*

St Louis, MO – Mixed Humid 4A







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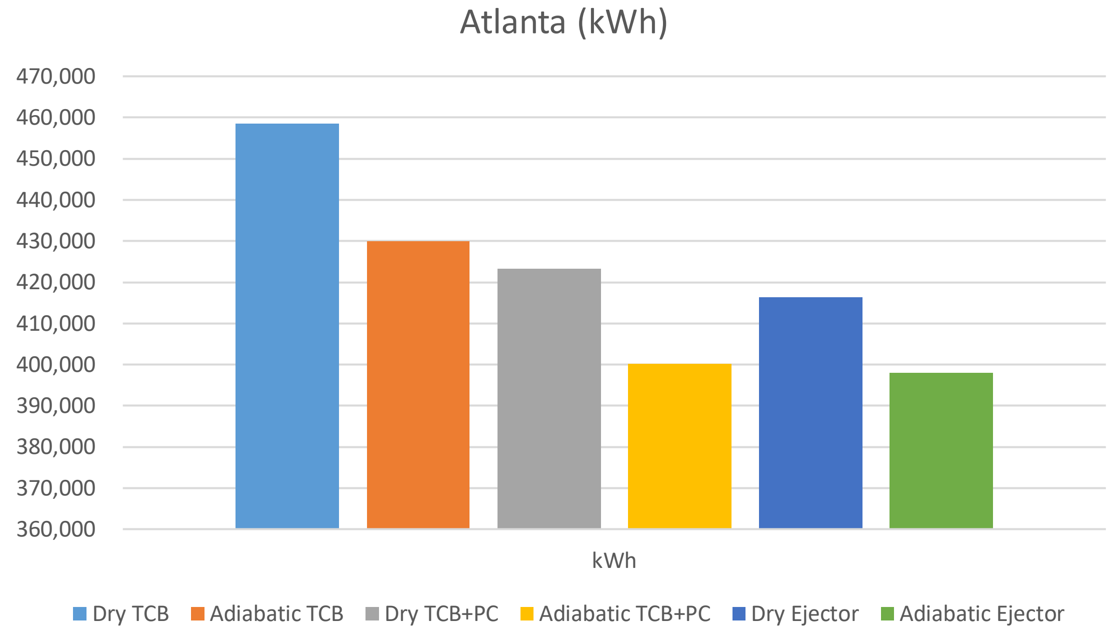
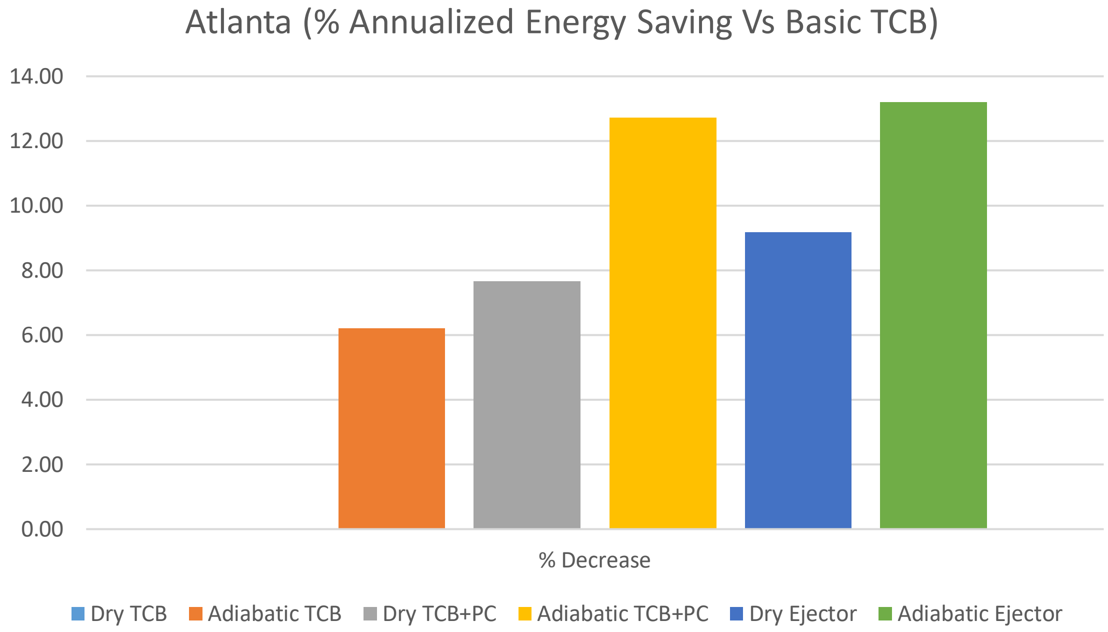
Atlanta, GA – Mixed Humid 3A





Atlanta	kWh	% Decrease
Dry TCB	458,379	0.00
Adiabatic TCB	429,937	6.20
Dry TCB+PC	423,316	7.65
Adiabatic TCB+PC	400,053	12.72
Dry Ejector	416,299	9.18
Adiabatic Ejector	397,913	13.19

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Additional Considerations

Electrical rate

Rate structure, peak demand charges

Water resources

Availability, cost, sewage charges

Service and maintenance skill levels

Regional CO_2 experience or knowledge gap

Heat reclaim

Volume and intensity requirements

Carbon intensity, electrical generation sources

Impact on Net-zero 2040 goals for scope 2 emissions

Carbon Credits

Summary

This study was commissioned to provide industry stakeholders with an unbiased third-party engineering evaluation of energy comparison of the most common high ambient strategies to support the uptake with CO2 Transcritical booster systems for the supermarket industry.

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Total Cost of Ownership

Andre Patenaude

Nov.16, 2023

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Total Cost of Ownership Study - Partners

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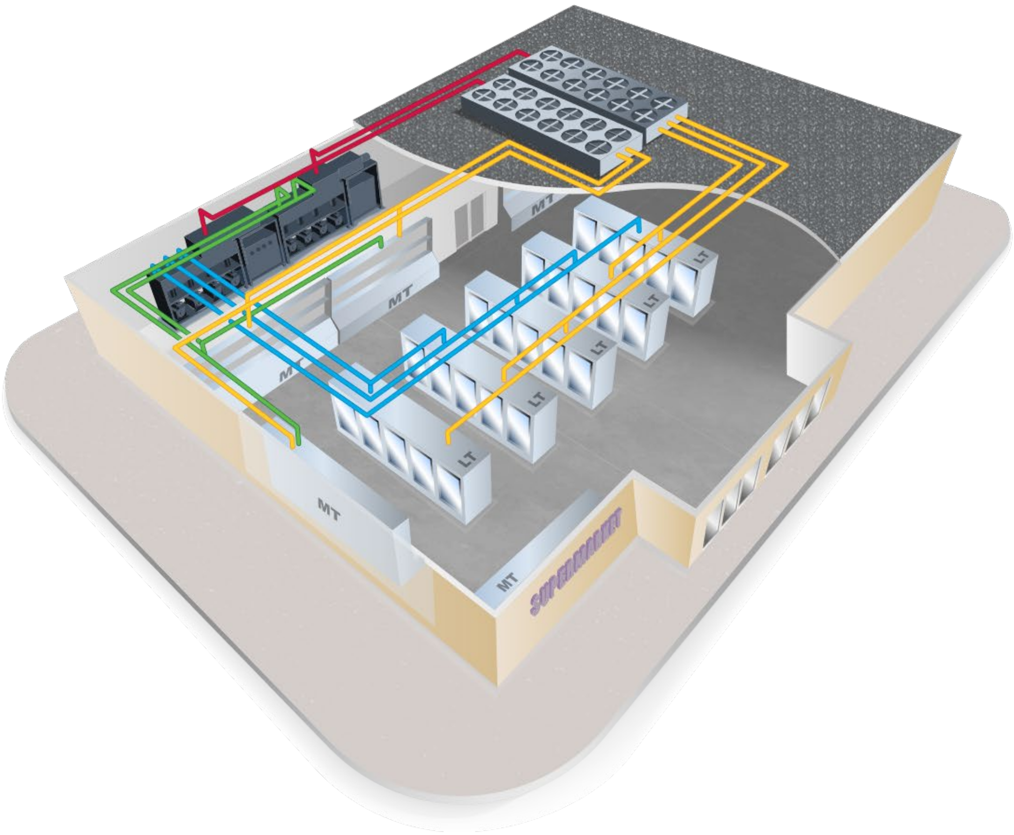

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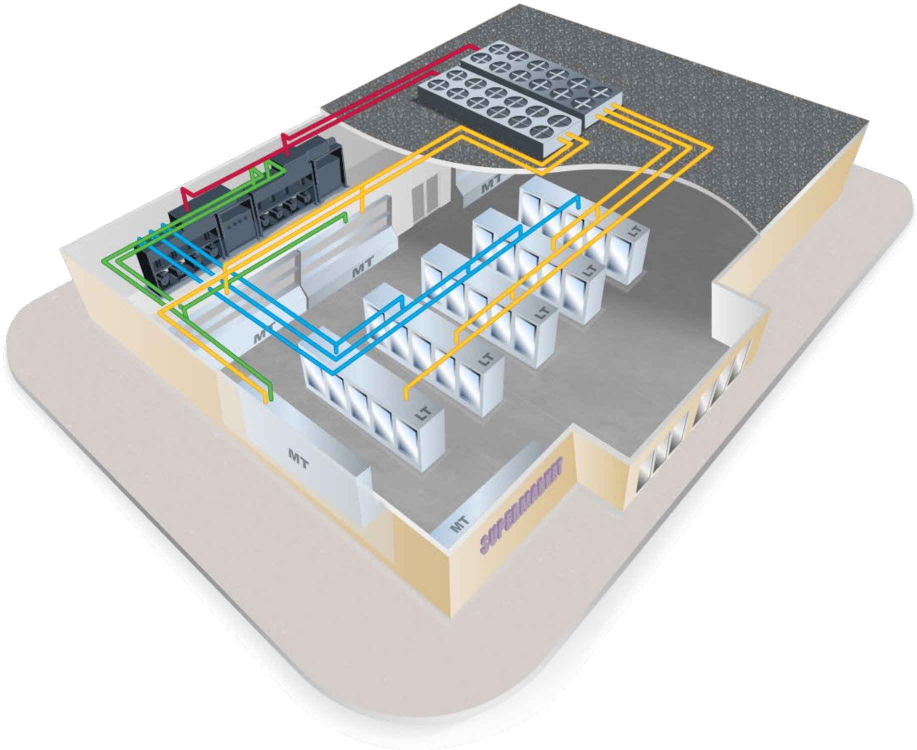
AAA Refrigeration Service, Inc.
"Dedicated to Excellence Since 1937"

Total Cost of Ownership Study

Architecture Options

1. Centralized DX
2. Distributed Scroll
3. Condensing Units
4. CO2 Booster (Adiabatic)
5. CO2 Booster
6. R290 Micro Distributed
7. Scroll Booster



Specifications

- ✓ 25,000 ft^2 Store Size
- ✓ 450MBH MT (30 Cases + 5 Coolers)
- ✓ 91MBH LT (16 Cases + 1 Freezer)
- ✓ Schedules for each;
  - ✓ Refrigeration
  - ✓ Electrical
- ✓ Floor Plans for each;
  - ✓ Refrigeration
  - ✓ Electrical
- ✓ LCCP Analysis

Desired Outputs: To understand the Total Cost of Ownership Relative to Centralized HFC

All Equipment, Installation, Commissioning, Service, Maintenance over 20 years

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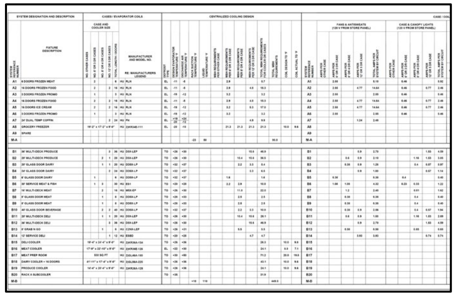
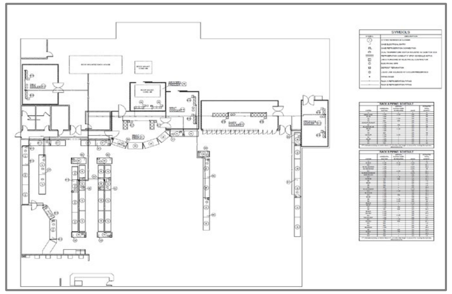
Layout Consistent Across All Systems

- 450 MBH MT
- 91 MBH LT

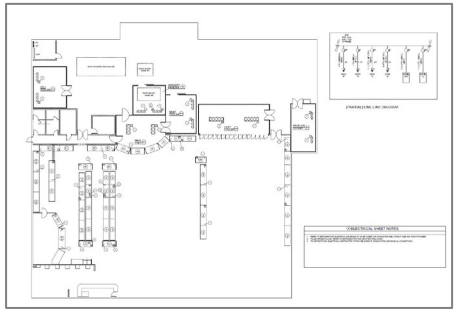
8x Refrigeration Schedules



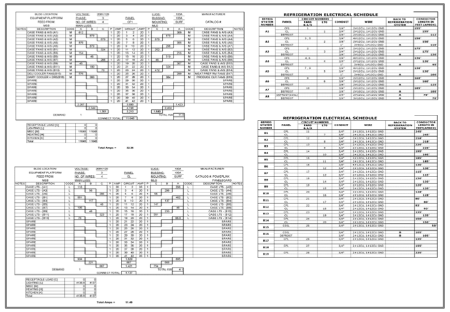
8x Refrigeration Floor Plan

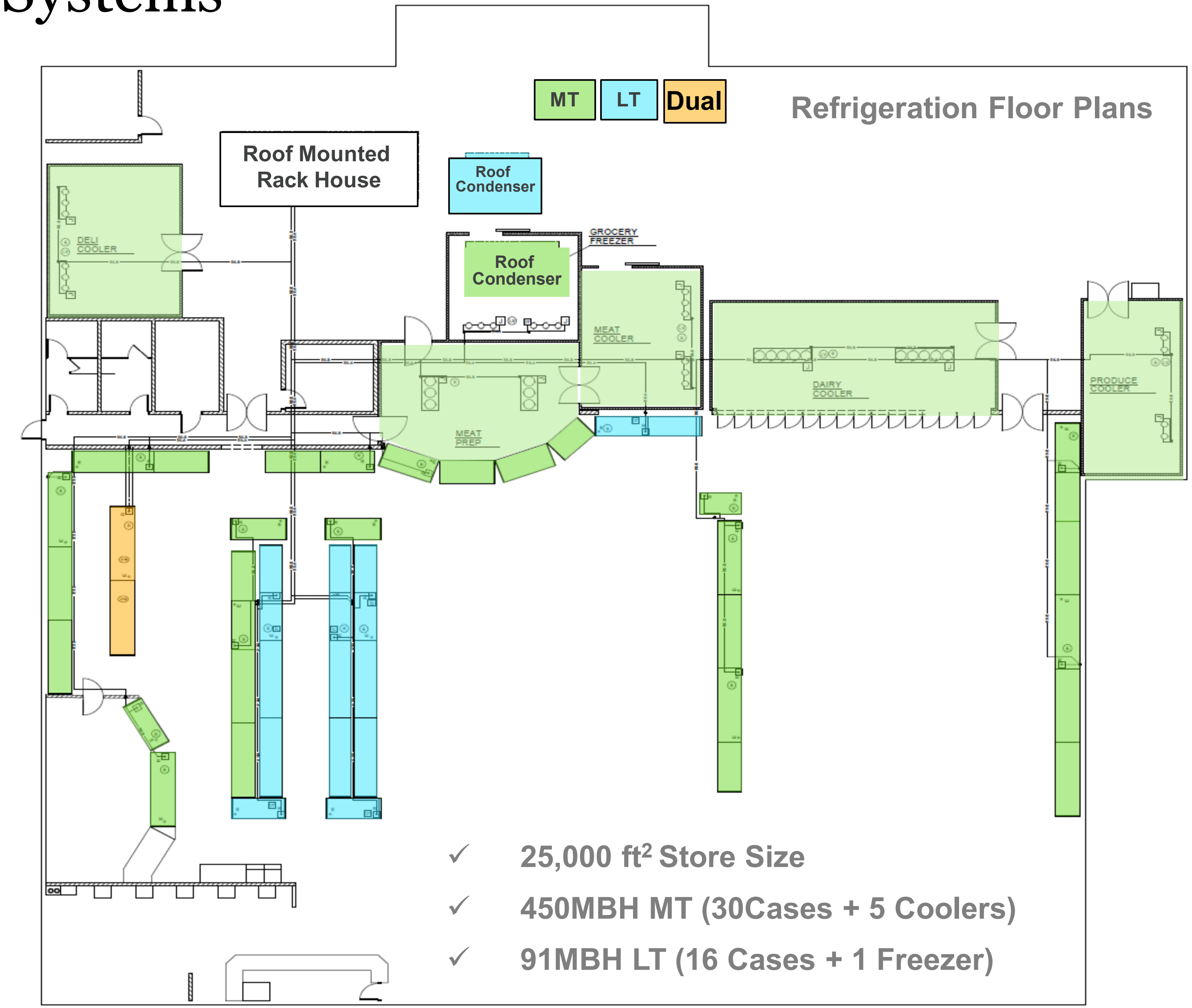


8x Electrical Floor Plans



8x Electrical Schedules





- ✓ 25,000 ft^2 Store Size
- ✓ 450MBH MT (30Cases + 5 Coolers)
- ✓ 91MBH LT (16 Cases + 1 Freezer)

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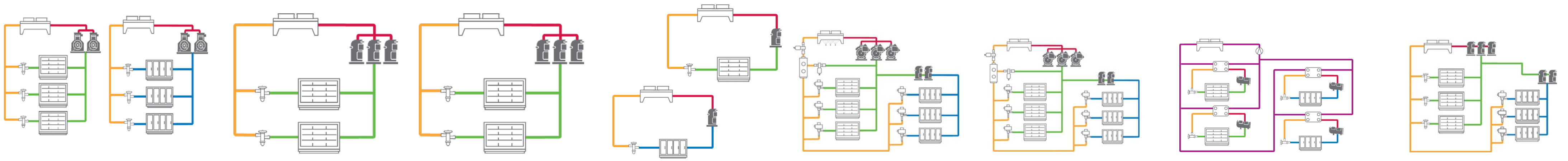
System Comparisons



	Traditional HFC Rack	Distributed Scroll	Distributed Scroll (A2L)	Condensing Unit	CO2 Booster With Adiabatic	CO2 Booster	Micro DS Adiabatic	Scroll Booster (MT/LT Packs)
# of Compressors	9	15	15-16	27	7	7	52	17
Case Controls	✗	✗	✗	✗	✓	✓	✓	✗
Refrigerant	R-448A	R-448A	**R-454C**	R-448A	CO2	CO2	R-290	R-513A
Expansion Valve	TXV	TXV	TXV	TXV	EEV	EEV	Capillary Tube / TXV	TXV
Condenser / Gas Cooler	Dry	Dry	Dry	Dry	Adiabatic (Water Required)	Dry	Adiabatic (Water Required)	Dry
Control	Centralized	Distributed	Distributed	Distributed	Distributed w/ Case Control	Distributed w/ Case Control	Distributed w/ Case Control	Centralized
Challenges	High AWGWP Obsolete in CA High Leak Rates	Meeting regulations with GWP	A2L approval and building code timing	27 Units to Service 27 Condensers to clean	Leaks Complexity, Technicians Highest CapEx	Leaks Complexity, Technicians Peak Energy	Annual Energy 52 Units to Service Units/Cases /Sales Floor	Larger Displacement Compressors Charge <50lb for Now

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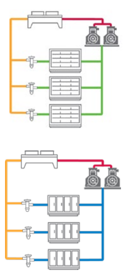
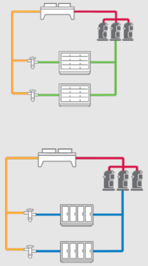
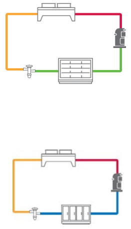
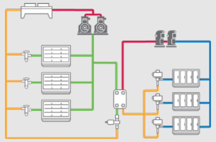
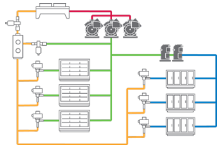
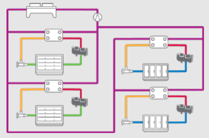
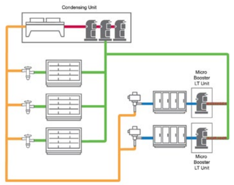
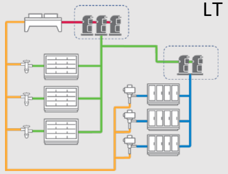
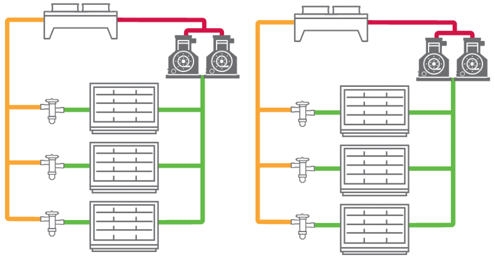
Assumptions

System Specifications	HFC Centralized Racks	HFC Distributed Systems	HFC Condensing Units	CO2 Cascade	CO2 Booster	Micro-Distributed	Scroll Booster LT Compressor Unit into MT Scroll Pack	Scroll Booster LT Scroll Pack into MT Scroll Pack
- 25,000 ft^2 Store Size - 450MBH MT (30 Cases + 5 Coolers) - 91MBH LT (16 Cases + 1 Freezer)	MT LT 	MT LT 	MT LT 	MT LT 	MT LT 	MT LT 	MT LT 	MT LT 

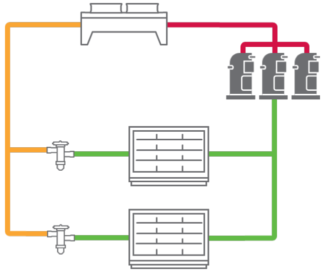
	HFC Centralized Racks		HFC Distributed Systems		HFC Condensing Units		CO2 Cascade		CO2 Booster		Micro-Distributed		Scroll Booster LT Compressor Unit into MT Scroll Pack		Scroll Booster LT Scroll Pack into MT Scroll Pack	
	R448A	kBtu	R448A	kBtu	R448A	kBtu	CO2/R513A	kBtu	CO2	kBtu	R290	kBtu	R513A	kBtu	R513A	kBtu
LT Load		90.8		90.8		90.9		90.8		90.8		87.422		91		90.839
MT Load		417.6		417.6		417.7		417.6		417.6		421.259		417.5		417.5
Total Load		508.4		508.4		508.6		508.4		508.4		508.681		508.5		508.339
Condenser TD	LT: 10	°F	LT: 10	°F	LT: 20	°F	MT: 15	°F	SC: 5, TC: 10	°F	Water Cooler: 15	°F	MT: 15	°F	MT: 15	°F
	MT: 15	°F	MT: 15	°F	MT: 20	°F					Unit2: 10	°F				
Comp RG	LT: 40	°F	LT: 40 RG	°F	LT: 20 SH	°F	LT: 36 SH	°F								
	MT: 65	°F	MT: 50 RG	°F	MT: 40 SH	°F	MT: 65	°F	SC: 36 SH, TC: 18 SH	°F	20 SH	°F	LT: 20 SH, MT 65 RG	°F	LT: 40 SH, MT 65 RG	°F
Min Cond	70	°F	70	°F	70	°F	70	°F	50	°F	60	°F	70	°F	70	°F
Leak Rate	0.15		0.1		0.05		0.15		0.15		0.05		0.15		0.15	
GWP (AR4)	1387		1387		1387		1/1387		1		3/1387		631		631	
Charge	LT: 460	lbs	LT: 380	lbs	A1	20.3	LT: 260 lbs		LT: 140 lbs		A1	0.661387	System 1:	470 lbs	System 1:	470 lbs
	MT: 790	lbs	MT1: 450	lbs	A2	33.4	MT: 560 lbs		MT: 560 lbs		A2	0.661387	System 2:	450 lbs	System 2:	450 lbs
	1250	lbs	MT2: 580	lbs	A3	20.3	**820 lbs**		**700 lbs**		A3	0.99208	Total	**920 lbs**	Total	**920 lbs**
			1410	**lbs**	A4	33.4					A4	0.99208				

Total Cost of Ownership Study – Architectures

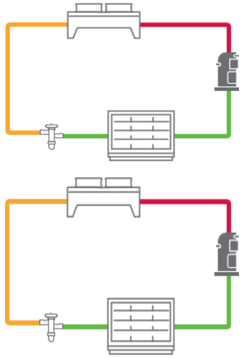
HFC Centralized
R448/9A



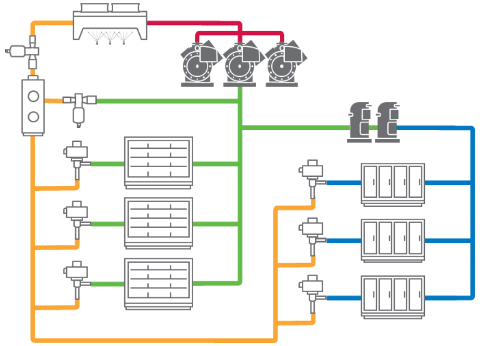
Distributed Scroll Pack
R448/9A



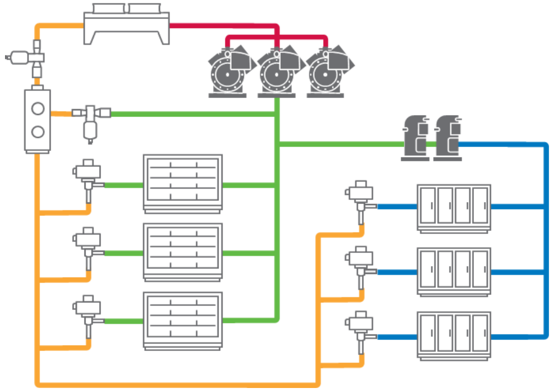
Single Condensing Units
R448/9A



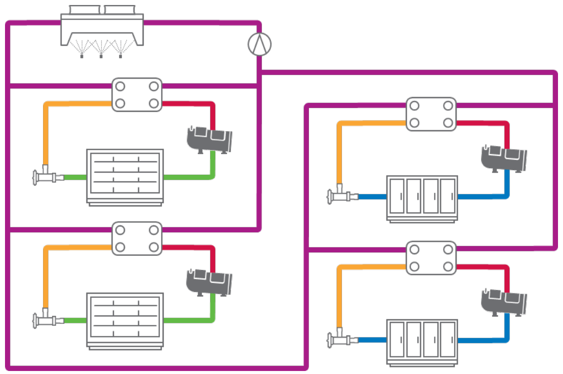
Transcritical Booster
CO2 (Adiabatic)



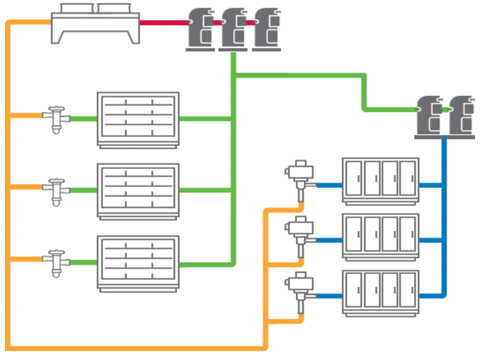
Transcritical Booster
CO2 (Non-Adiabatic)



Micro Distributed
R290 Water Cooled (Adiabatic)



Scroll Booster
LT Rack into MT Rack
R513A



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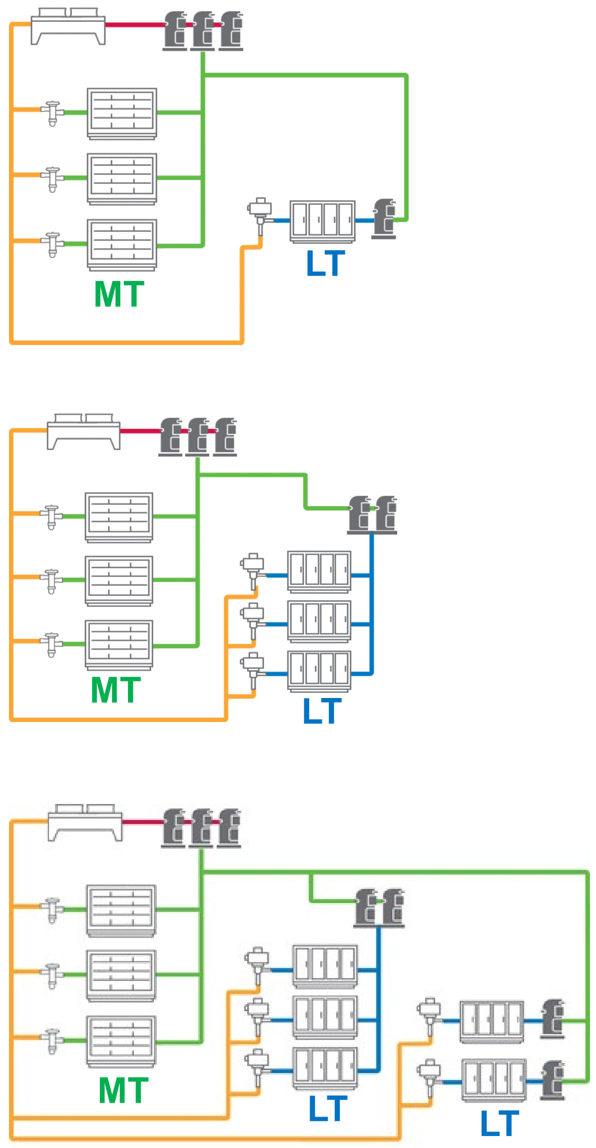
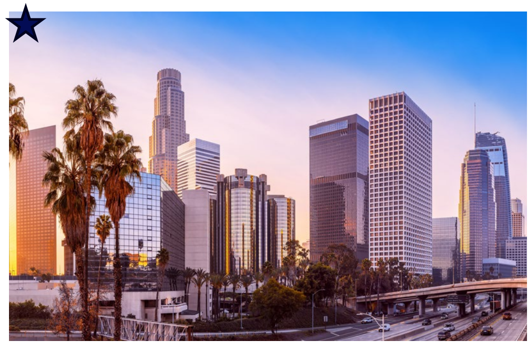
Scroll Booster

Basic Design:

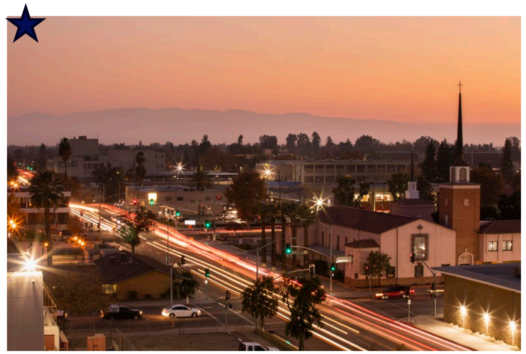
- Future Potential CARB Compliant A2L Capable <150 GWP
  - 170lbs Releasable (UL-60335-2-89 Standard)
- Multiple Configuration Creates Flexibility
- Grocery Store, C-Stores, Restaurant, etc
- R513A (~600 GWP) Both MT & LT
- Low Pressure, Low Leaks Rates
- High Ambient Friendly, Low Discharge Temps
- Low Compression Ratio
- LT Loads w/Unit per Case; Dual Temp Capable
- High Reliability
- Simple Layout
- No Specialized Training



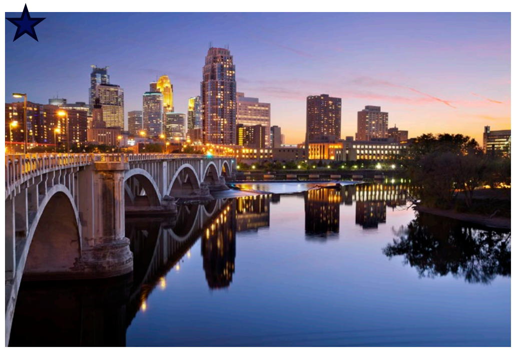
Location Assessments



Los Angeles

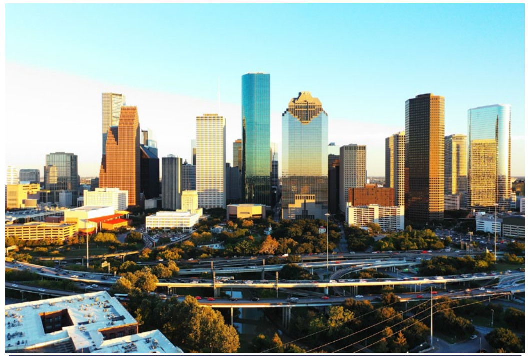


Bakersfield

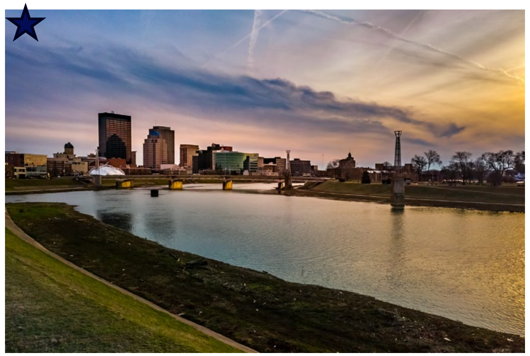


Minneapolis

San Francisco



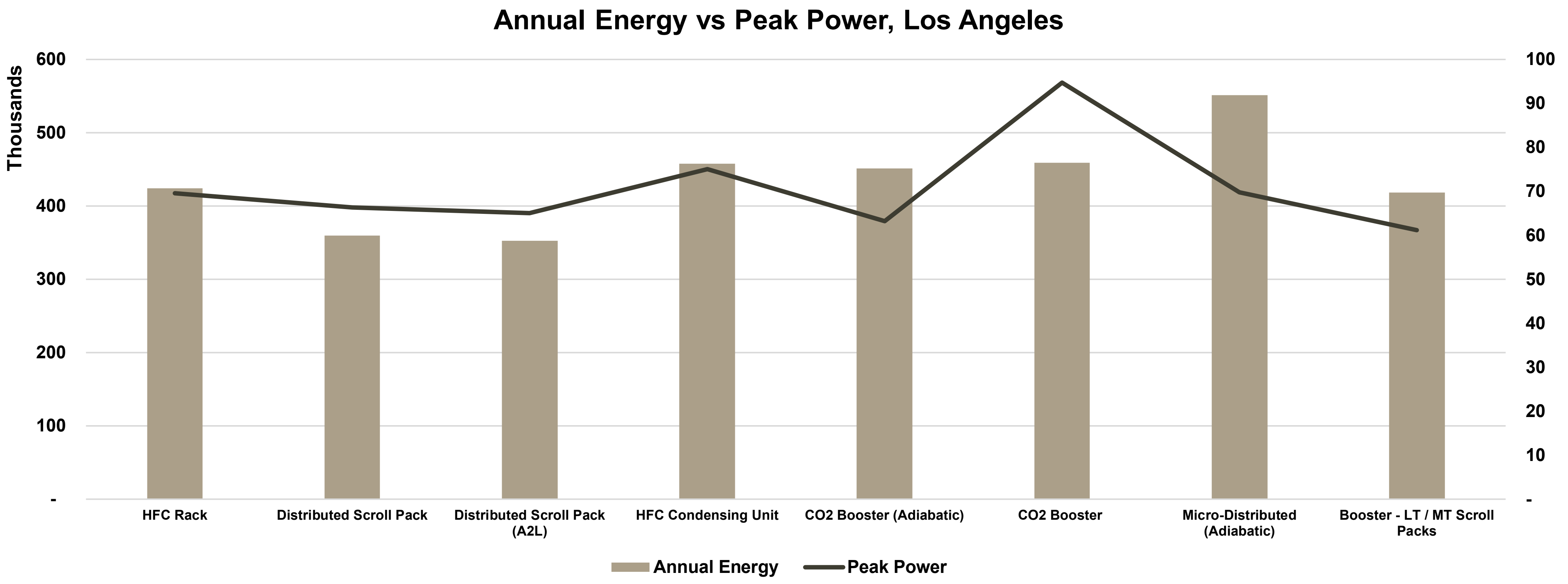
Houston



Dayton

Los Angeles

Los Angeles Energy Comparison

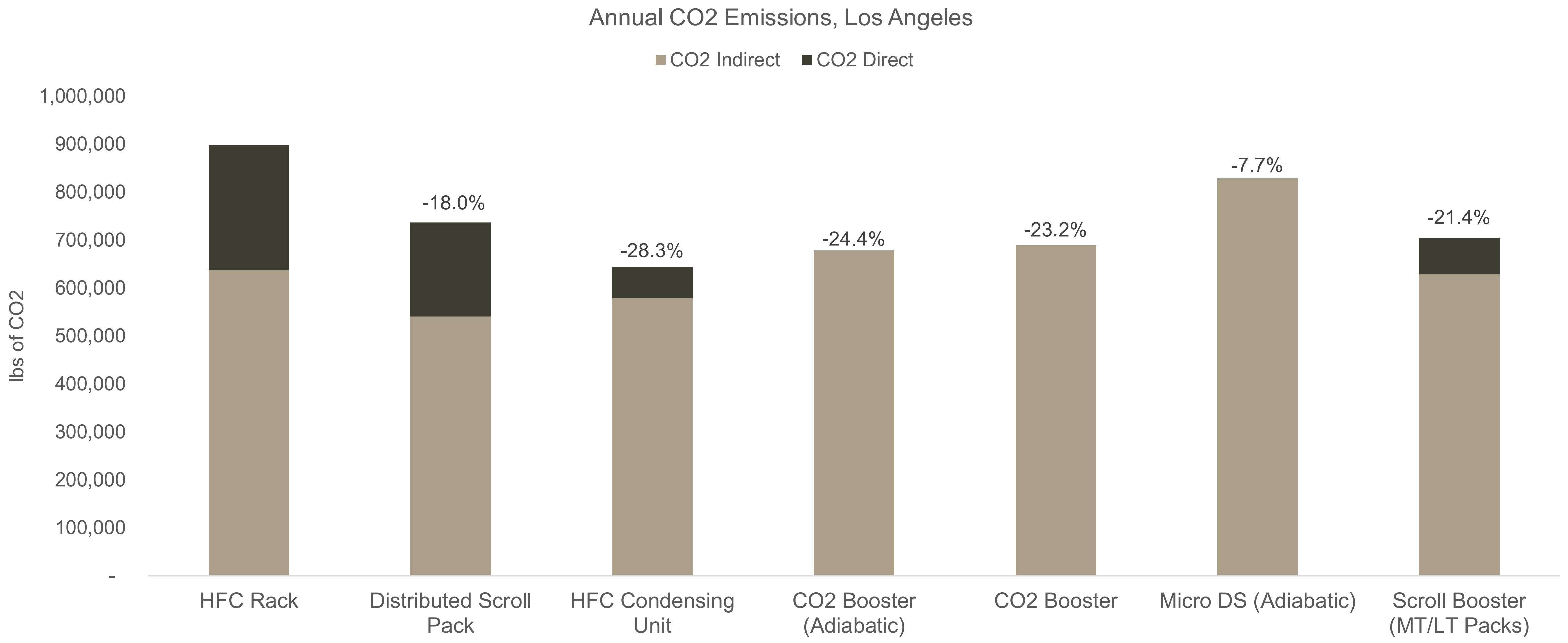


	HFC Rack	Distributed Scroll Pack	HFC Condensing	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Annual Energy (Los Angeles)	424,581	360,108	458,144	451,696	459,383	551,154	418,793
$ Usage (Based on $0.11 /KWh)	$ 46,704	$ 39,612	$ 50,396	$ 49,687	$ 50,532	$ 60,627	$ 46,067
Peak Power	70	66	75	63	95	70	61
Peak Power $ (Based on $25kW)	$ 20,888	$ 19,914	$ 22,517	$ 18,985	$ 28,434	$ 20,944	$ 18,372
Annual total Power	**$ 67,592**	**$ 59,525**	**$ 72,913**	**$ 68,671**	**$ 78,967**	**$ 81,571**	**$ 64,439**

COPELAND

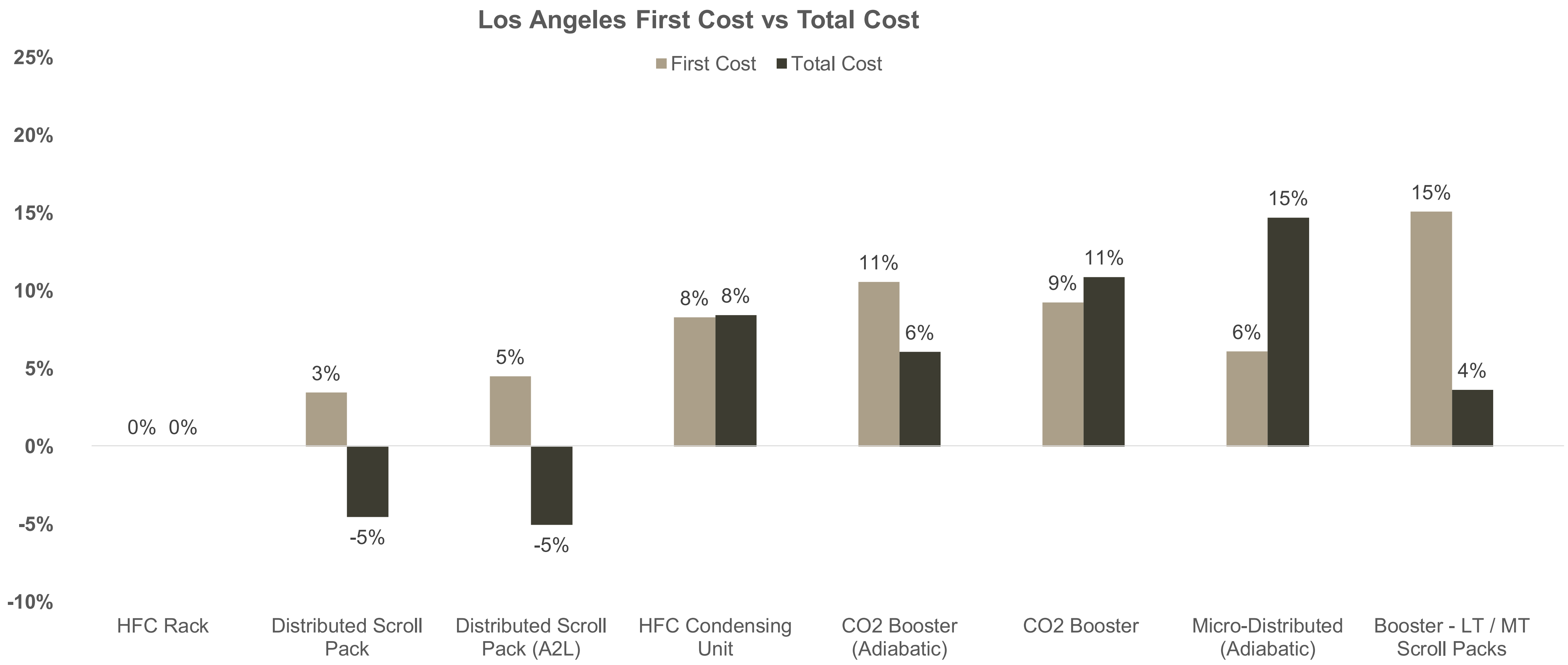
Notes: Condensing unit energy modeled based on 20°F TD (MT and LT) with min 70° F SCT and 40° F superheat
Cycling losses not included in energy comparisons. Energy assessment based on constant load.

Los Angeles Annualized CO2 Emissions



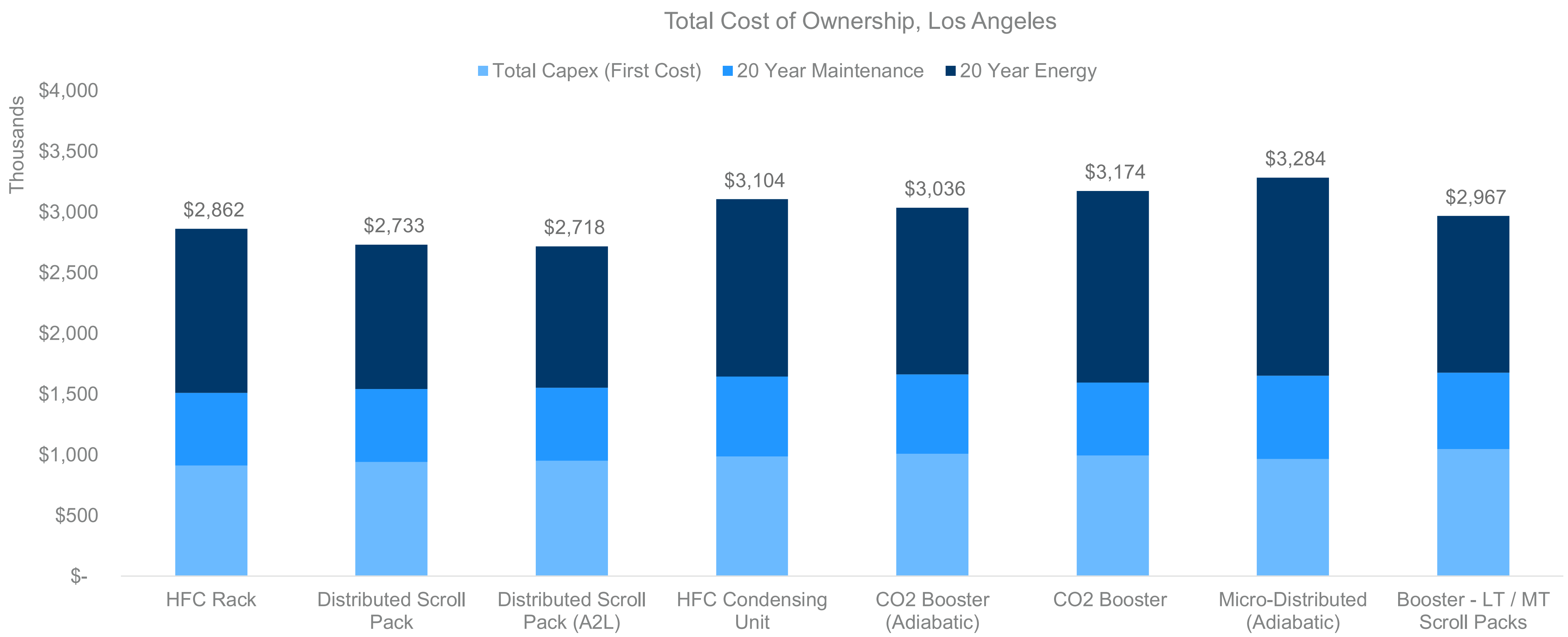
COPELAND

Los Angeles First Cost vs Total Cost Comparison



COPELAND

Los Angeles



COPELAND

Explore Another Location

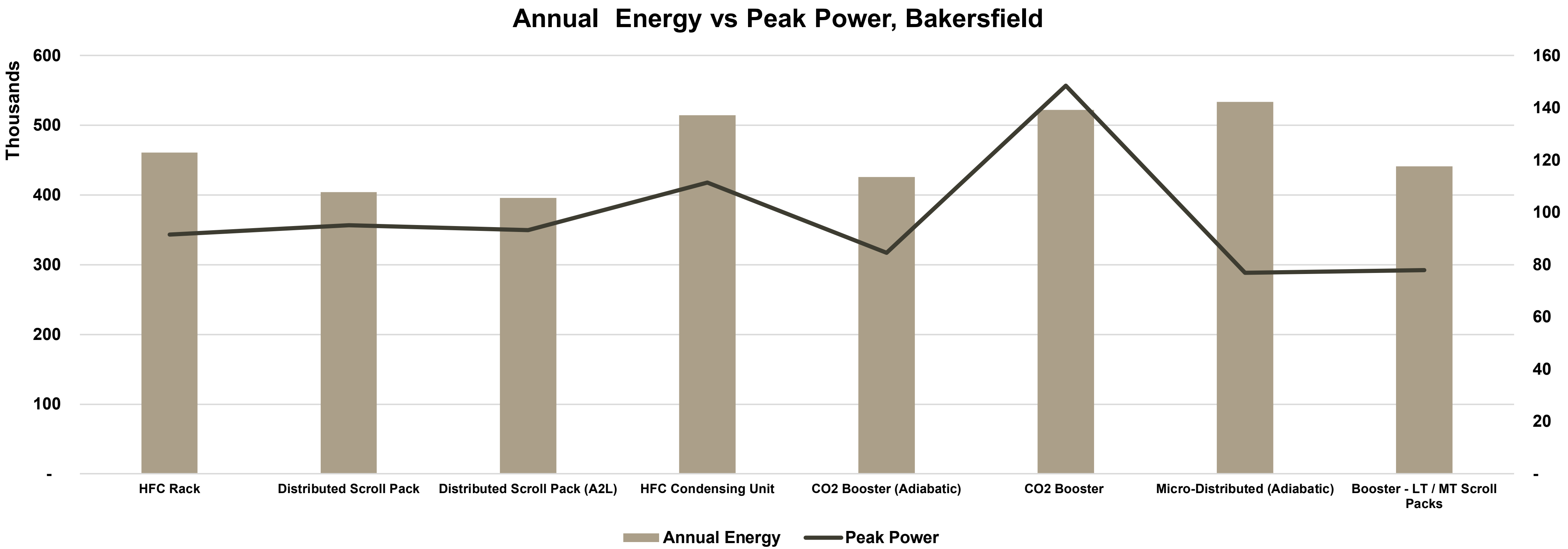
Continue To End of Section

Summary: Los Angeles

	HFC Rack	Distributed Scroll Pack	Distributed Scroll Pack (A2L)	HFC Condensing Unit	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Energy	Very Good	Excellent	Excellent	Good	Good	Good	Poor	Good
Peak Power	Very Good	Excellent	Excellent	Fair	Excellent	Poor	Good	Excellent
First Cost	-	+3%	+5%	+8%	+11%	+9%	+6%	+15%
Total Cost	-	-5%	-5%	+8%	+6%	+11%	+15%	+4%
Emissions	Poor	Very Good	Very Good	Good	Excellent	Excellent	Fair	Very Good

Bakersfield

Bakersfield Energy Comparison

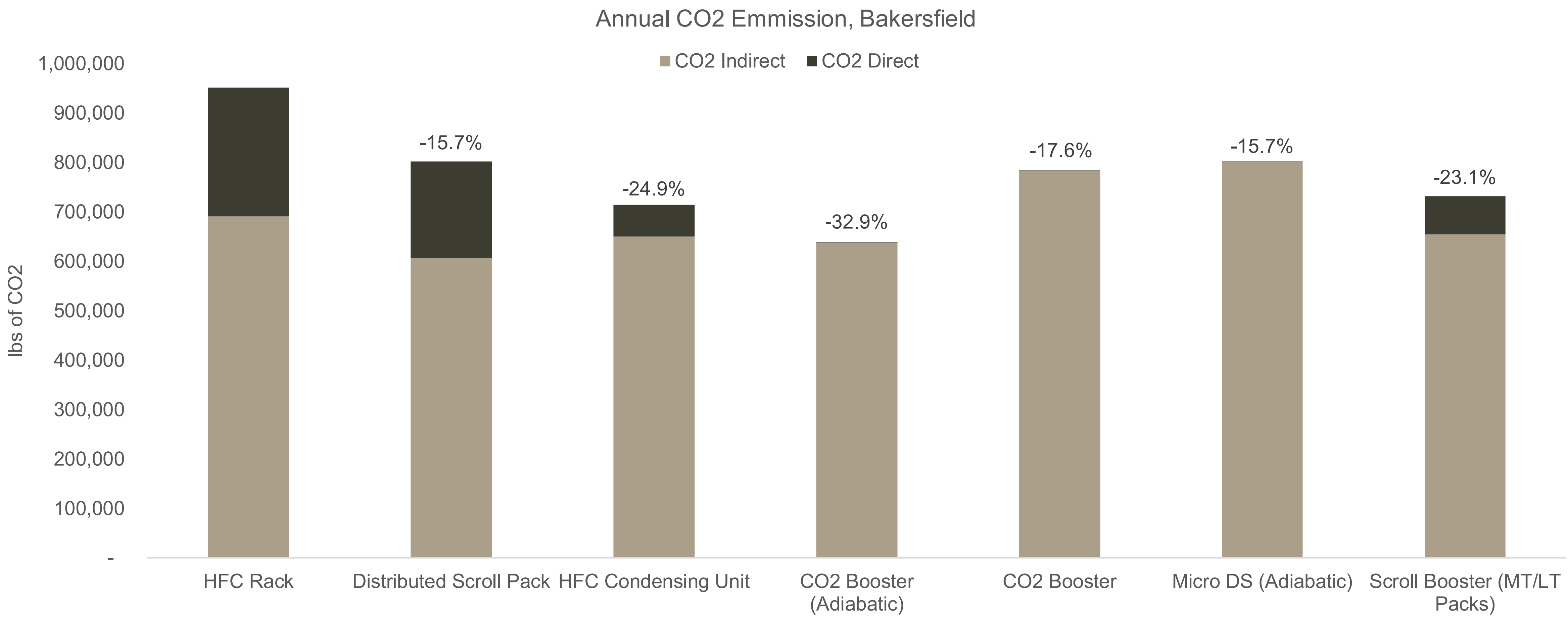


	HFC Rack	Distributed Scroll Pack	HFC Condensing	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Annual Energy (Bakersfield)	460,783	404,250	514,566	425,612	522,168	533,913	441,440
$ Usage (Based on $0.11 /KWh)	$ 50,686	$ 44,467	$ 56,602	$ 46,817	$ 57,439	$ 58,730	$ 48,558
Peak Power	92	95	112	85	149	77	78
Peak Power $ (Based on $25kW)	$ 27,471	$ 28,518	$ 33,451	$ 25,353	$ 44,561	$ 23,055	$ 23,396
Annual Total	**$ 78,157**	**$ 72,985**	**$ 90,053**	**$ 72,170**	**$ 102,000**	**$ 81,785**	**$ 71,955**

COPELAND

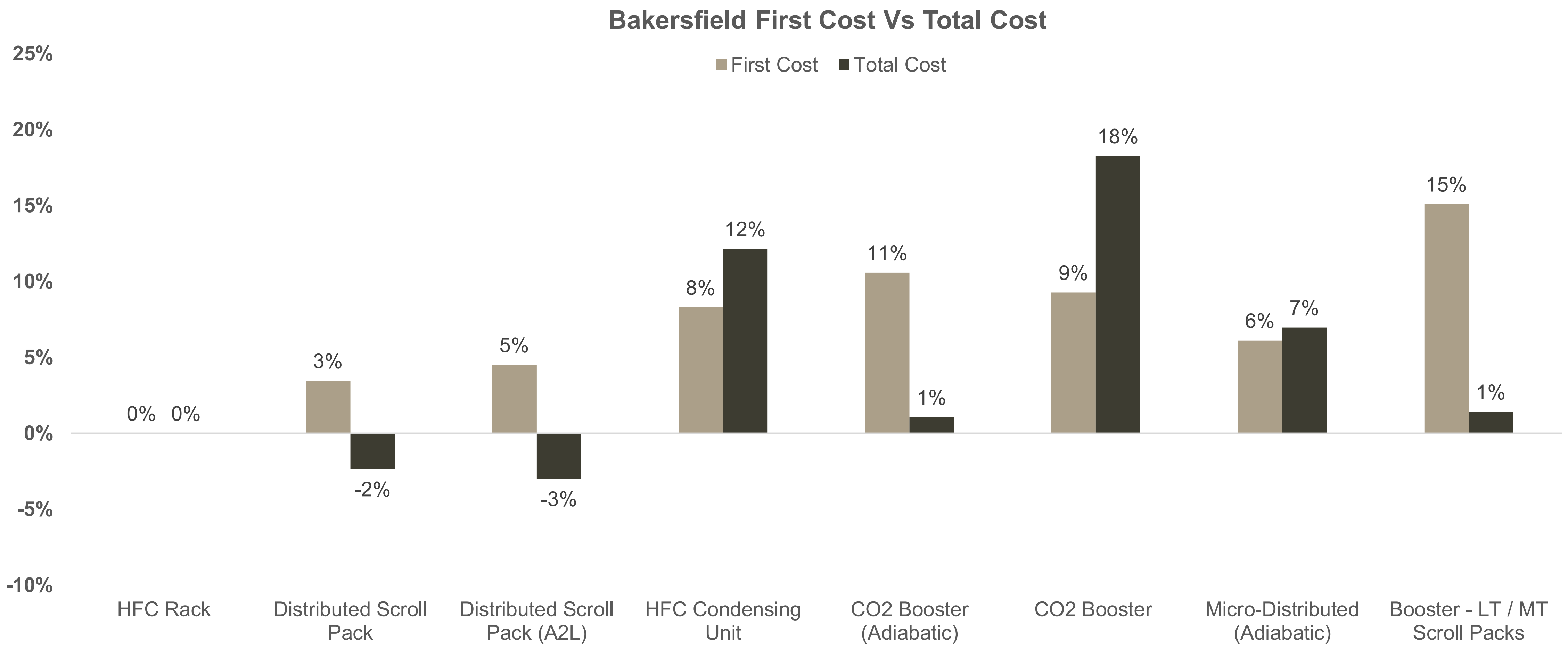
Notes: Condensing unit energy modeled based on 20ºF TD (MT and LT) with min 70º F SCT and 40º F superheat
Cycling losses not included in energy comparisons. Energy assessment based on constant load.

Bakersfield Annualized CO2 Emissions



COPELAND

Bakersfield First Cost vs Total Cost Comparison



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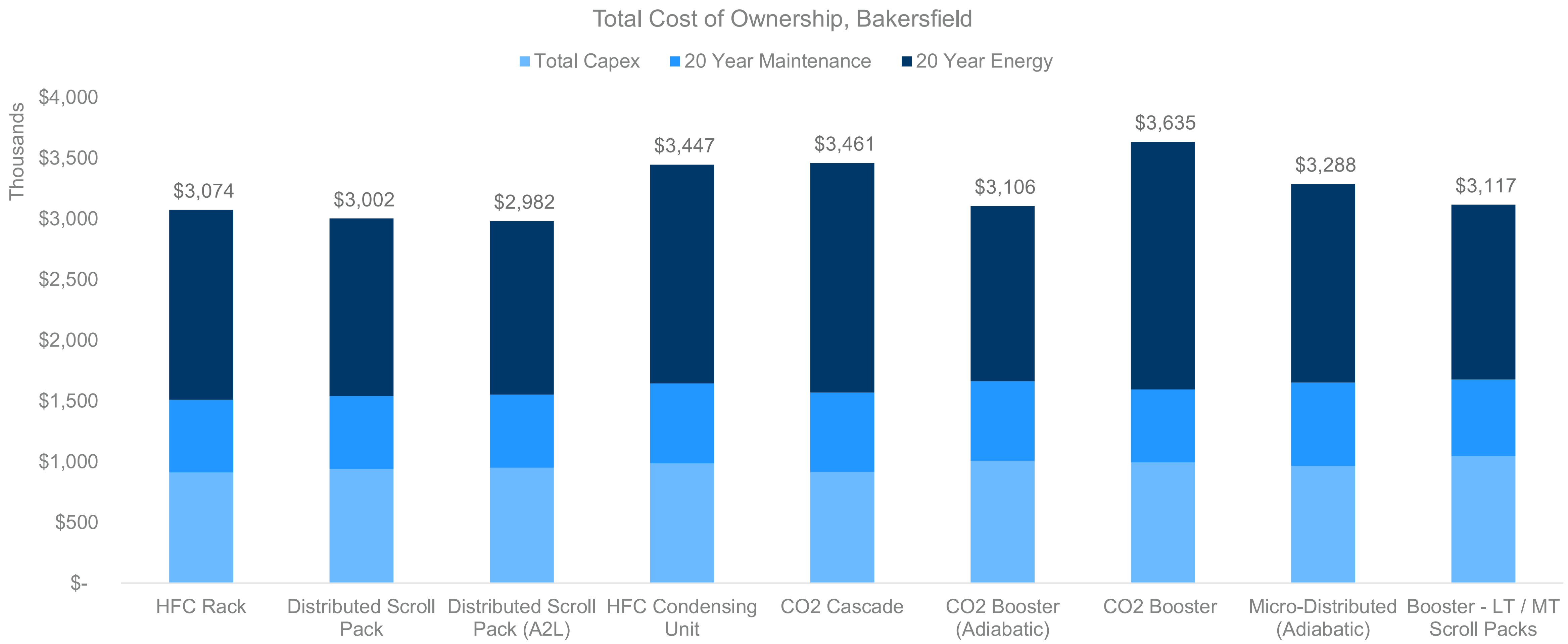
Bakersfield



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Explore Another Location

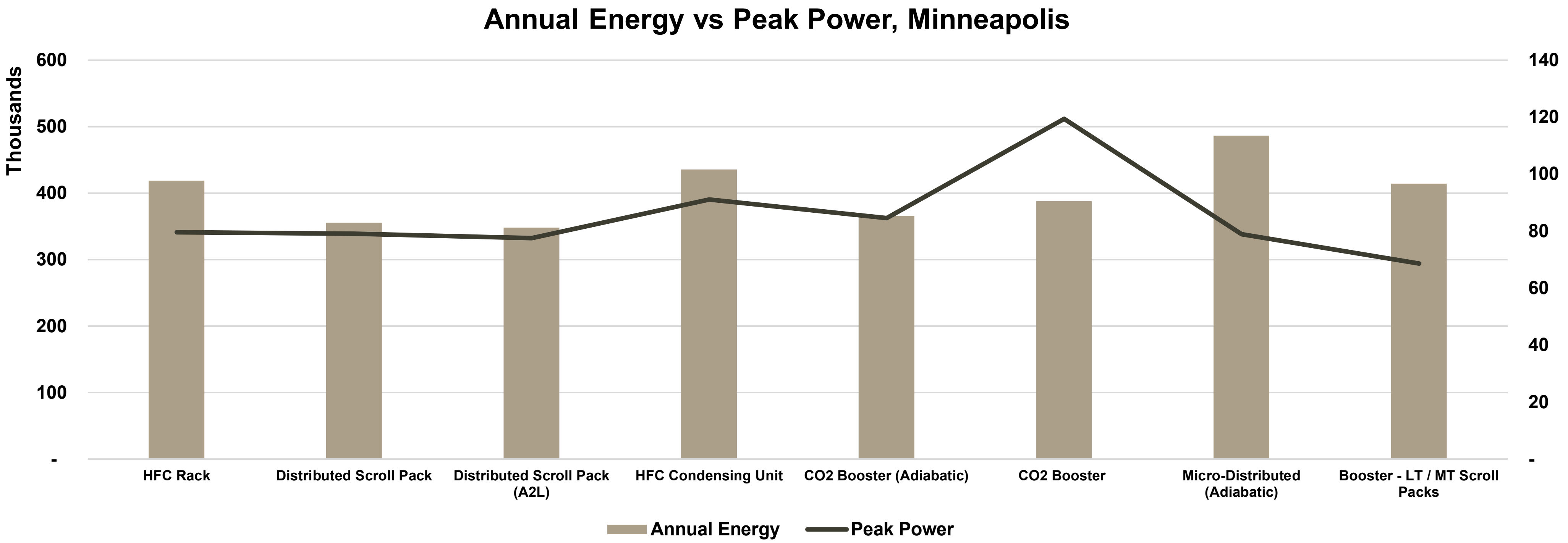
Continue To End of Section

Summary: Bakersfield

	HFC Rack	Distributed Scroll Pack	Distributed Scroll Pack (A2L)	HFC Condensing Unit	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Energy	Very Good	Excellent	Excellent	Fair	Excellent	Fair	Fair	Very Good
Peak Power	Very Good	Very Good	Very Good	Good	Excellent	Poor	Excellent	Excellent
First Cost	-	+3%	+5%	+8%	+11%	+9%	+6%	+15%
Total Cost	-	-2%	-3%	+12%	+1%	+18%	+7%	+1%
Emissions	Poor	Good	Very Good	Good	Excellent	Good	Good	Very Good

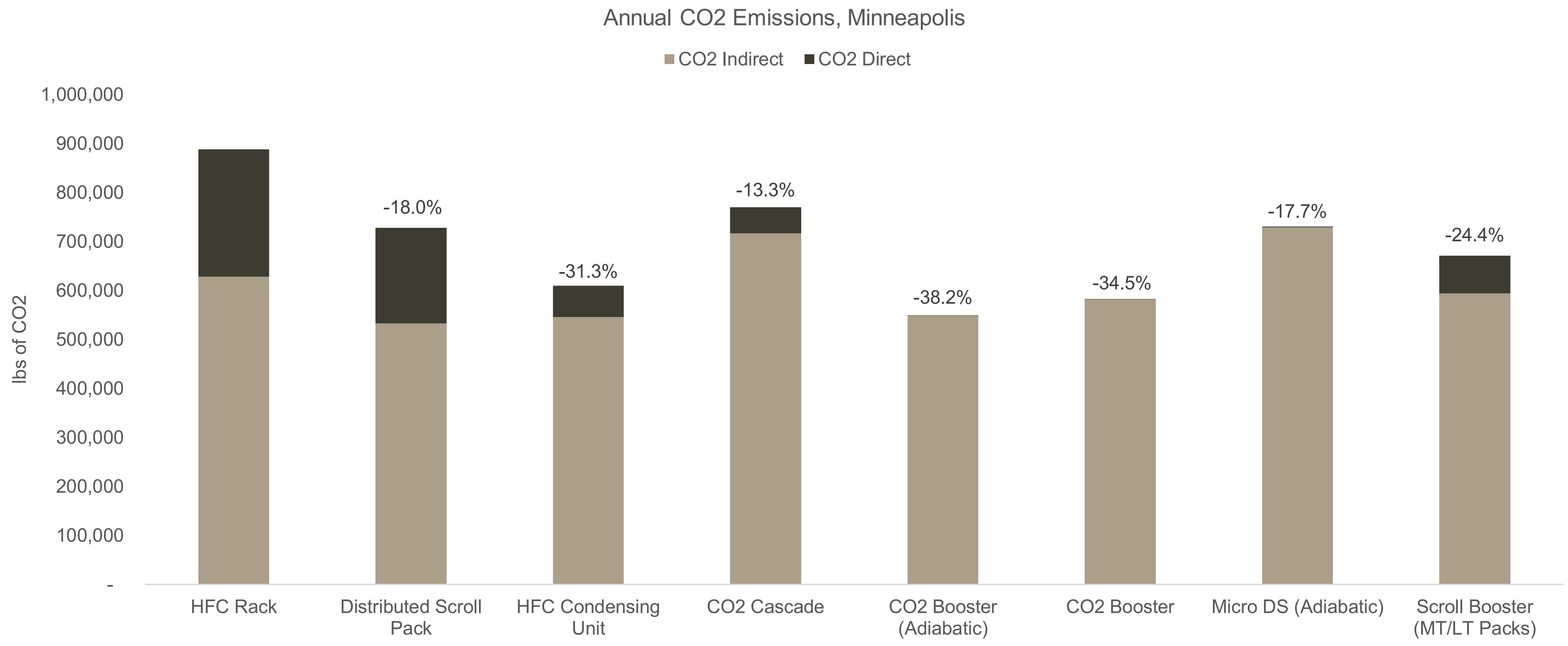

Minneapolis

Minneapolis Energy Comparison



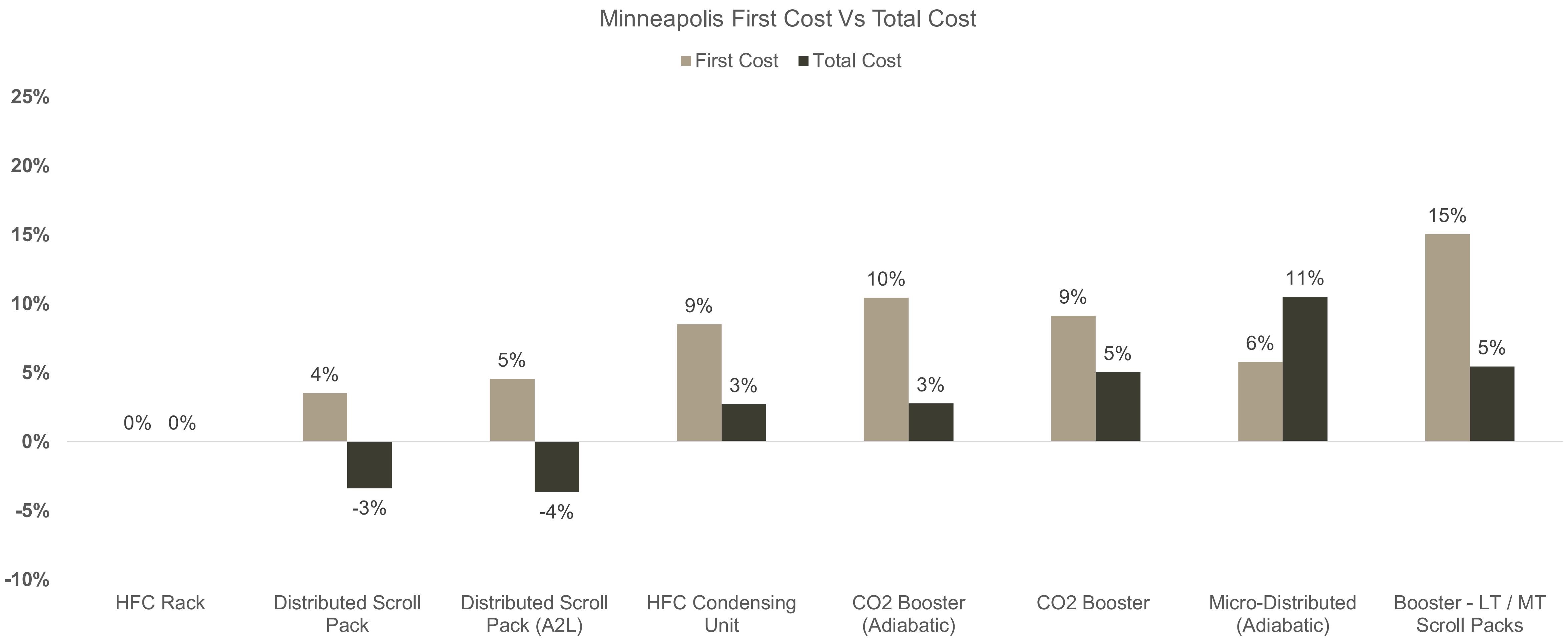
	HFC Rack	Distributed Scroll Pack	HFC Condensing Unit	CO2 Booster (Adiabatic)	CO2 Booster	Micro DS (Adiabatic)	Booster - LT / MT Scroll Packs
Annual Energy (Minneapolis)	418,911	355,372	363,945	365,774	387,974	486,319	414,649
$ Usage (Based on $.09/KWh)	$ 37,702	$ 31,983	$ 32,755	$ 32,920	$ 34,918	$ 43,769	$ 37,318
Peak Power	80	79	91	85	119.4	79	69
Peak Power $ (Based on $10.02kW)	$ 9,570	$ 9,515	$ 10,956	$ 10,161	$ 14,360	$ 9,492	$ 8,257
Annual Total	**$ 47,272**	**$ 41,498**	**$ 43,711**	**$ 43,081**	**$ 49,278**	**$ 53,261**	**$ 45,575**

Minneapolis Annualized CO_2 Emissions



COPELAND

Minneapolis First Cost vs Total Cost Comparison



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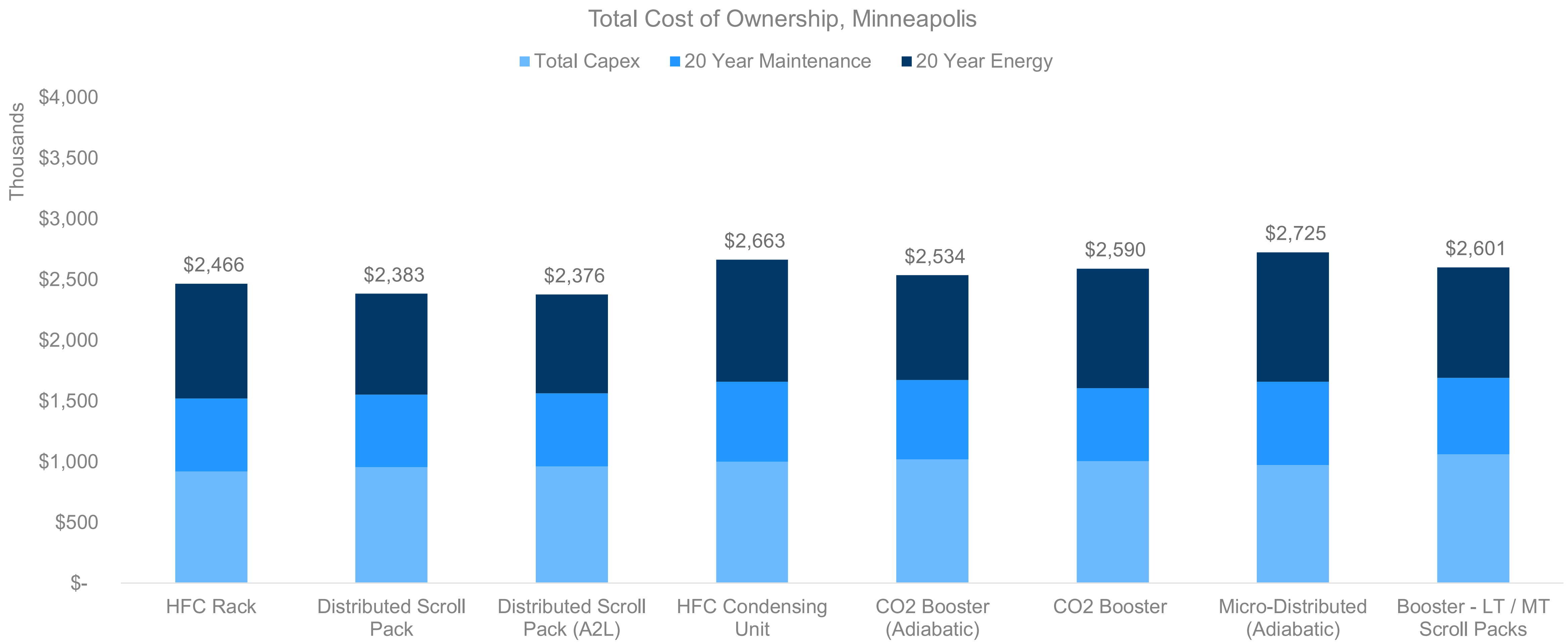
Minneapolis



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Explore Another Location

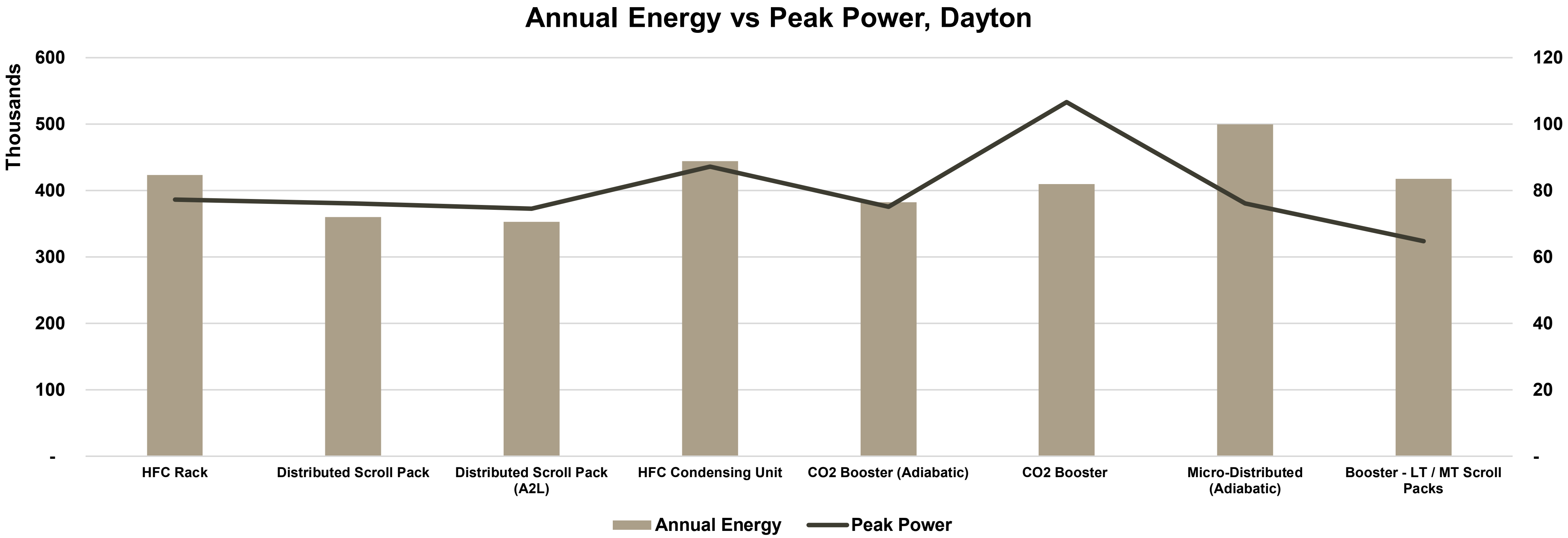
Continue To End of Section

Summary: Minneapolis

	HFC Rack	Distributed Scroll Pack	Distributed Scroll Pack (A2L)	HFC Condensing Unit	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Energy	Good	Excellent	Excellent	Good	Excellent	Very Good	Poor	Good
Peak Power	Very Good	Very Good	Excellent	Good	Very Good	Poor	Very Good	Excellent
First Cost	--	+4%	+5%	+9%	+10%	+9%	+6%	+15%
Total Cost	--	-3%	-4%	+3%	+3%	+5%	+11%	+5%
Emissions	Poor	Good	Very Good	Excellent	Excellent	Excellent	Good	Very Good

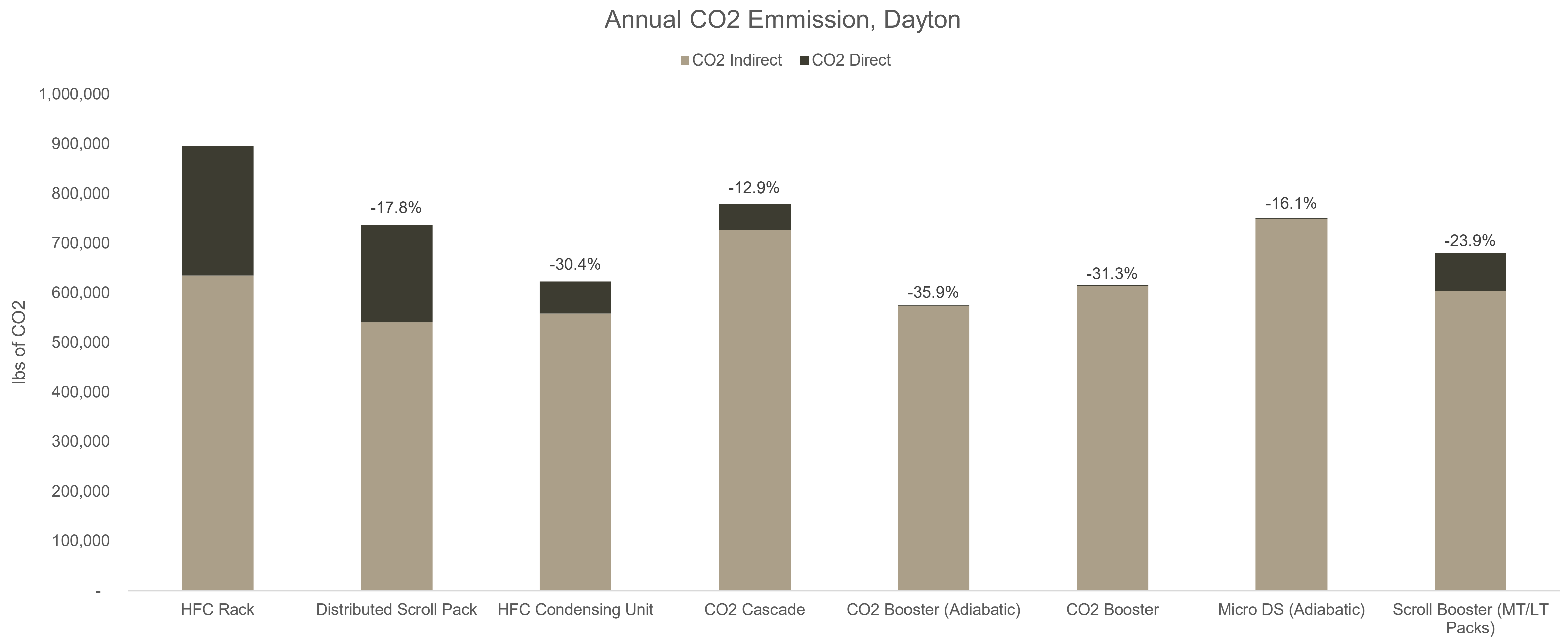

Dayton

Dayton Energy Comparison



	Centralized Racks	Distributed Scroll Pack	Condensing Units	CO2 Booster (Adiabatic)	CO2 Booster	Micro DS (Adiabatic)	Booster - LT / MT Scroll Packs
Annual Energy (Dayton)	423,343	360,407	372,353	382,719	409,716	499,678	417,508
$ Usage Based on $.05/KWh.	$ 21,167	$ 18,020	$ 18,618	$ 19,136	$ 20,486	$ 24,984	$ 20,875
Peak Power	77.2	76.1	87.3	75.1	106.6	76.1	64.7
Peak Energy $ (Based on $2.03KW)	$ 1,882	$ 1,853	$ 2,126	$ 1,830	$ 2,597	$ 1,853	$ 1,577
Annual Total	**$ 23,049**	**$ 19,874**	**$ 20,743**	**$ 20,966**	**$ 23,083**	**$ 26,837**	**$ 22,453**

Dayton Annualized CO2 Emissions



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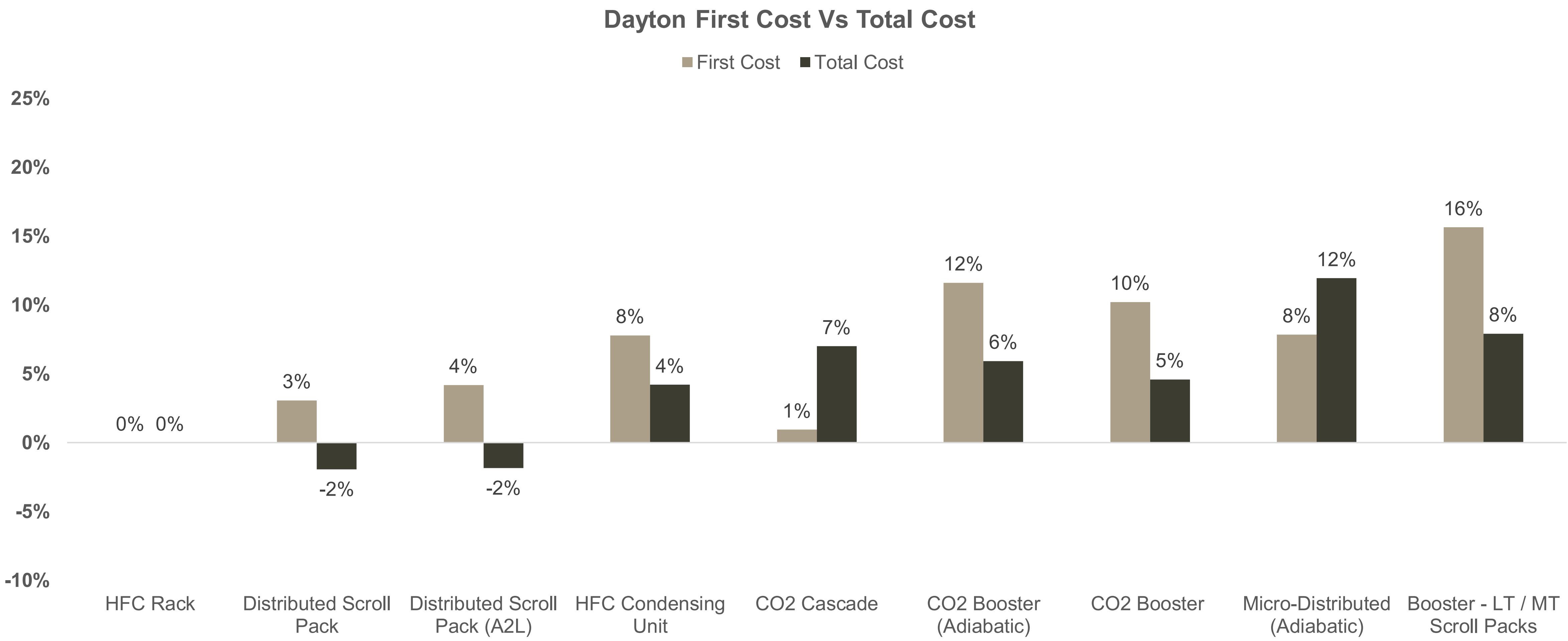
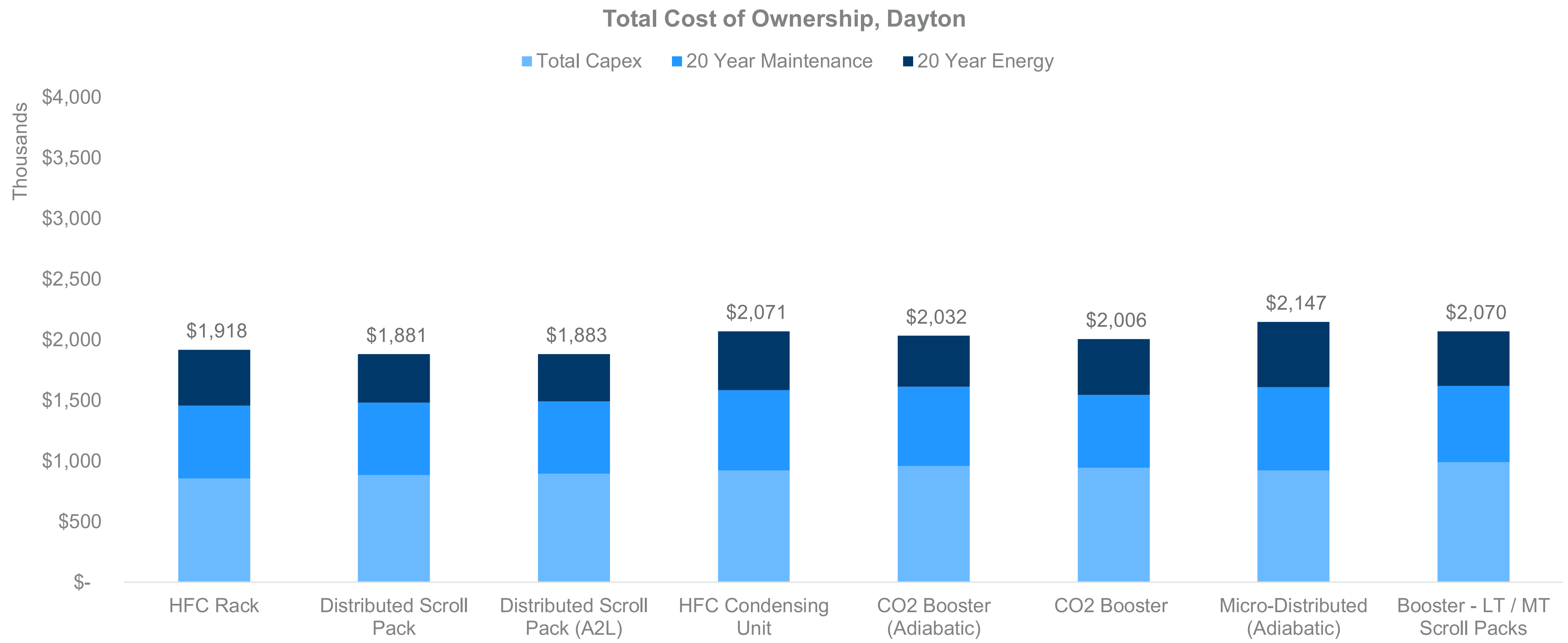
Dayton First Cost vs Total Cost Comparison



COPELAND

Dayton



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Summary: Dayton

	HFC Rack	Distributed Scroll Pack	Distributed Scroll Pack (A2L)	HFC Condensing Unit	CO2 Booster (Adiabatic)	CO2 Booster	Micro-Distributed (Adiabatic)	Booster - LT / MT Scroll Packs
Annual Energy	Good	Excellent	Excellent	Excellent	Excellent	Very Good	Poor	Good
Peak Power	Very Good	Very Good	Very Good	Good	Very Good	Poor	Very Good	Excellent
First Cost	--	3%	4%	8%	12%	10%	8%	16%
Total Cost	--	-2%	-2%	4%	6%	5%	12%	8%
Emissions	Poor	Good	Very Good	Excellent	Excellent	Excellent	Good	Very Good

Additional Considerations

Electrical rate

Rate Structure, Peak Demand Charges

Water resources

Availability, Cost, Sewage Charges

Service & maintenance skill level

Regional CO2 experience or knowledge gap

Heat Reclaim

Volume and Intensity Requirements

Fossil fuel charges

Carbon Intensity, Electrical Generation Sources

Impact on Net-Zero 2040 Goals for Scope 2 Emissions

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Summary

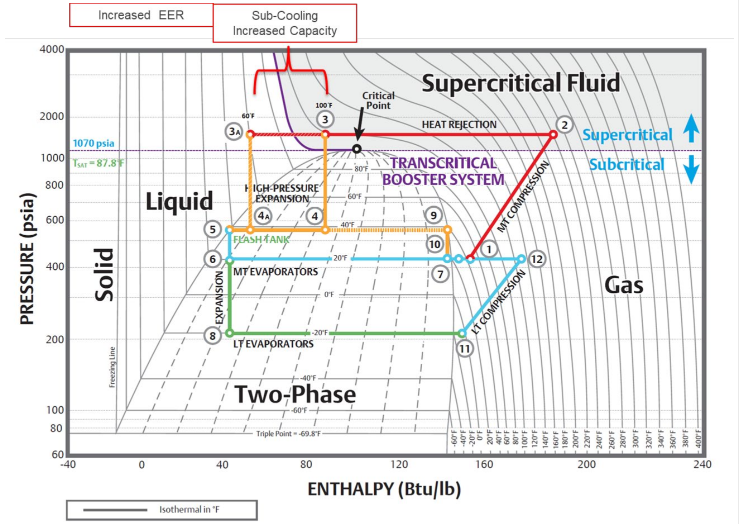
This study was commissioned to provide industry stakeholders with an unbiased 3rd party engineering evaluation of system comparison of the most common architectures to support low GWP System Transitions for the Refrigeration industry

EMERSON

Additional Industry Support Tools

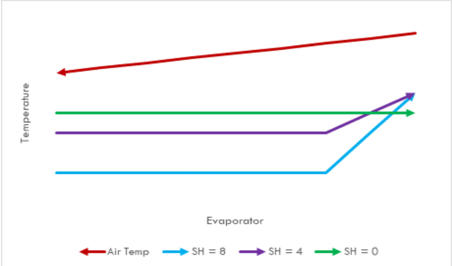
Mechanical Subcooling on CO2 System

- 3rd Party Engineering Study
- Evaluated net energy saving potential of various strategies used for to reduce Gas Cooler CO2 fluid temperature



Ultra Low Superheat Study; CO_2

- 3rd Party Engineering Study
- Evaluated energy saving potential
  - 50 Units Coolers (Max/Min/Ave delta T)
  - 254 Display cases (Max/Min/Ave delta T)
- All followed North American Standards: AWEF, NRCan , Energy Star.
- Compared 10 SH Coils to;
  - Ultra-low to Zero SH
  - Liquid Ejectors
  - Other OEM specific low SH Strategies
  - Flooded Coils



CO_2 Stewardship

- E-book

- Video Series (20)

- Article Series, Blogs, Ect..
- White Papers, A2L and CO2
- E360 Webinars

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Copeland ESG

We commit to reaching

Science-Based Aligned

Net Zero

GHG Emissions

across all Scopes (1, 2 & 3)

by **2045**

from 2021

To get us on the right pathway by **2030**

we commit to achieving...

1.5ºC Aligned

Net Zero

Operations

Scopes 1 & 2 GHG Emissions

25% **Absolute Reduction**

Scope 3 GHG Emissions

Source

100%

Renewable Electricity

in our offices and facilities

Reduce

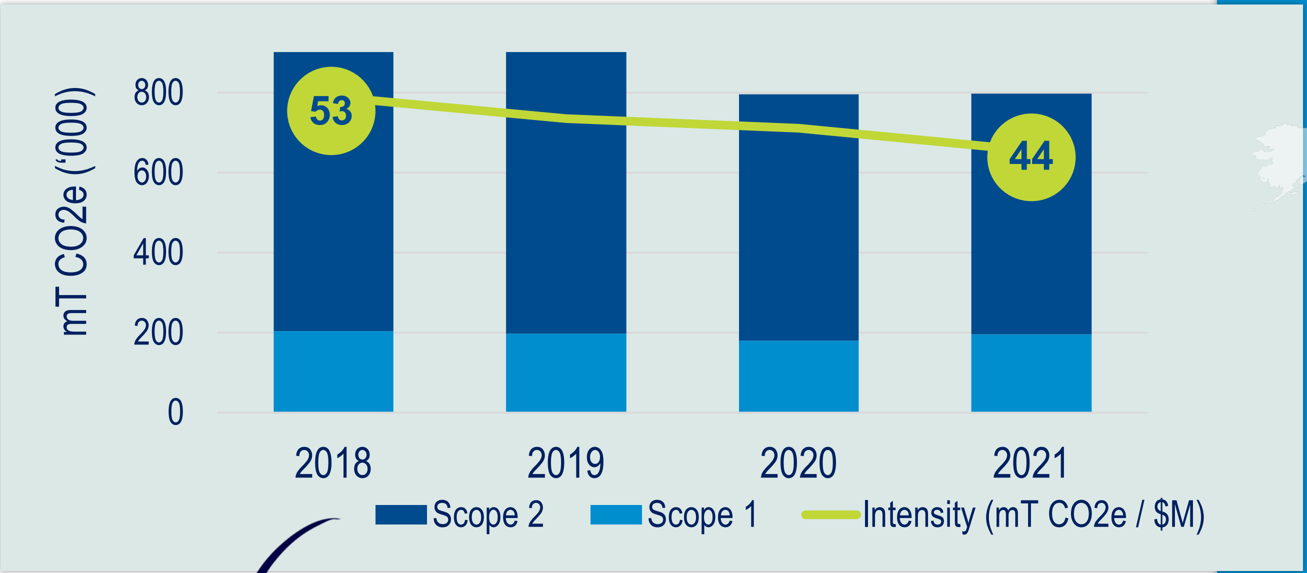
25%

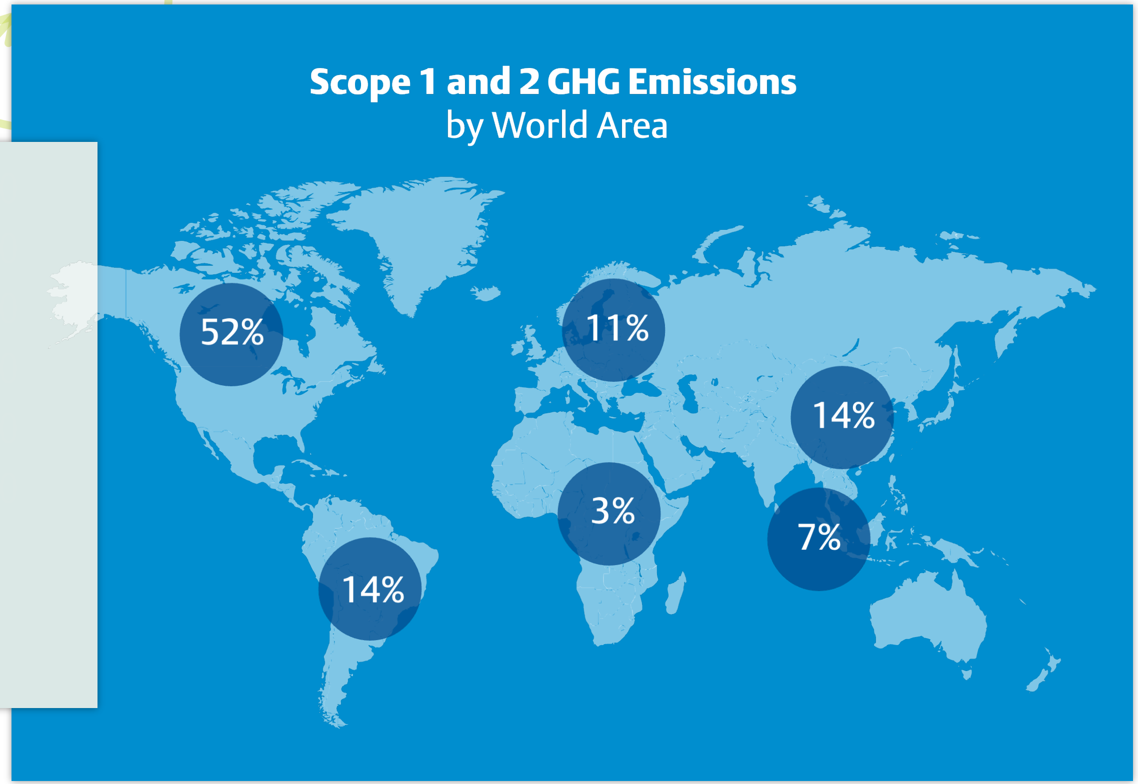
our **Energy Intensity**

COPELAND EMERSON

Our journey so far…

In 2019, Emerson/Copeland committed to reduce GHG emissions by **20%** normalized to sales by 2028 from 2018





Scope 1 & 2 Emissions Intensity

42%

from 2018

Energy Intensity (MWh/$)

Reduced by

19%

from 2018

Percentage **Renewable Electricity**

30%

World Wide

COPELAND

Beyond our four walls, we have a huge opportunity to influence change in our value chain

Total Scope 3 GHG Emissions

~591,400,000 $mTCO_2e$

Copeland's **Scope 3 Emissions**

99% from the Use of **Our Products**

~ **South Korea's** annual emissions

Running on electricity for **+15 years**

Heating, cooling & refrigerating

Controlling & optimizing operations

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WHERE DO THE REST OF OUR EMISSIONS COME FROM?

From the materials, components & capital goods that we purchase

2,049,500 $mTCO_2e$

From the transportation & distribution of our products

803,000 $mTCO_2e$

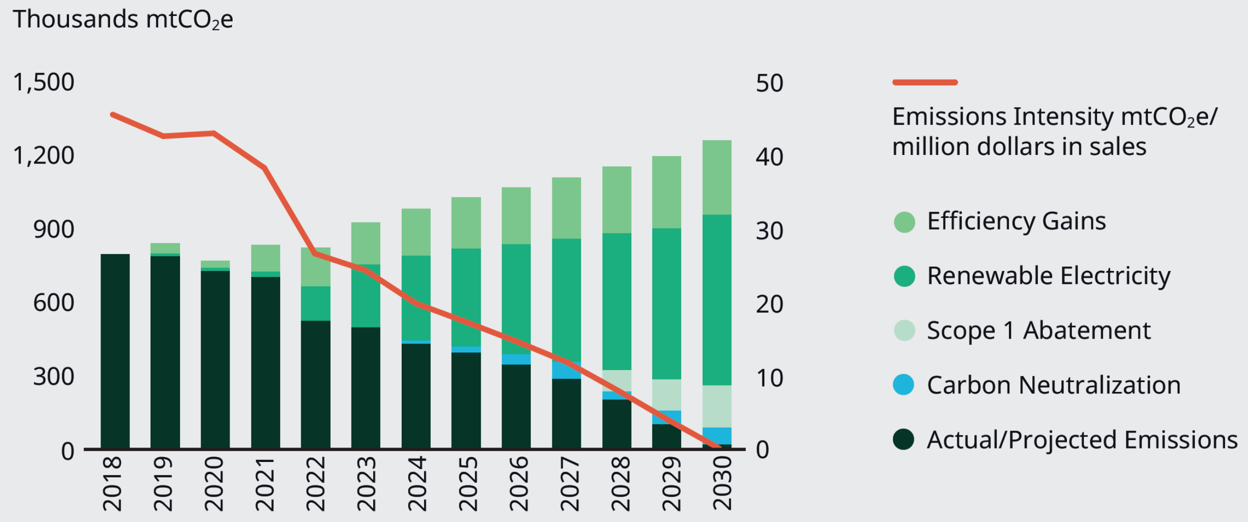
From the daily commute of Emerson employees

155,000 $mTCO_2e$

From the disposal or recycling of our products

150,000 $mTCO_2e$

Net Zero Operations — 2030 Roadmap



Emission and intensity calculations include data from all Emerson manufacturing and non-manufacturing facilities worldwide. Data from 2018-2022 represents actual emissions, and data for 2023 and beyond are estimates.

Progress on Emissions Intensity Target Since 2018

53%

Energy Efficiency Gain Examples

- Energy Treasure Hunts
- Compressed Air Optimization
- HVAC Setback
- Footprint Consolidation
- Equipment Shutdown
- LED Lighting

22%

Renewable Electricity

5% (2021) ↗ 30% (2022)

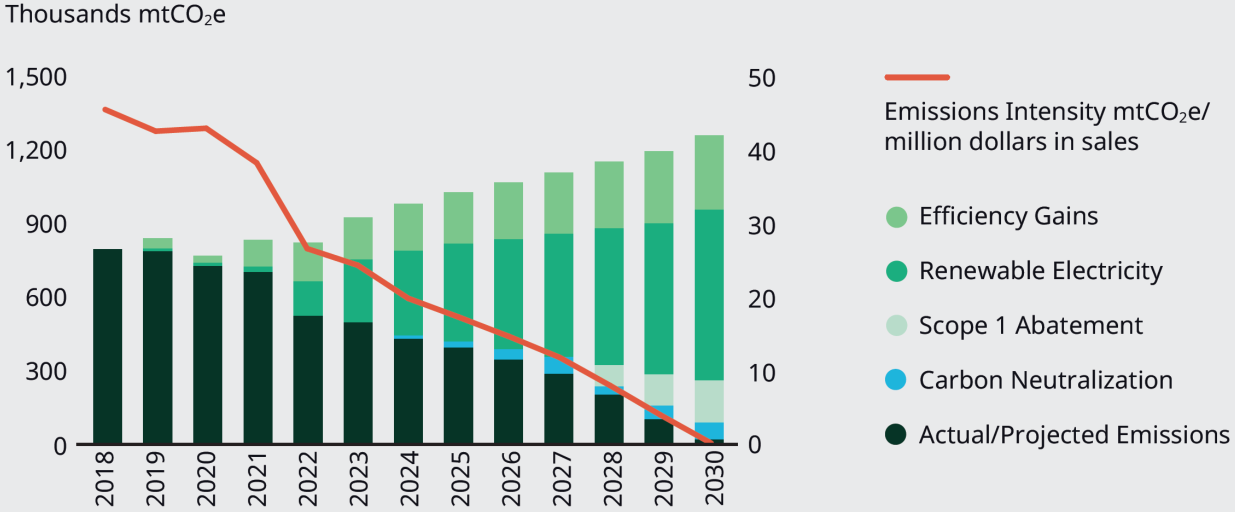
25%

Grid Decarbonization*

521 gCO_2e/kWh (2018) ↘ 450 gCO_2e/kWh (2022)

**Grid emission factors represent computed, weighted average values accounting for Emerson's geographical mix of global electricity consumption in each year. The International Energy Agency (IEA) emission factors are generally used, with more granular, regional factors also employed in certain cases (e.g. eGRID factors in the United States).*

Net Zero Operations — 2030 Roadmap



Emission and intensity calculations include data from all Emerson manufacturing and non-manufacturing facilities worldwide. Data from 2018-2022 represents actual emissions, and data for 2023 and beyond are estimates.

Energy Efficiency Project Examples

Below are several examples of energy reduction projects driving noteworthy savings across world areas.

LED LIGHTING RETROFIT

67
MWh saved
Actuation Technologies, Italy

TIMERS TO SHUT DOWN PROCESS EQUIPMENT

500
MWh saved
Measurement & Analytical, Mexico

DESK PHONE REMOVAL

82
MWh saved
Corporate Shared Services, Philippines

Emerson/Copeland is highly relevant in a lower carbon future

Four Major Strategies for Environmental Sustainability

ENERGY SOURCE DECARBONIZATION

- Low-carbon Power (Solar, Wind, Nuclear, Hydro)
- Low-carbon Fuels (Biofuels, LNG)
- Hydrogen & Hydrogen-based Fuels

ELECTRIFICATION & SYSTEM INTEGRATION

- End-use Electrification (Heat Pumps)
- Energy Supply Optimization
- Energy Storage & Grid Management

ENERGY EFFICIENCY & OPTIMIZATION

- Advanced Controls & Analytics
- Simulation & Remote Monitoring
- Waste Management

EMISSIONS MANAGEMENT

- Emissions Monitoring & Control
- Carbon Capture Utilization & Storage
- Natural & Low GWP Refrigerants

Report At-A-Glance

Environment

Net Zero Value Chain emissions by 2045 from a 2021 baseline

Net Zero Operations by 2030 from a 2021 baseline

Near-term and net zero targets have been **approved** by the **Science Based Targets initiative (SBTi)***

Achieved our goal of decreasing emissions intensity 20% from 2018, **6 years ahead of schedule**

Reduced Scope 1 and 2 GHG emissions intensity by **42%** since 2018

30% of electricity procured from renewable sources at Emerson locations worldwide

Announced new waste target **Zero Waste to Landfill** by 2032 from a fiscal 2022 baseline

Social

40% of global leadership targeted to be women and **30%** of U.S. leadership targeted to be minorities by 2030

Employee Resource Groups have grown to **over 13,000 members**

Initiated company-wide **continuous listening** strategy with 85% employee participation and an employee engagement score of 78%*

$200M pledged to address education equity over 10 years

Launched Emerson's Employee Value Proposition: ***Let's Go****

Governance

ESG targets integrated in compensation programs for leadership

46% of Directors are women or persons of color*

Introduced a new **Technology and Environmental Sustainability** Board committee*

40% decrease in total recordable rate of injuries since 2018

Peter Zornio
Appointed Chief Technology Officer, November 2022

Mike Baughman
Appointed Chief Financial Officer, May 2023

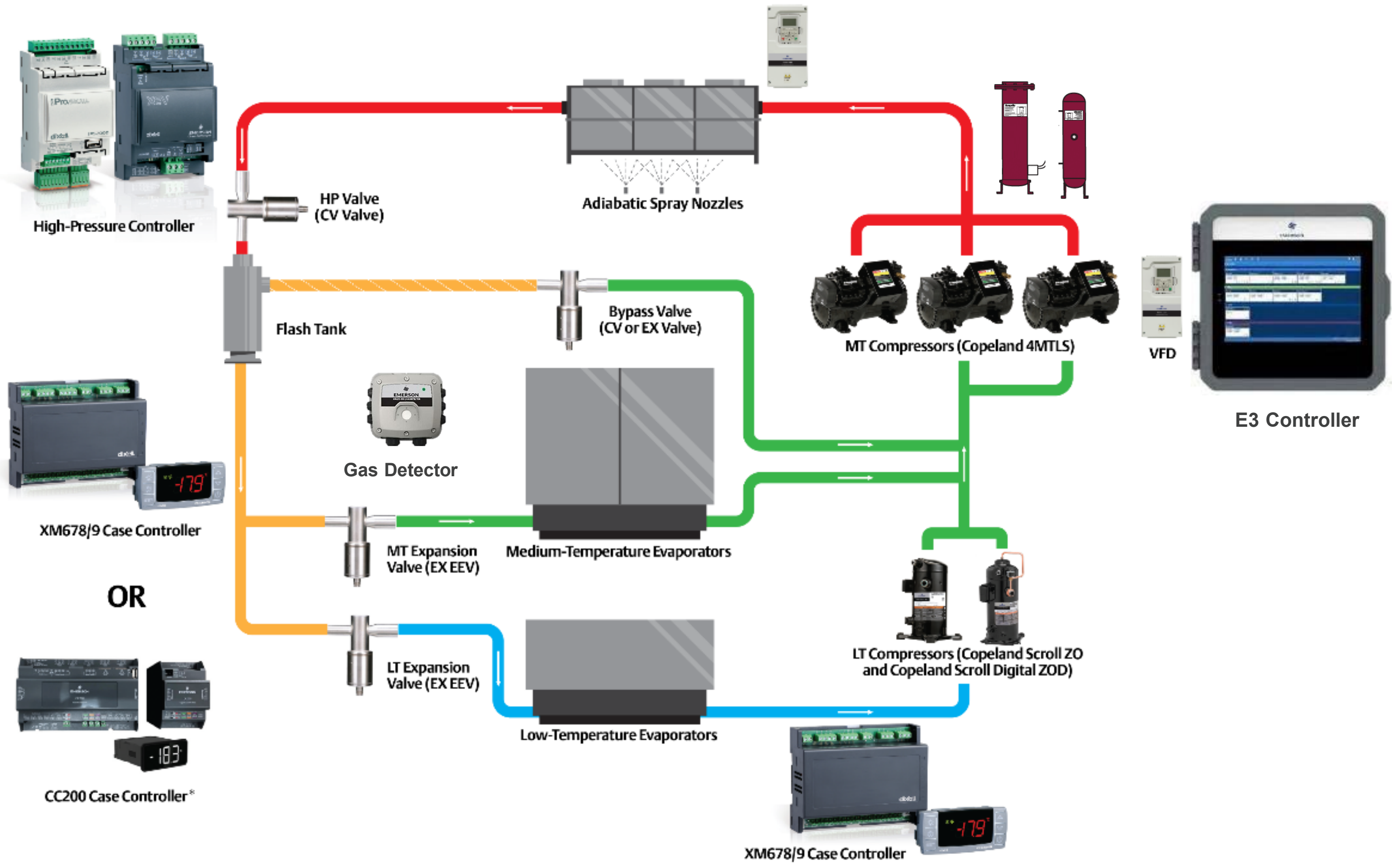
Vidya Ramnath
Appointed Chief Marketing Officer, June 2023

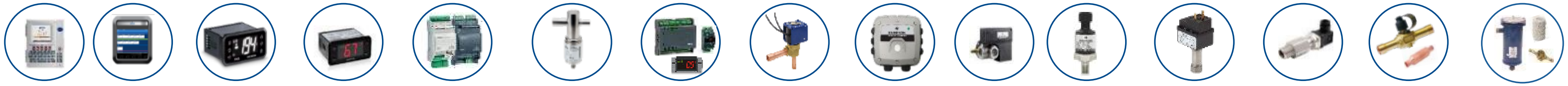
Great Smoky Mountains National Park, U.S.
Photo By:
Jesse Renfroe
Emerson Employee

*Depicts data/information as of June 2023.

Building an Effective Controls Transition Plan in your Food Retail Operation

CO_2 Transcritical Booster System

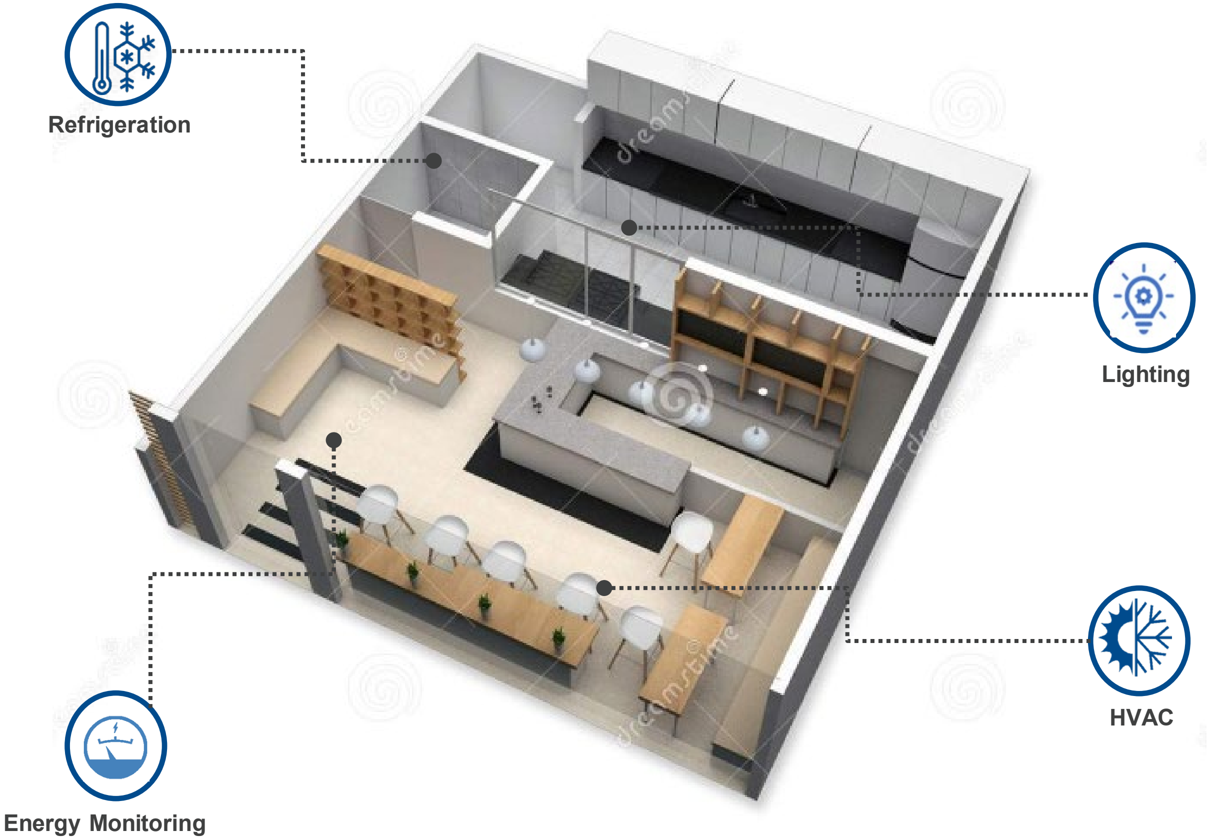




What Does Copeland Supervisory Control System Do?

New Store

Remodel



- **Built In Display**
- **Communicates to Modbus, BACnet Devices**
- **Multiple Ethernet Ports**
- **Onboard Graphics**

- **Cost flexibility**
- **Ideal for space constrained areas**
- **Flexible display options**
- **Onboard I/O**
- **Flexible mounting**

- HVAC Control
- Refrigeration Control
- Lighting Control
- Energy Metering
- Remote Monitoring
- Operational Optimization
- Energy Savings

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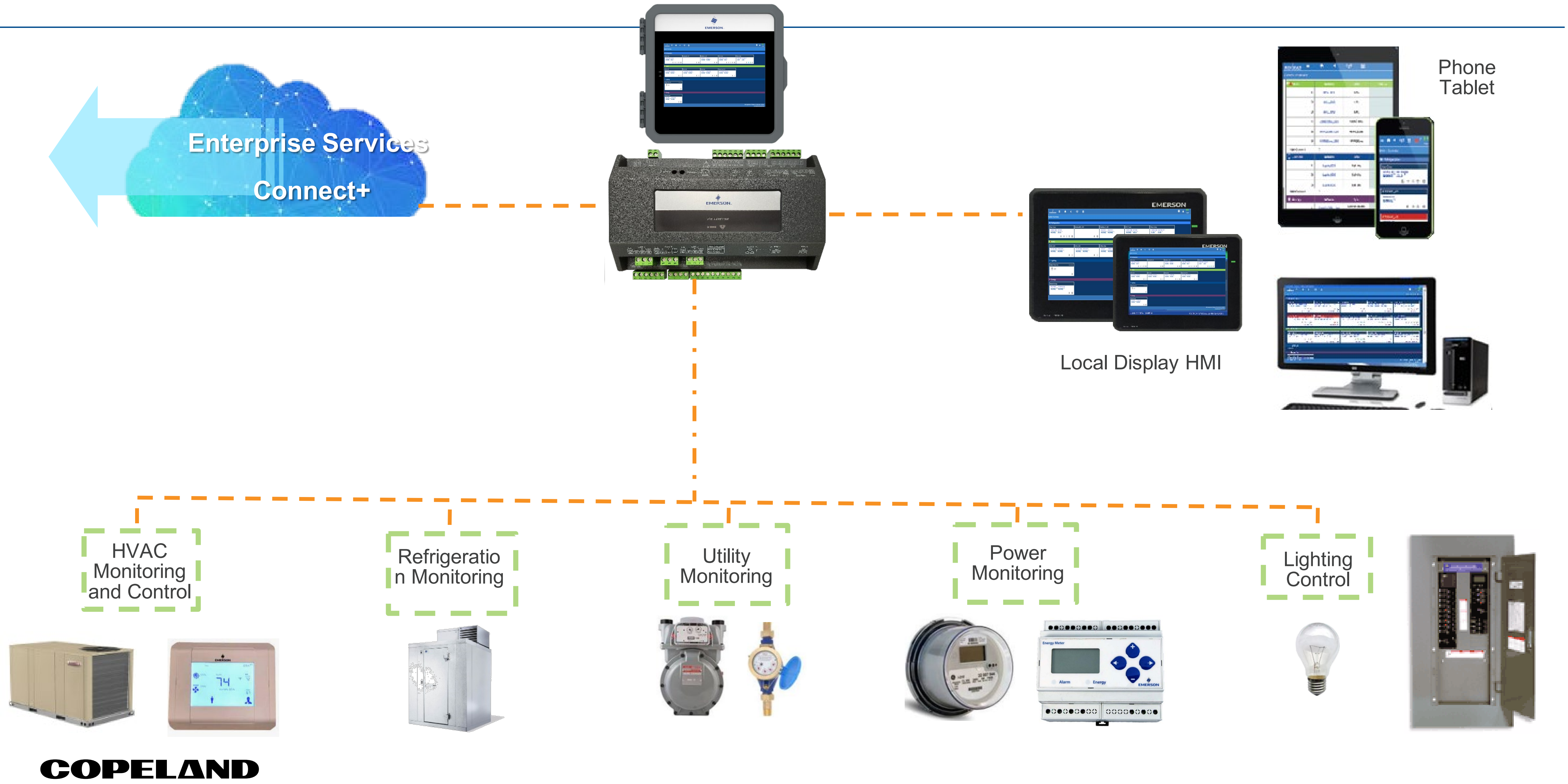
Touch Screen's 10, 15, 21 Inch Models Available

2. Optional Touch Screen and Sizes Available

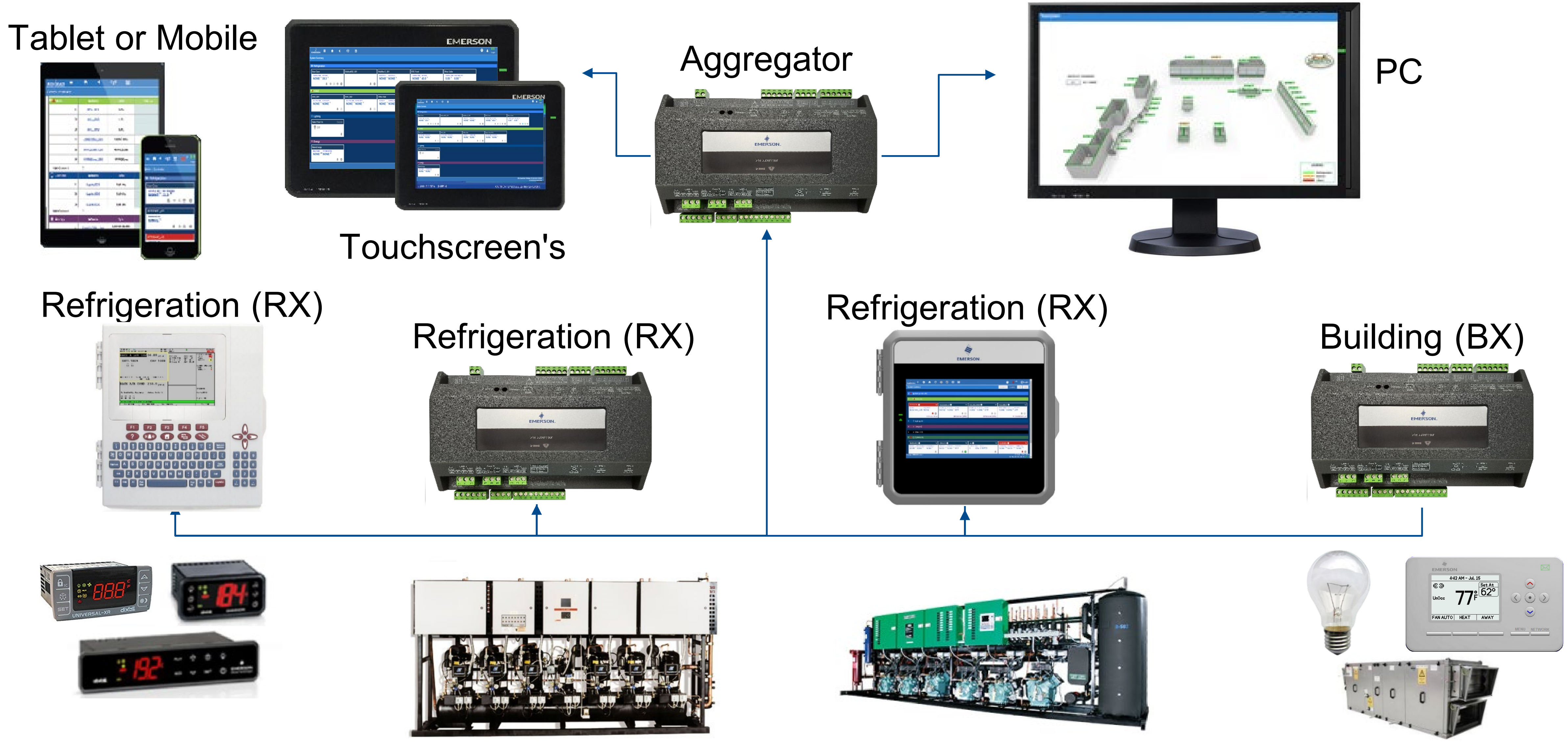
Wall-Mounted Control Screen and Interface

- Optional Sizes/Price point and user experience
- Primary access for local-level users
- Touchscreen color display
- Icon- and menu-driven operation
- Intuitive functions are familiar to all; no special training required
- View-only default
- Password protected access to advanced functions for managers and technician user modes
- Access to advanced functions requires authorization

Network Architecture



Network Layout _ Flexibility with Existing and New Controllers



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E3 vs E2e

Introduction to the Platform

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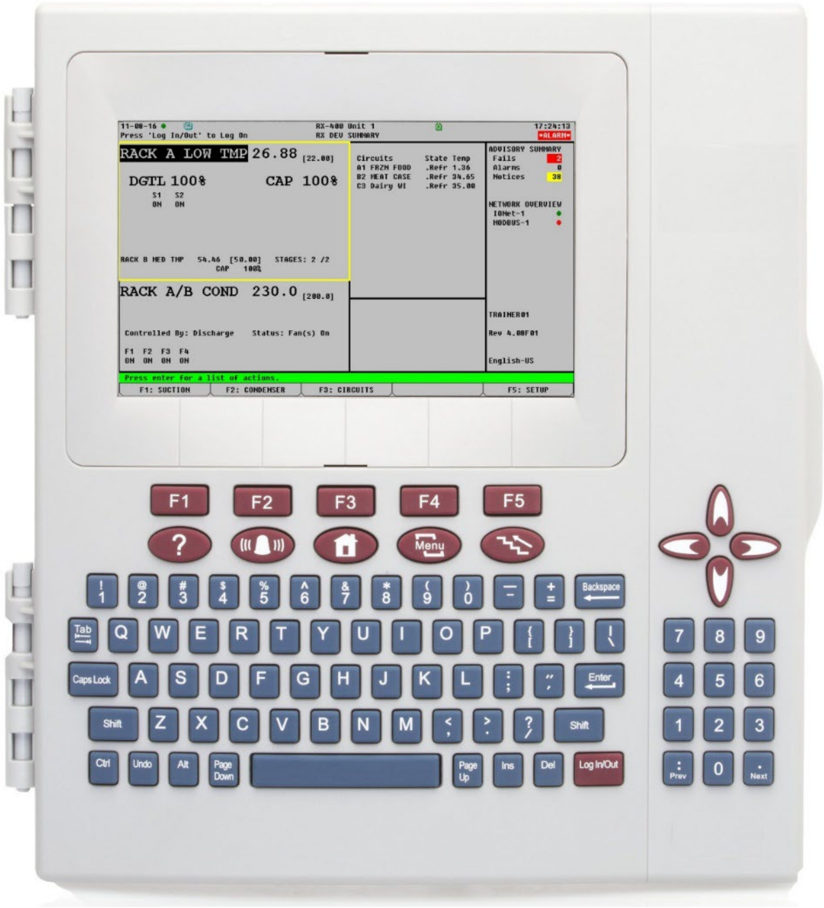
E3 vs E2

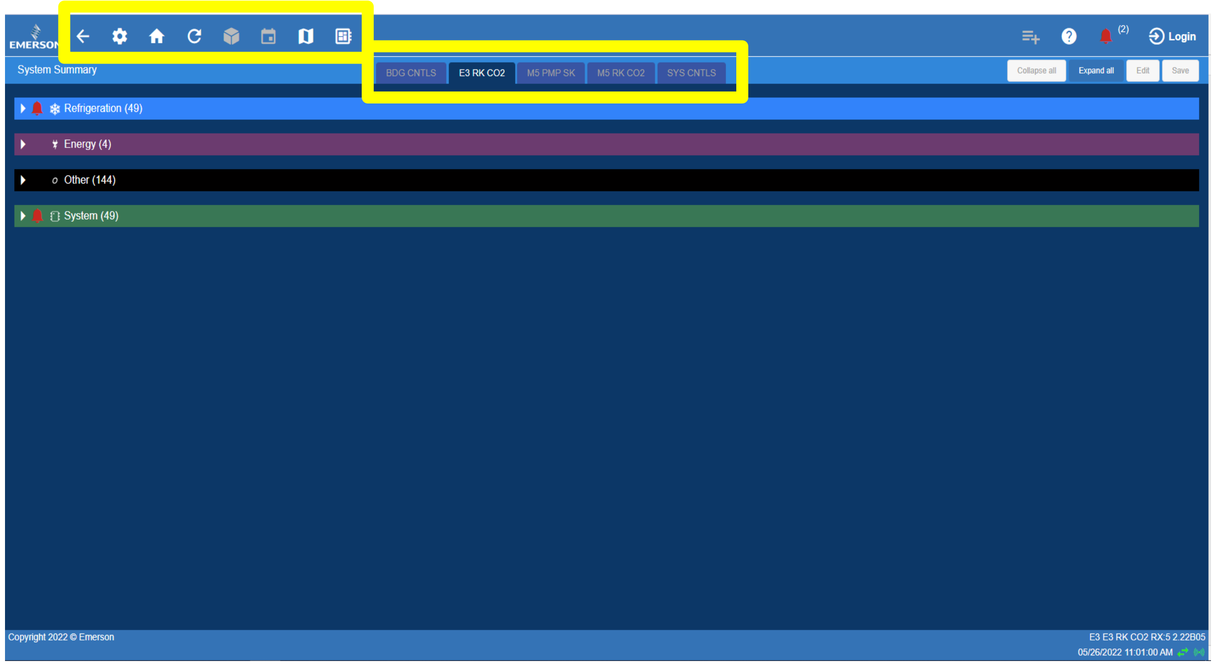
E3 front view

E2e front view

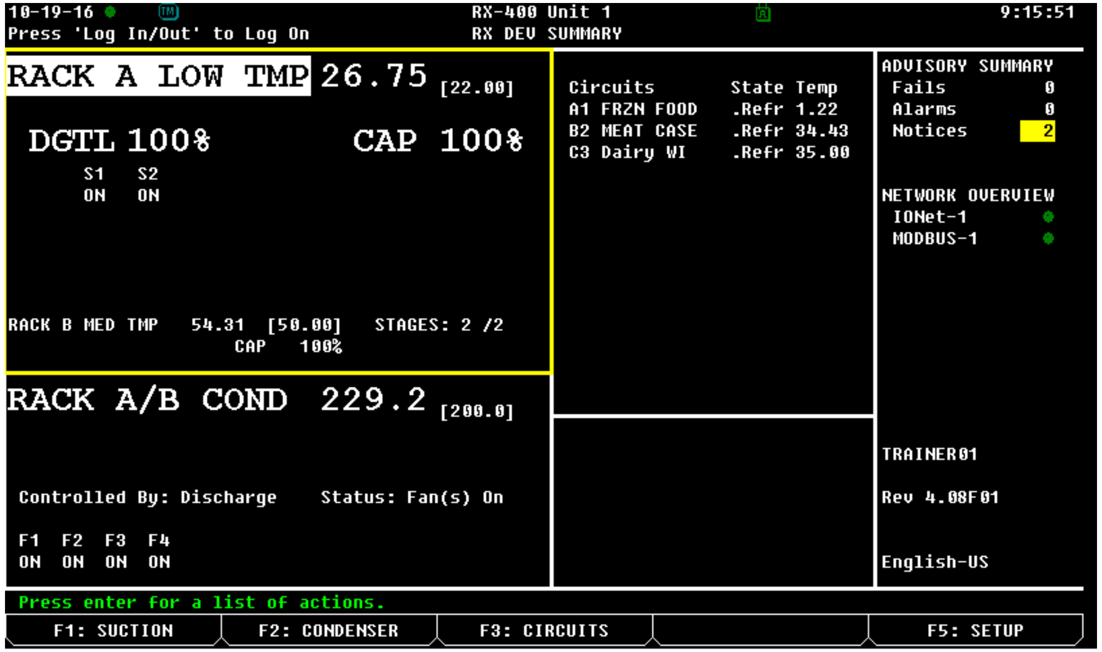


E3 vs E2

E3 software: Supervisory Control Software



E2 Software:



The E3 operates on a shared software platform with Site Supervisor. This new format offers intuitive navigation that technicians will find familiar and easy to use.

E3 Controller is a Drop-in Replacement for the E2 Product

- **True E2 Drop-in Replacement**
  - **Identical** wiring holes, mounting points and vents
  - Enclosure fits into existing panel cut-out
- **Updated Integrated Display**
  - **Larger** 10” capacitive color touch-screen
  - User-friendly interface with on-screen keyboard
- **Equivalent COM Port Configuration and Power Connections**
  - **Total of four COM ports** for connected devices with two isolated COM ports
  - Easily swap out an E2 with no need for rewiring
- **Fully Backward Compatible With MultiFlex and IONet Boards**

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E3 Technical Specifications

Operating Temperature	-40°F to 149°F (-40°C to 65°C)
Operating Humidity Storage Humidity	5% - 95% RH non-condensing at 90°F 5% - 100% RH
24 VAC	24 VAC ±20%, 50/60 Hz, Class 2, 80VA
Dimensions	12” L x 12.5” W x 3.75 H”
4 RS485 ports	COMM 1 = RS485 Com 2 A and B COMM 2 = RS485 Com 6 (isolated) COMM 3 = RS485 (isolated) COMM 4 = RS485 Com 4 A and B
2 Ethernet ports	Ports 0,1
2 USB ports	J2, J3

Hardware Enhancements and Modified Applications

Hardware Enhancements

E2 Hardware	E3 Hardware
500 MHz Single Core	1.6 GHz Quad Core
128 MB RAM	2 GB RAM
1 Ethernet Port (1 MAC/PHY)	2 Ethernet Ports (2 MAC/PHY)
3 RS-485 COM Ports	4 RS-485 COM Ports (2 Isolated)
Plug for Optional I/O Daughter Card	Plug for Optional I/O Daughter Card

Modified Applications in E3

E2 Application Name	New E3 Application Name
Eng. Unit Converter	Localization
Heat/Cool Control	Thermostat or Sensor Control
Power Monitoring	Utility Monitoring
Pulse Accumulator	Utility Monitoring
Time Schedule	Scheduler

Twelve times faster processing power and 16X additional memory built in to E3 and SS for faster response time and increased storage.

Model Cross Reference for Supervisory Control Platform (SS/E3) vs E2

E3 or Site Supervisor to E2 Cross-Reference Guide

	E3 / Site Supervisor Models								
E2 Models	**Small Format Controller SF**	**Refrigeration Controller RXS**	**Refrigeration Controller RXSe**	**Building Controller BXS**	**Building Controller BXSe**	**Combination Controller CXS**	**Combination Controller CXSe**	**Service Replacement SR**	**Site Aggregator SA**
RX300		✓						✓	
RX400			✓					✓	
BX300				✓				✓	
BX400					✓			✓	
CX100	✓							✓	
CX300						✓		✓	
CX400						✓	✓	✓	
Overlay E2									✓

New Service Replacement (SR) Model

- **Max** number of all applications RX, BX, CX, 400 level
- **Save time** when emergency replacement needed
- **Reduce complexity** of carrying/stocking multiple types for service calls
- **Simplify** your enterprise with one controller that does the max of everything

Site Aggregator (SA)

- True System Supervisor. Dedicated processing power and memory for logging and analytics
- Single view of controllers, compatible with E2's and Supervisors
- Overlay Existing E2 network

Emerson Retail Solutions Apps and Popular Sites

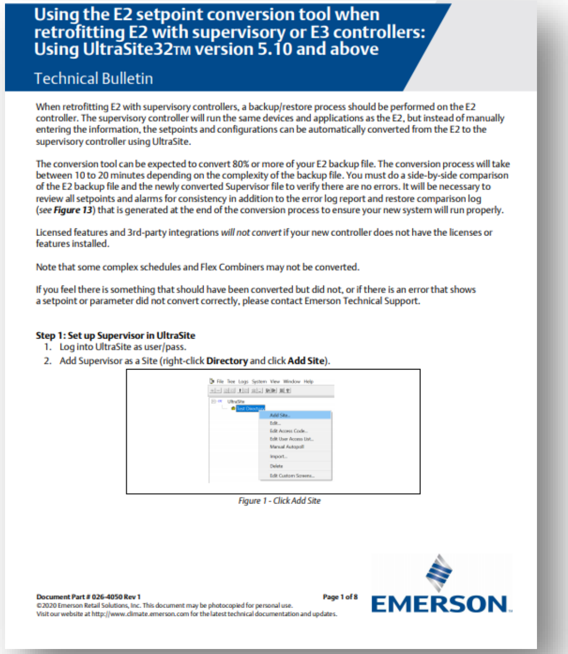
Training

https://emersonbeta.myshopify.com/pages/instructor-led-courses

Software Updates

https://climate.emerson.com/en-us/products/controls-monitoring-systems/facility-controls-electronics/facility-and-system-controls/

Technical Support Material



Using the E2 setpoint conversion tool when retrofitting E2 with supervisory or E3 controllers: Using UltraSite32TM version 5.10 and above

Technical Bulletin

When retrofitting E2 with supervisory controllers, a backup/restore process should be performed on the E2 controller. The supervisory controller will run the same devices and applications as the E2, but instead of manually entering the information, the setpoints and configurations can be automatically converted from the E2 to the supervisory controller using UltraSite.

The conversion tool can be expected to convert 80% or more of your E2 backup file. The conversion process will take between 10 to 20 minutes depending on the complexity of the backup file. You must do a side-by-side comparison of the E2 backup file and the newly converted Supervisor file to verify there are no errors. It will be necessary to review all setpoints and alarms for consistency in addition to the error log report and restore comparison log (*see Figure 13*) that is generated at the end of the conversion process to ensure your new system will run properly.

Licensed features and 3rd-party integrations *will not convert* if your new controller does not have the licenses or features installed.

Note that some complex schedules and Flex Combiners may not be converted.

If you feel there is something that should have been converted but did not, or if there is an error that shows a setpoint or parameter did not convert correctly, please contact Emerson Technical Support.

Step 1: Set up Supervisor in UltraSite

1. Log into UltraSite as user/pass.
2. Add Supervisor as a Site (right-click **Directory** and click **Add Site**).

Figure 1 - Click Add Site

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Visit our website at http://www.climate.emerson.com for the latest technical documentation and updates.

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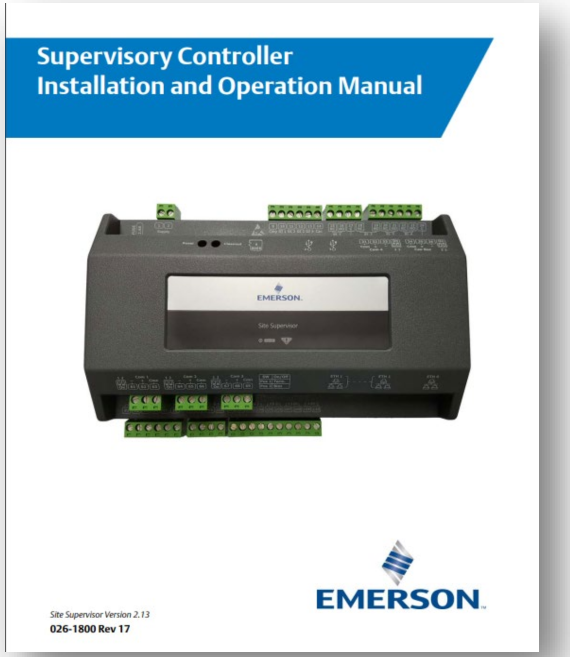
[Conversion Tool](#)



Supervisory Controller Installation and Operation Manual

EMERSON

Site Supervisor Version 2.13
026-1800 Rev 17

Supervisor Controller Manual

Site Supervisor Controller

Quick Setup Guide

The Site Supervisor is a system that combines energy management with the ability to monitor various facility systems and provide alerts when there are issues that need attention. This system provides HVAC control, Refrigeration System Monitoring and Control, as well as Lighting Control. In addition, the Site Supervisor can monitor and report energy consumption and take action to reduce the energy demand during peak periods. This can have a direct impact on utility bills by reducing total energy costs. Site Supervisor ensures that the HVAC and lighting systems are on and off at the appropriate times. This ability to monitor store conditions can potentially minimize energy consumption.

For a copy of the full Site Supervisor Guide (P/N 026-1800), visit the Site Supervisor page on the Emerson website: **http://climate.emerson.com/en-us/products/controls-monitoring-systems/facility-controls-electronics/facility-and-system-controls/site-supervisor-facility-control** to download or contact Emerson Electronics and Solutions Customer Service at 770-425-2724.

Figure 1 - Site Supervisor

Ethernet Connection

1. **ETH1** is designed to be used for directly connecting to laptop, PC, or optional touchscreen with a CAT5 network cable.
2. The default IP for **ETH1** is 192.168.1.250.
3. The optional Site Supervisor Display touchscreen default IP is 192.168.1.200 and will connect automatically to the Site Supervisor when plugged into **ETH1**. *It is recommended that you do not change these defaults.*

Figure 2 - Site Supervisor ETH 1 Ports

4. ETH0 should be reserved for the secure network connections: store or corporate networks. Ask your network administrator for the correct network IP address for **ETH0**.
5. **ETH0** and **ETH1** are physically separated for added security. Directly connecting to **ETH1** will not access the secure network connection on **ETH0**.

Figure 3 - Site Supervisor ETH 0 Port

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Visit our website at http://www.emerson.com for the latest technical documentation and updates.

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Supervisor Quick Setup Guide

24/7 Technical Support

Email - coldchain.technicalservices@emerson.com
Phone Number – [833-409-7505 (opt 2)](#)

[Offline Manager](#) - [offlinemanager.emerson.com](#)

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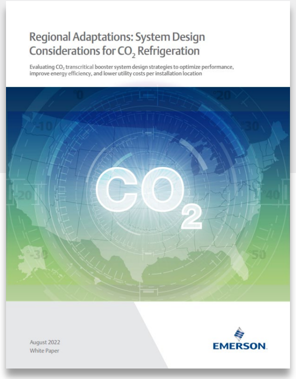
CO_2 Technical White Papers – Update and Promotional Plan

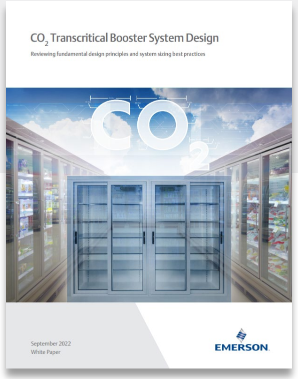
1 ***Regional Adaptations: System Design Considerations for CO_2 Refrigeration *(Not Published Yet)***

2 **CO_2 Transcritical Booster System Design**

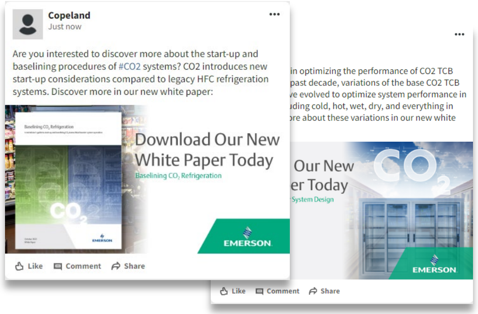
3 **Baselining CO_2 Refrigeration**

4 **Total Cost Of Ownership**

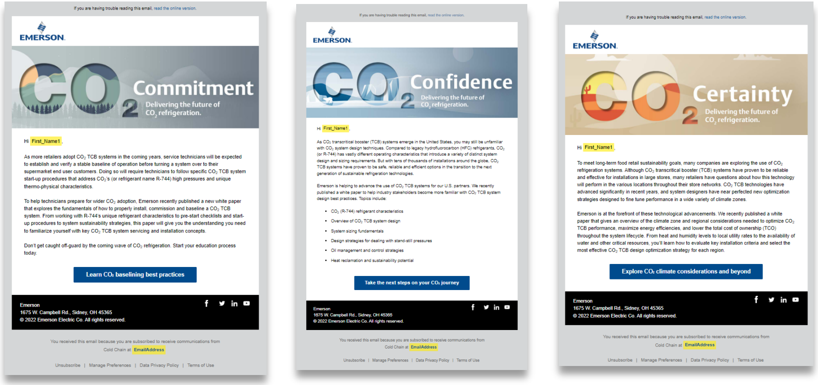




Social



Email Communications



→ You can access the white papers within our https://e360hub.copeland.com/