Munters
Your Perfect Climate

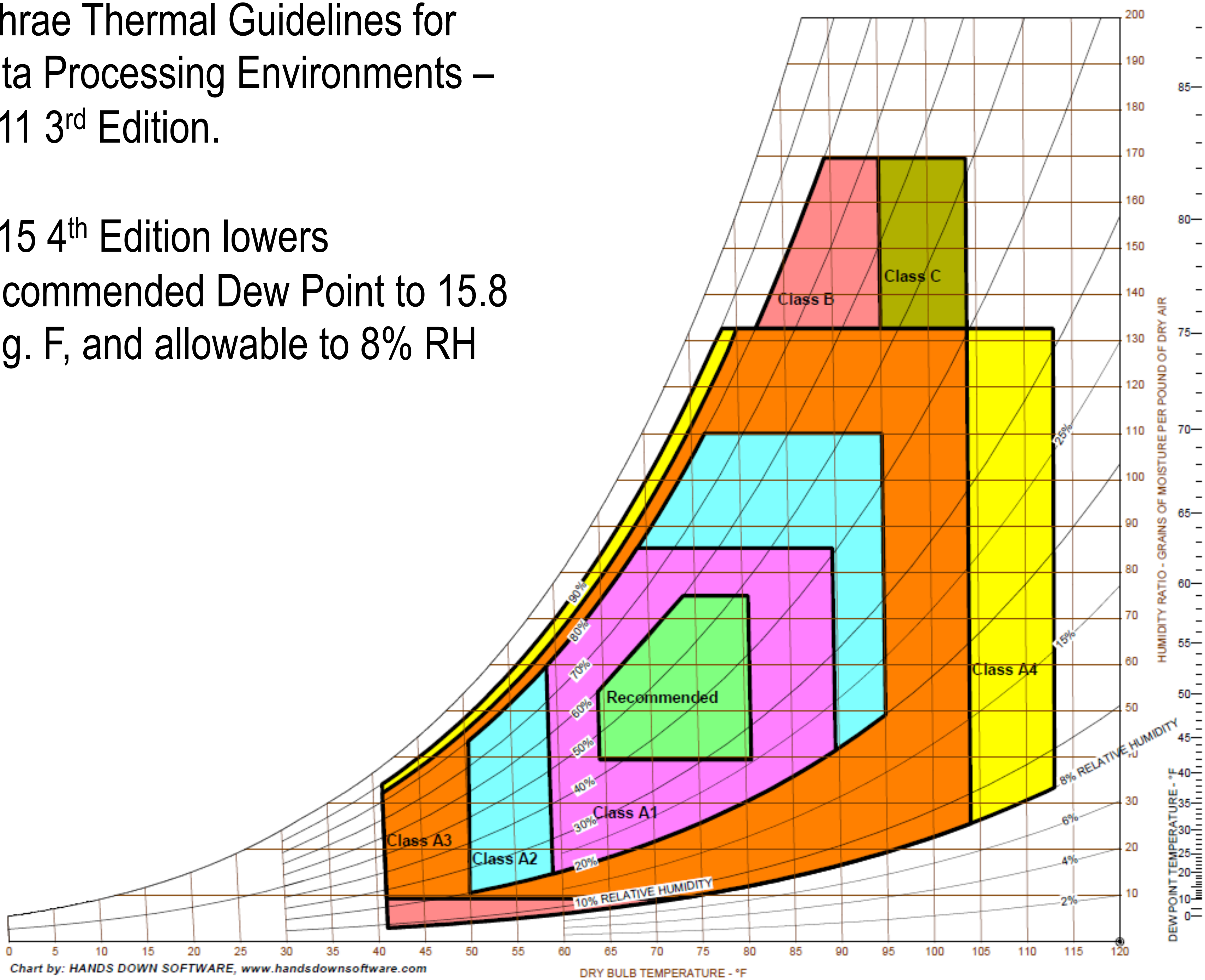
7x24 Lone Star Chapter
Lunch & Learn 11/28/2018

Topics of Discussion

- Direct Air Side Economizer (DASE)
- Indirect Air Side Economizer (IASE)
- New Waterless IASE - SyCool ITC
- IASE Efficiency Parameters
- Oasis IASE
- IASE Dry vs. Wet Comparison

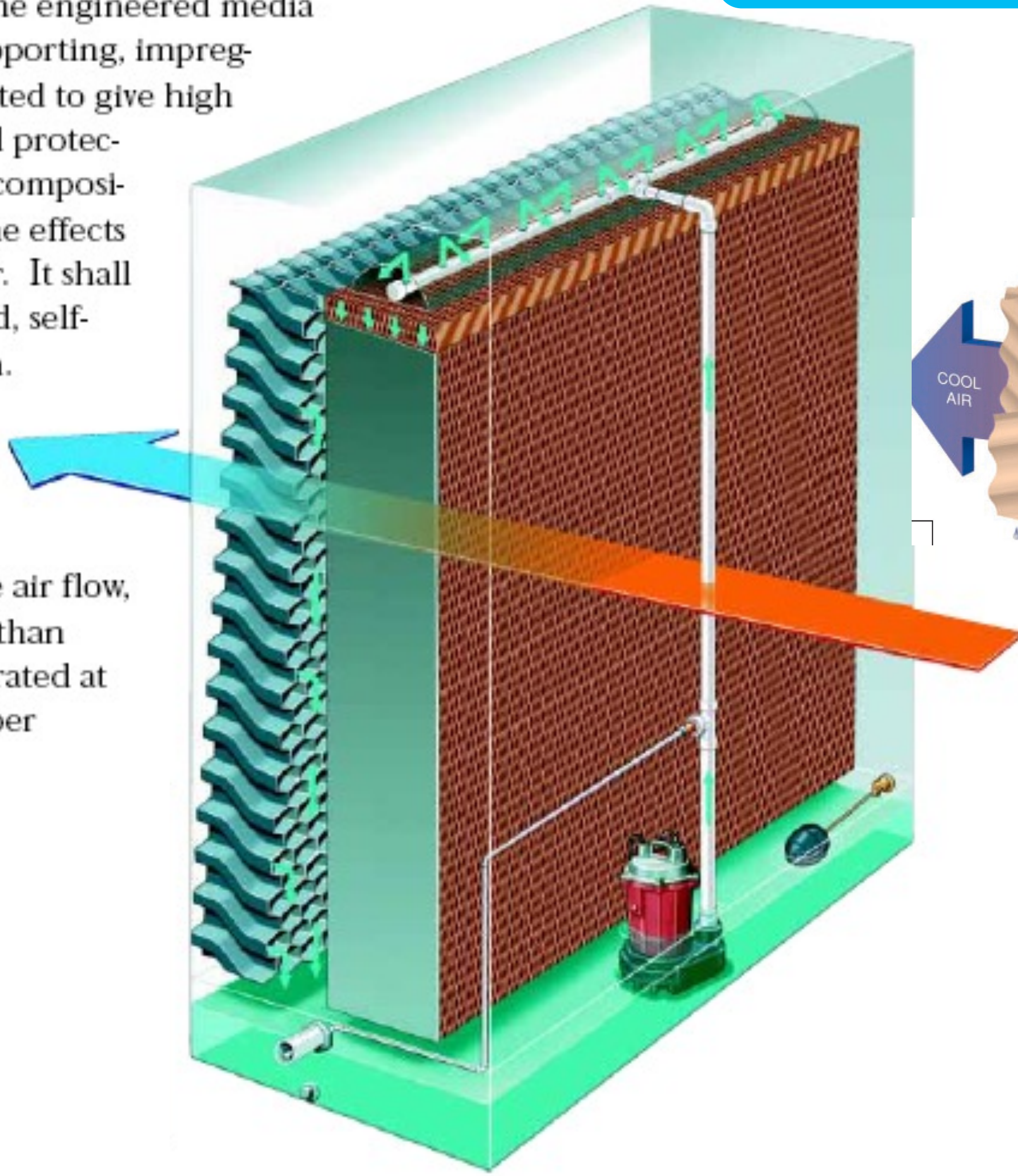
Ashrae Thermal Guidelines for Data Processing Environments – 2011 3rd Edition.

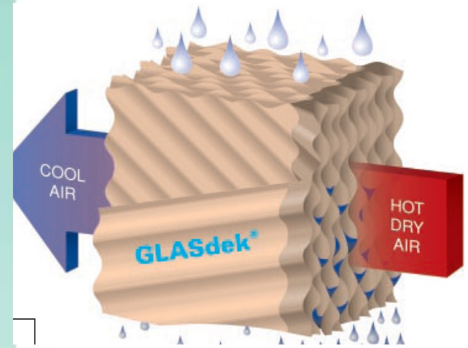
2015 4th Edition lowers Recommended Dew Point to 15.8 Deg. F, and allowable to 8% RH



■ **GLASdek Evaporative Cooling/ Humidification Media:** GLASdek media shall be fire rated with UL 900, Class II. The engineered media shall be self-supporting, impregnated, and treated to give high absorbency and protection against decomposition through the effects of water and air. It shall be a cross-fluted, self-cleaning design. Saturation efficiency for a 12 inches depth in the direction of the air flow, will not be less than 90% when operated at up to 400 feet per

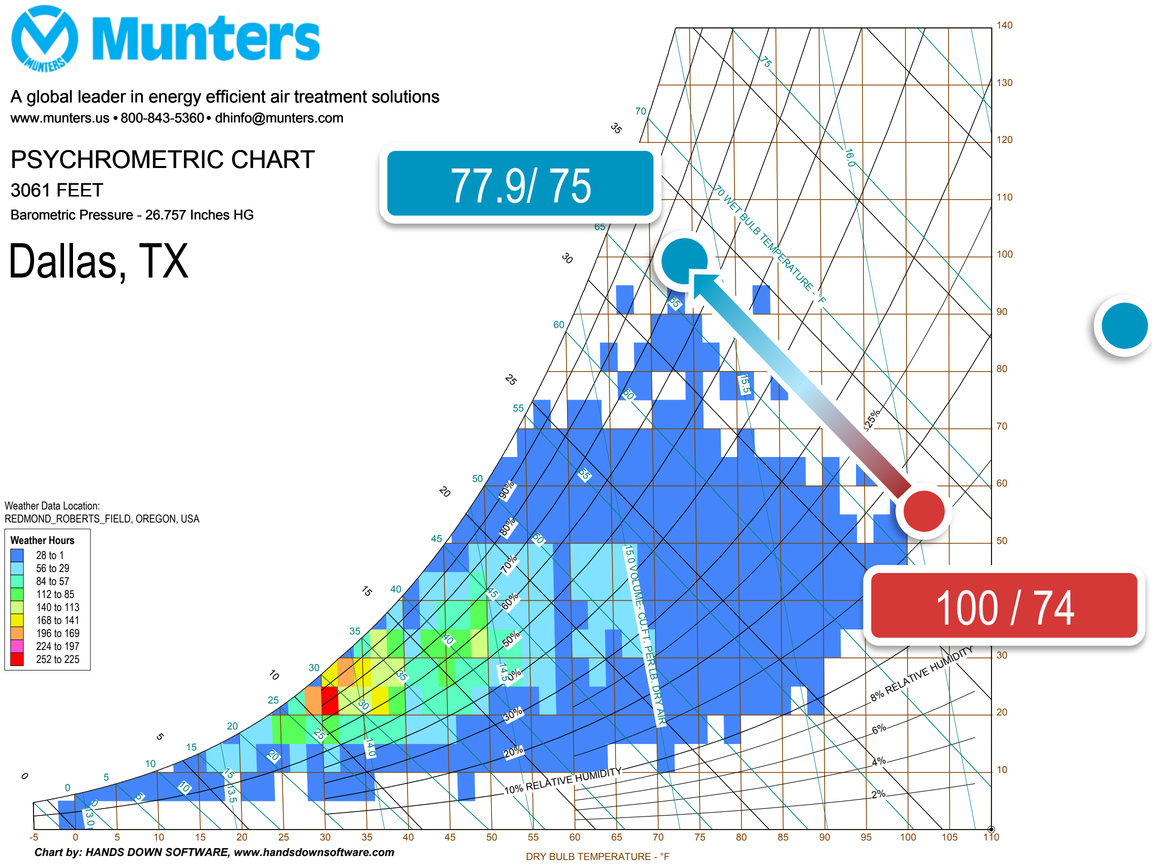
Direct Evaporative Cooling and Humidification

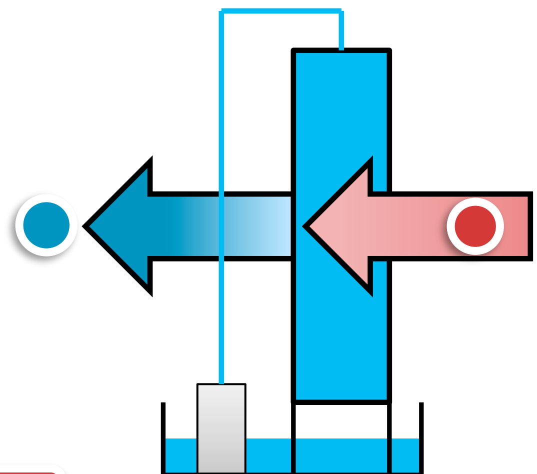




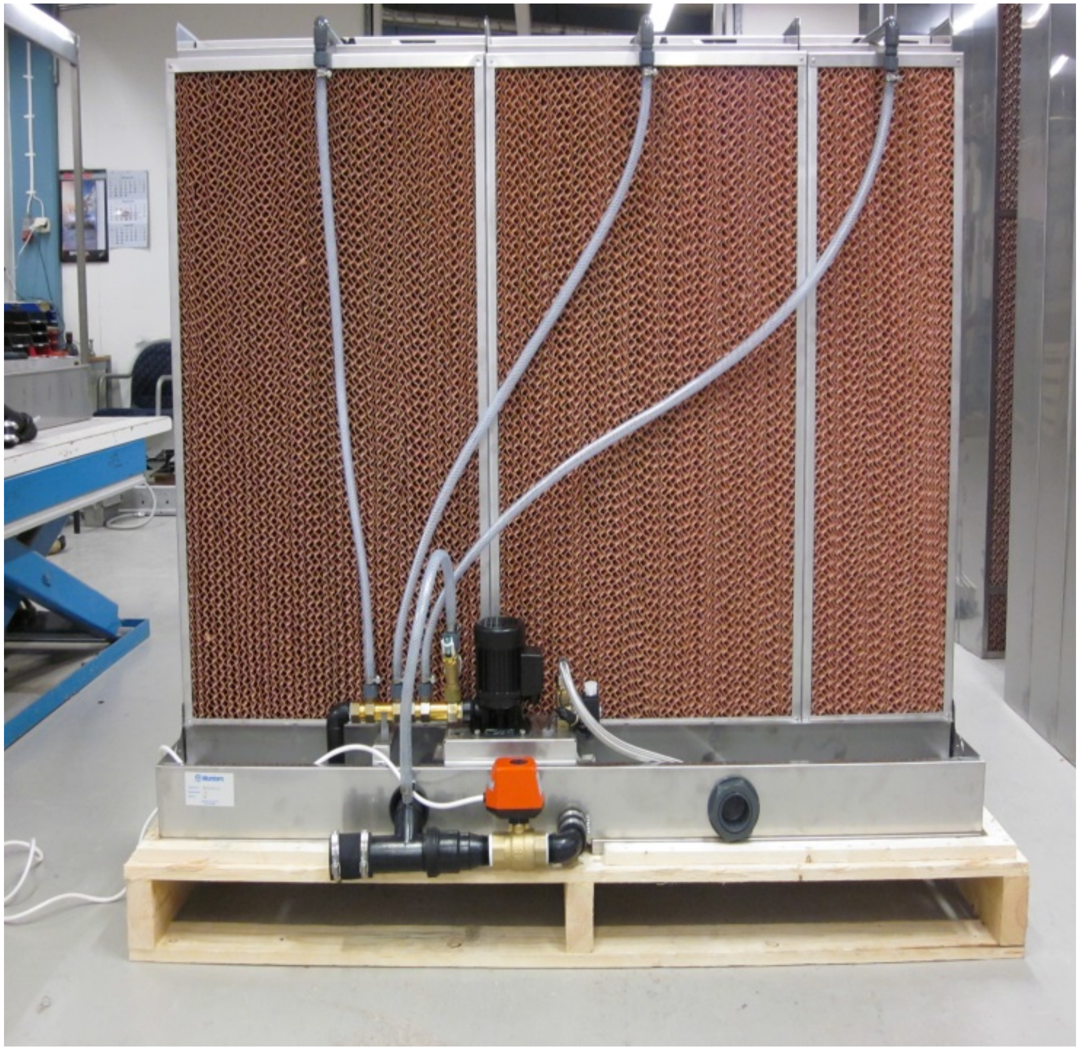
Typical Direct Evaporative Cooler (DEC) Operation

- DEC cools by adding moisture to dry air





Direct Evaporative Media Bank – FA6



- Media is encased in stainless steel frames for easy replacement
- Design allows for face split staging for capacity control
- Designs available for incorporating into building infrastructure or air handlers

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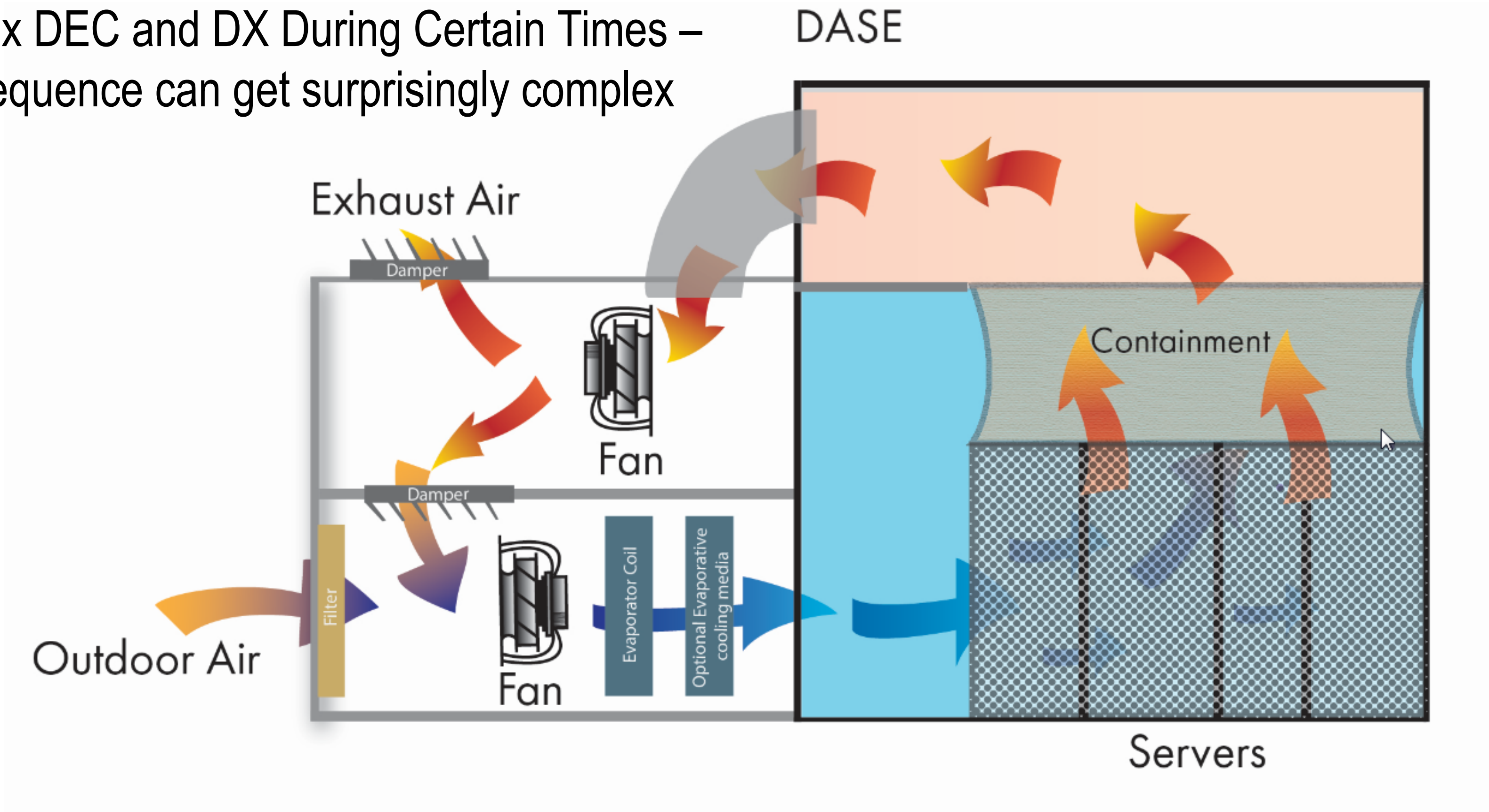
Direct Air Side Economizer (DASE)

Cooling = DEC When 100% Outside Air is Advantageous.   Cooling = All Mechanical When O/A Dew Point Above 59 F. Can Mix DEC and DX During Certain Times – Sequence can get surprisingly complex



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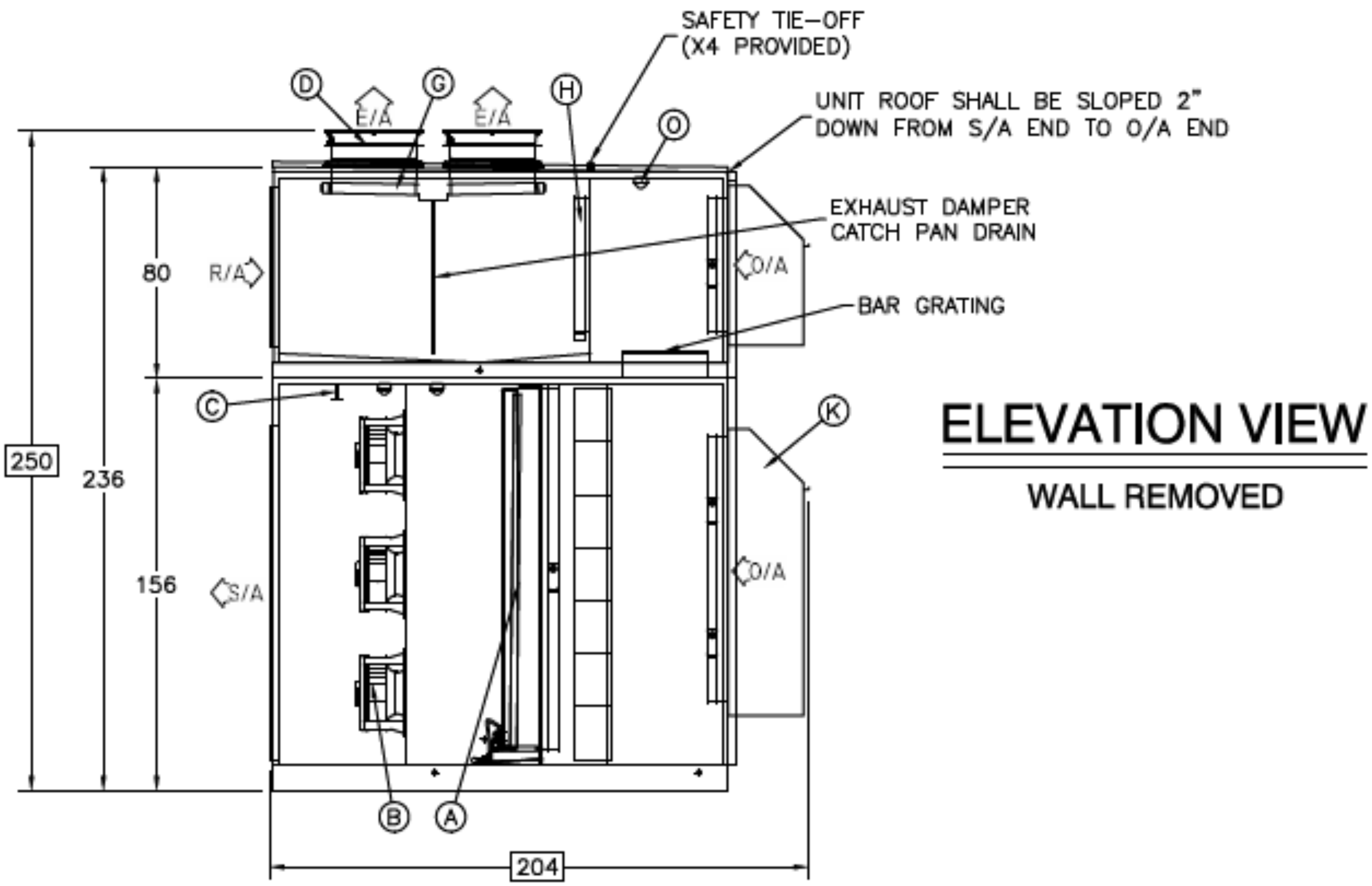
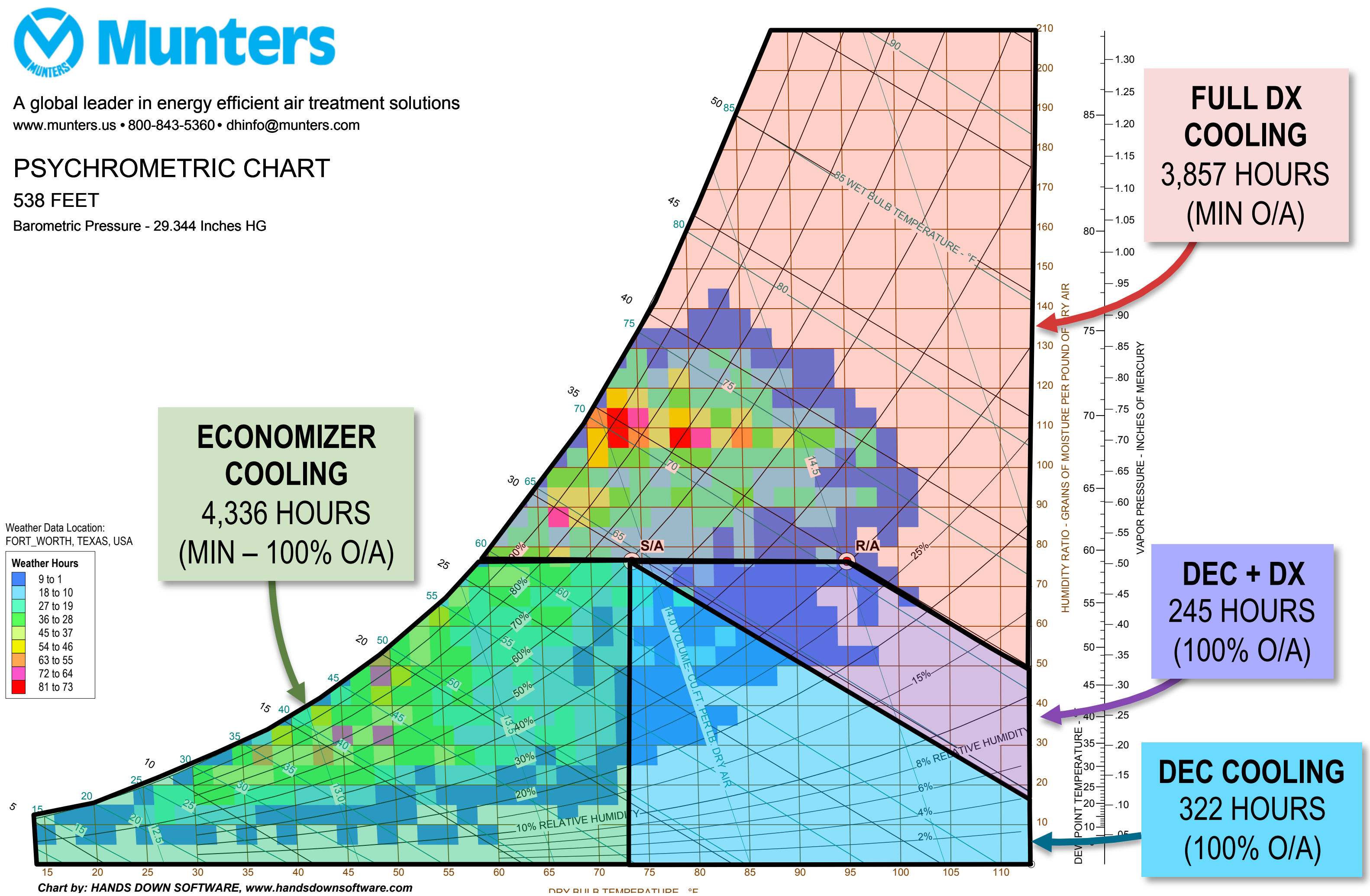
DASE Cooling System Layout



COOLING MODES FOR DALLAS FT WORTH DIRECT AIR SIDE ECONOMIZER (DASE) SYSTEM



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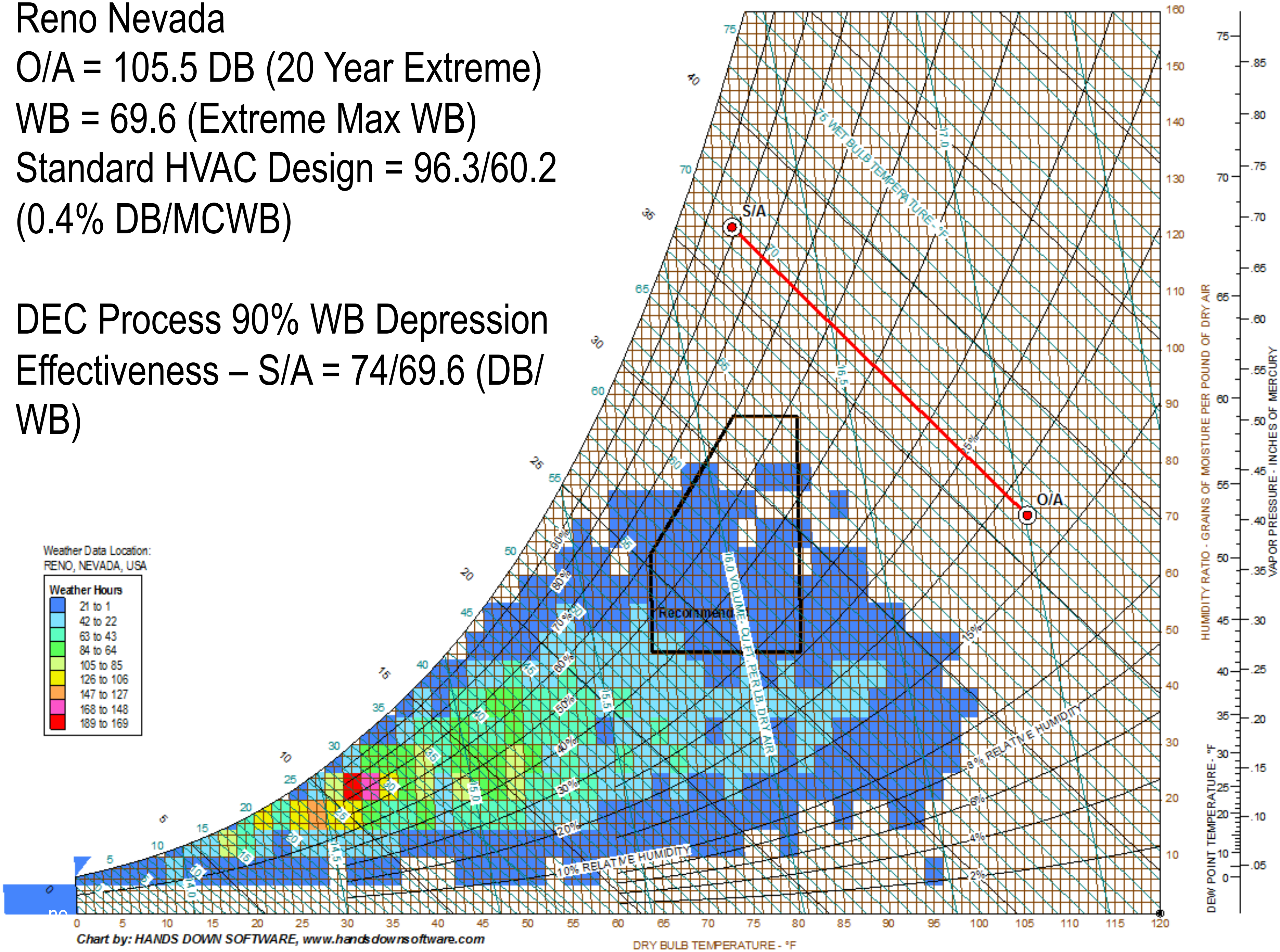
Reno Nevada
O/A = 105.5 DB (20 Year Extreme)
WB = 69.6 (Extreme Max WB)
Standard HVAC Design = 96.3/60.2 (0.4% DB/MCWB)

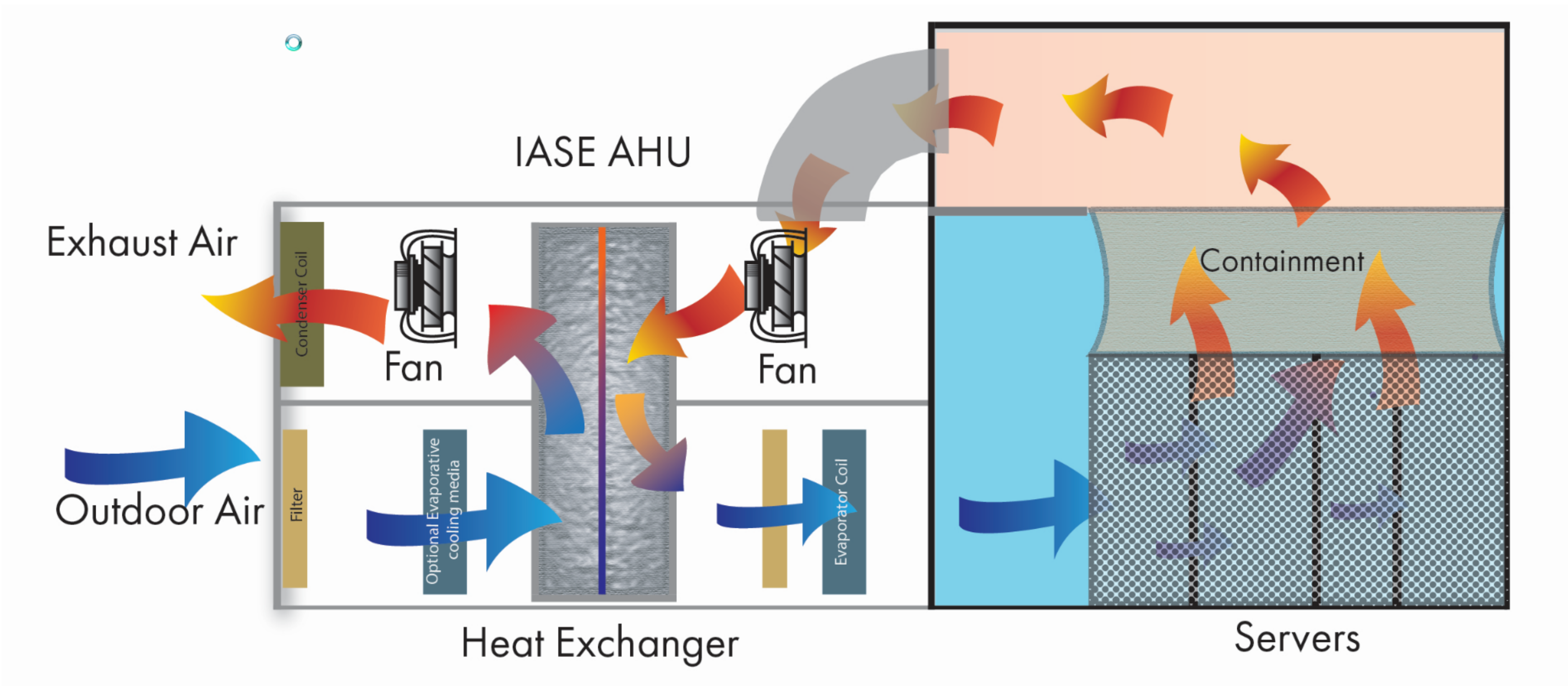
DEC Process 90% WB Depression Effectiveness – S/A = 74/69.6 (DB/WB)



Summary of Direct Air-Side Cooling Systems

- Efficient during cool and dry conditions but can be very inefficient during Humid summer conditions when 100% recirculation with full DX is required
- Risk from Outdoor Air Pollutants entering the data-center
- High filtration costs
- Modulating OSA & RA dampers, relief fans with VSDs, complex control
- When winter humidification is required there can be risks of water freezing
- Introducing OSA impacts space humidity and requires active pressure controls
- Rapid Restart following Power Loss, except in humid climates during summer when full DX is implemented
- Partial PUEs of compressor-less, optimally designed systems as low as **1.01**

Indirect Air Side Economizer (IASE)



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Heat Exchanger Options

"Dry" Indirect Airside Economizers

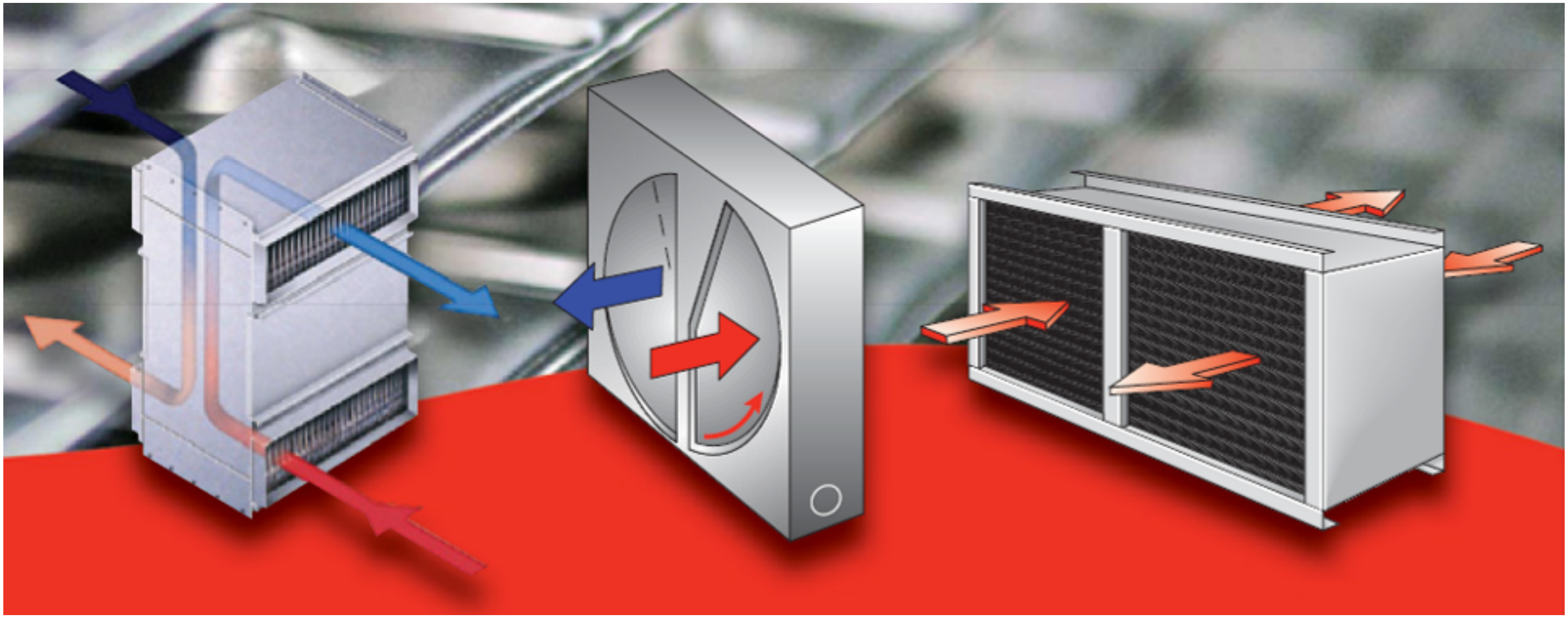
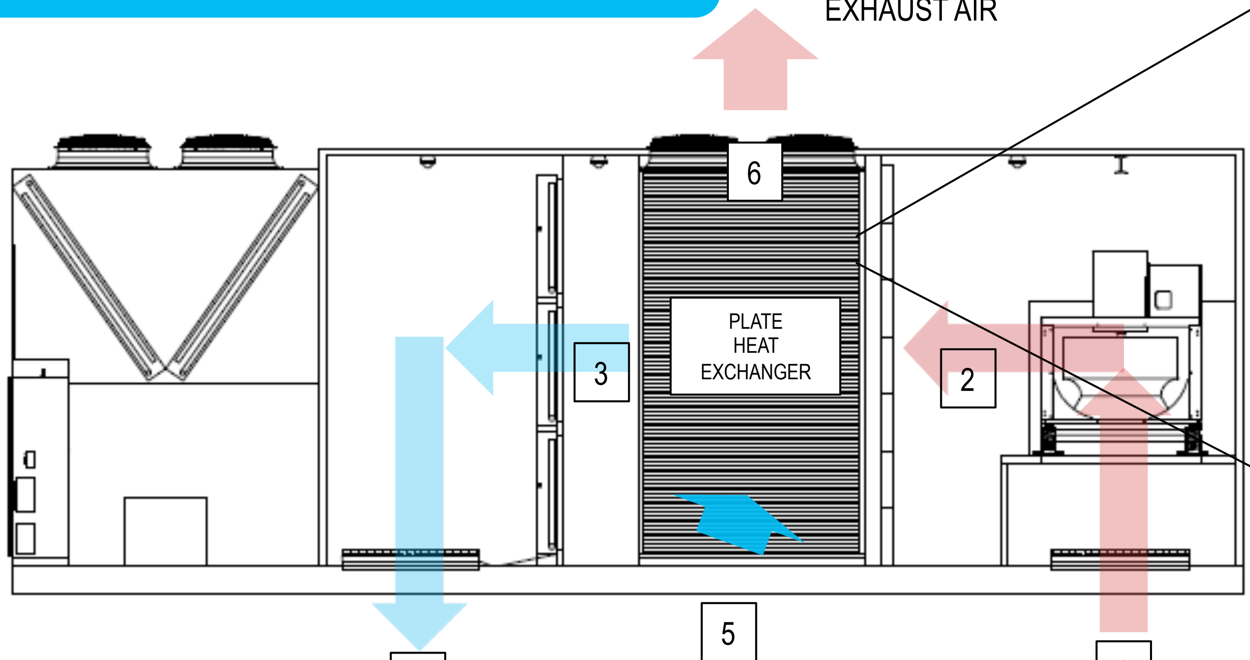


Plate Type   Rotary   Heat Pipe

PVX Dry Heat Exchanger



Hot Air From the Data Center Enters the aluminum plate heat exchanger. As scavenger air flows on the other side of the plates, the hot air is indirectly cooled against ambient dry bulb temperature.

State	Summer - Design			Summer - Mild			Full Economizer (Ambient DB)			Winter - Design		
Point	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM
1 (R/A)	97	69.3	62,469	97	69.3	62,469	97	69.3	62,469	97	69.3	62,469
2	99	69.9	62,699	99	69.9	62,699	99	69.9	62,699	99	69.9	62,699
3	99	69.9	62,699	92.5	68.0	61,964	75	62.3	60,000	75	62.3	60,000
4 (S/A)	75	62.3	60,000	75	62.3	60,000	75	62.3	60,000	75	62.3	60,000
5 (O/A)	105	83	0	85	70	37,984	48	48	36,000	20	17	18,500
6	-	-	0	95.5	72.9	38,716	86.3	62.9	38,716	89.8	54.4	21,192

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Plate Heat Exchanger

450 KW Plate Heat Exchanger PVX

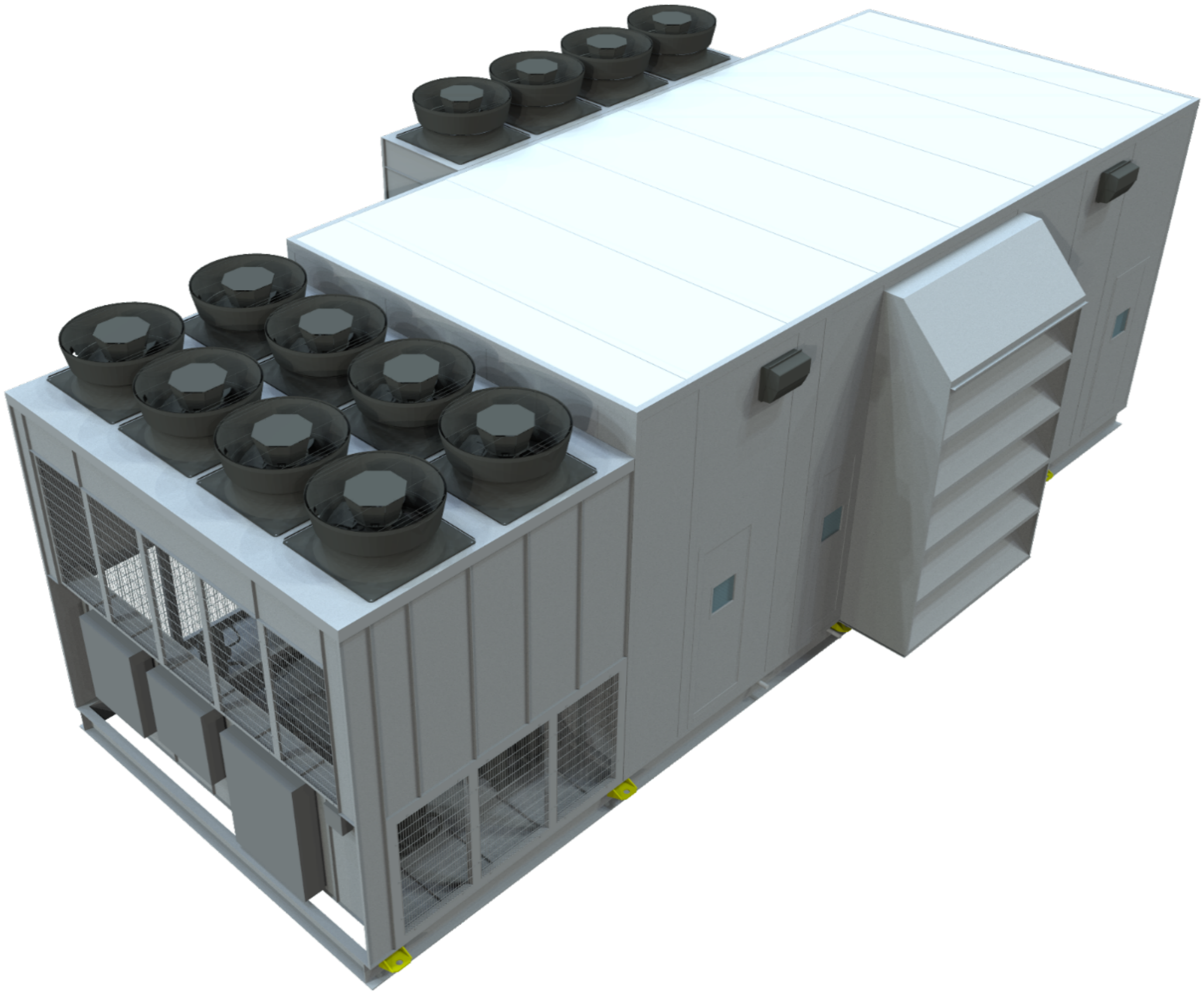

Plate Heat Exchanger Characteristics

Operating Characteristics
- No Moving parts
- Very Little Maintenance
- Not susceptible to particulate fouling
- Easily Cleaned if Needed
- Less than 0.2% Leakage Rate
- No Chance for Humidity Transfer
- Up to 85% Heat Transfer Effectiveness
- Reliable Characteristics for Life of Equipment

Munters' Experience
- Invented Technology in 1974 - ZDuct
- Over 300 Million CFM Installed
- Commercial & Industrial HVAC
- Embossed foil and Welded Plate
- Telecom Electronics Cooling in 1990's
- DC Cooling Projects over past 10 Years

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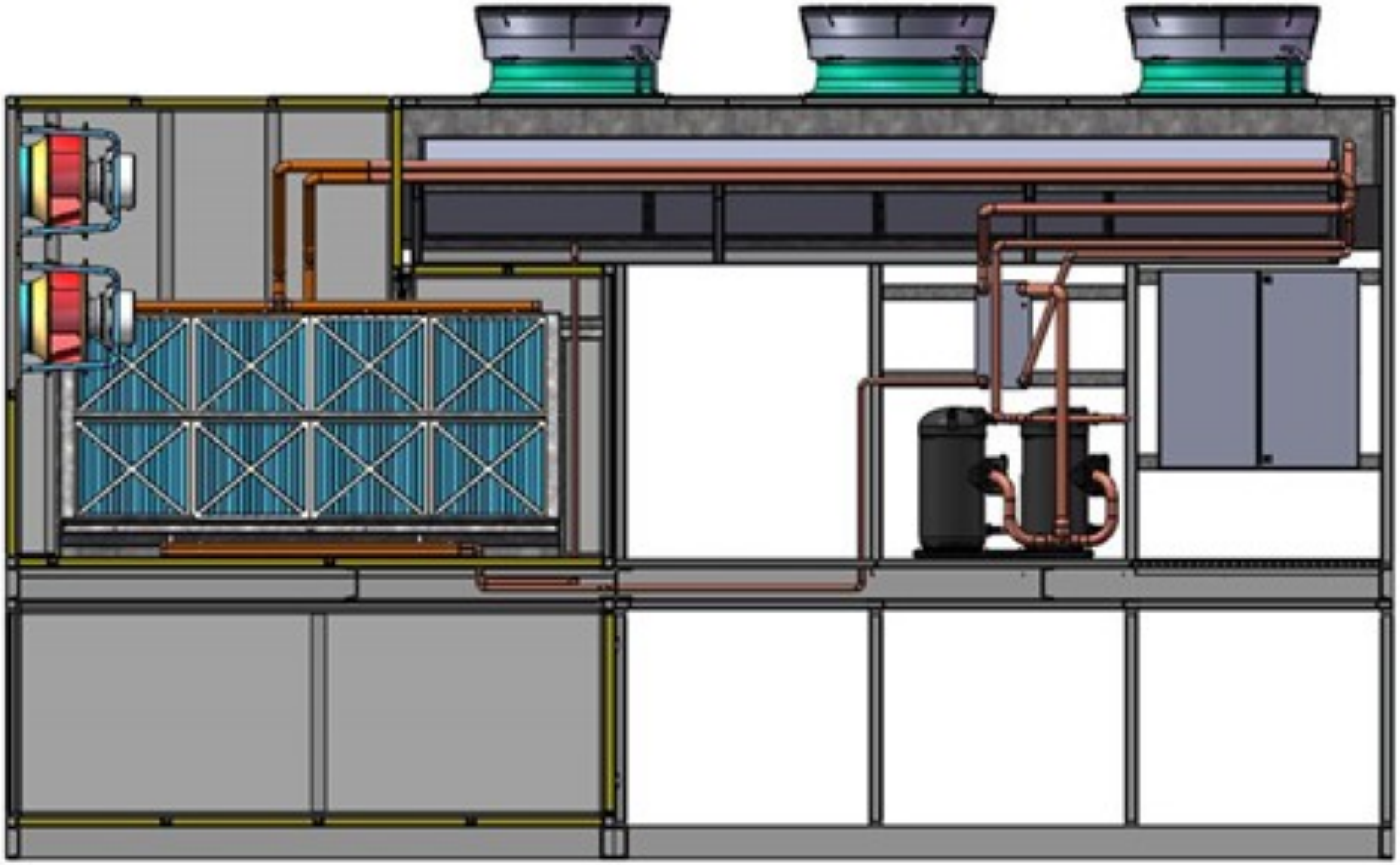
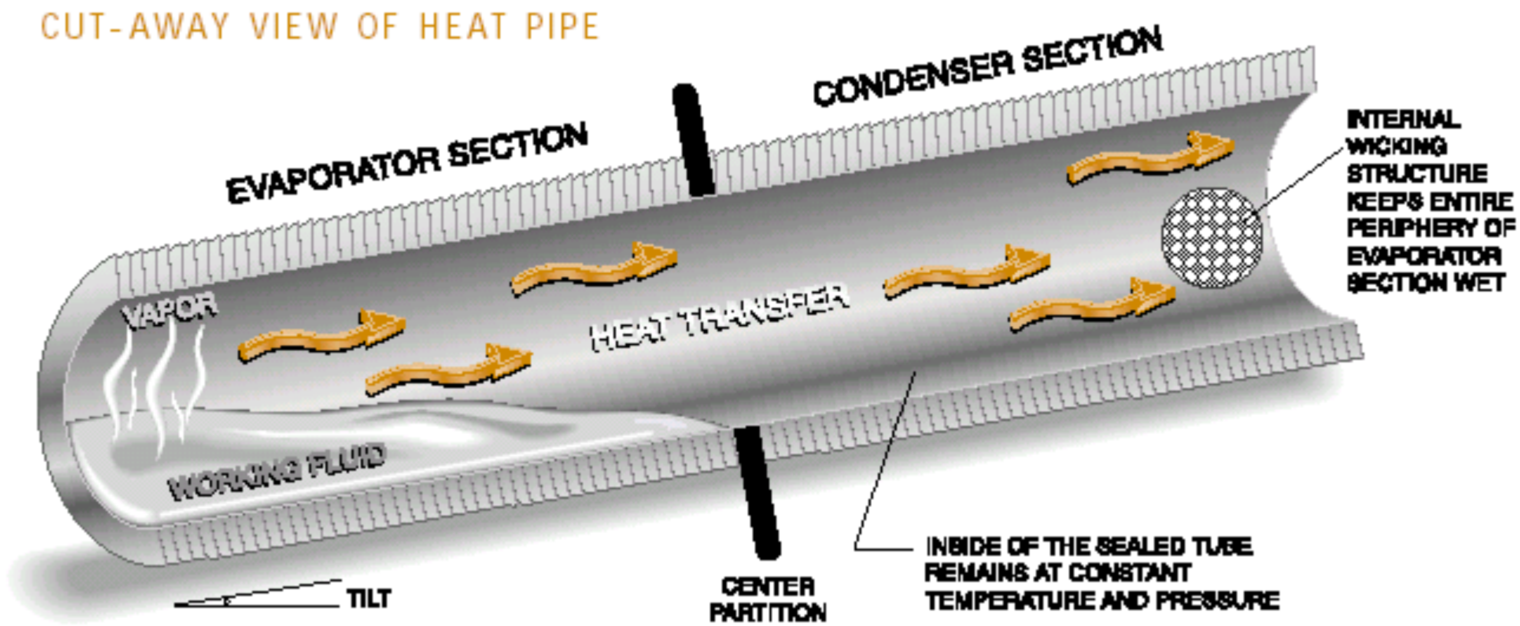
SyCool

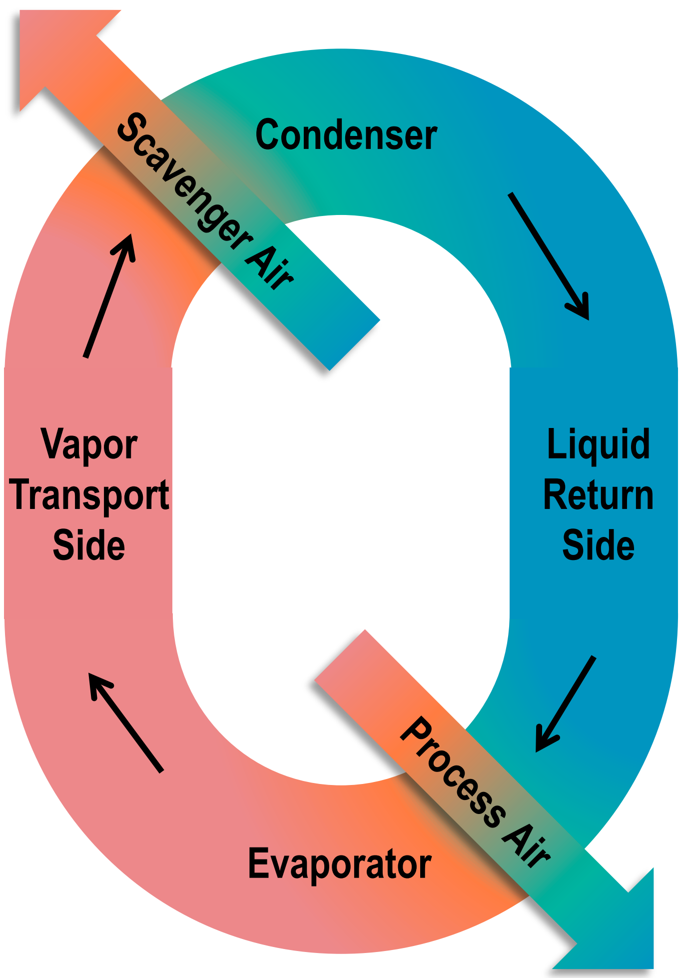


Heat Pipe

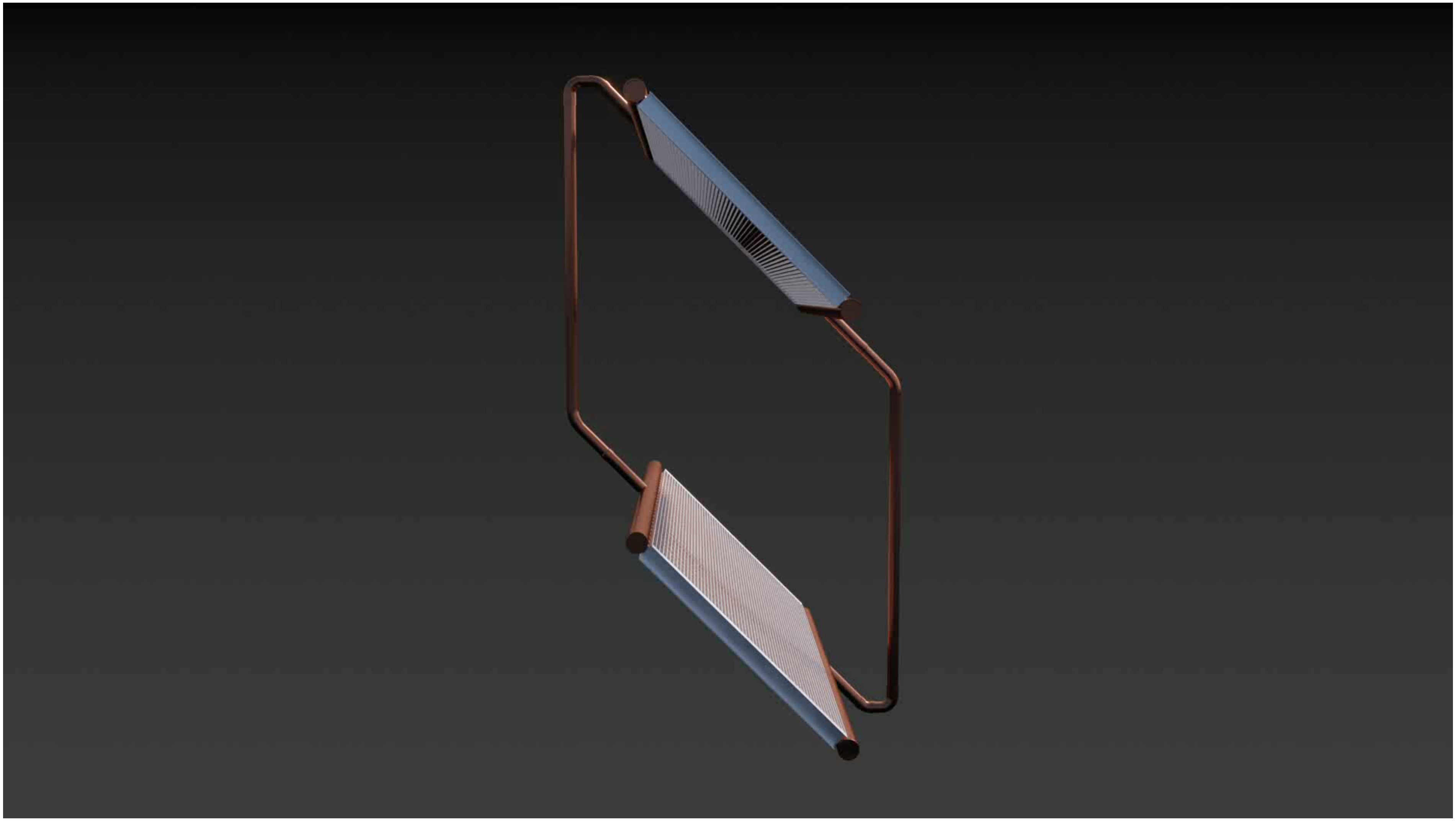


CUT-AWAY VIEW OF HEAT PIPE
EVAPORATOR SECTION
CONDENSER SECTION
INTERNAL WICKING STRUCTURE KEEPS ENTIRE PERIPHERY OF EVAPORATOR SECTION WET
VAPOR
HEAT TRANSFER
WORKING FLUID
TILT
CENTER PARTITION
INSIDE OF THE SEALED TUBE REMAINS AT CONSTANT TEMPERATURE AND PRESSURE

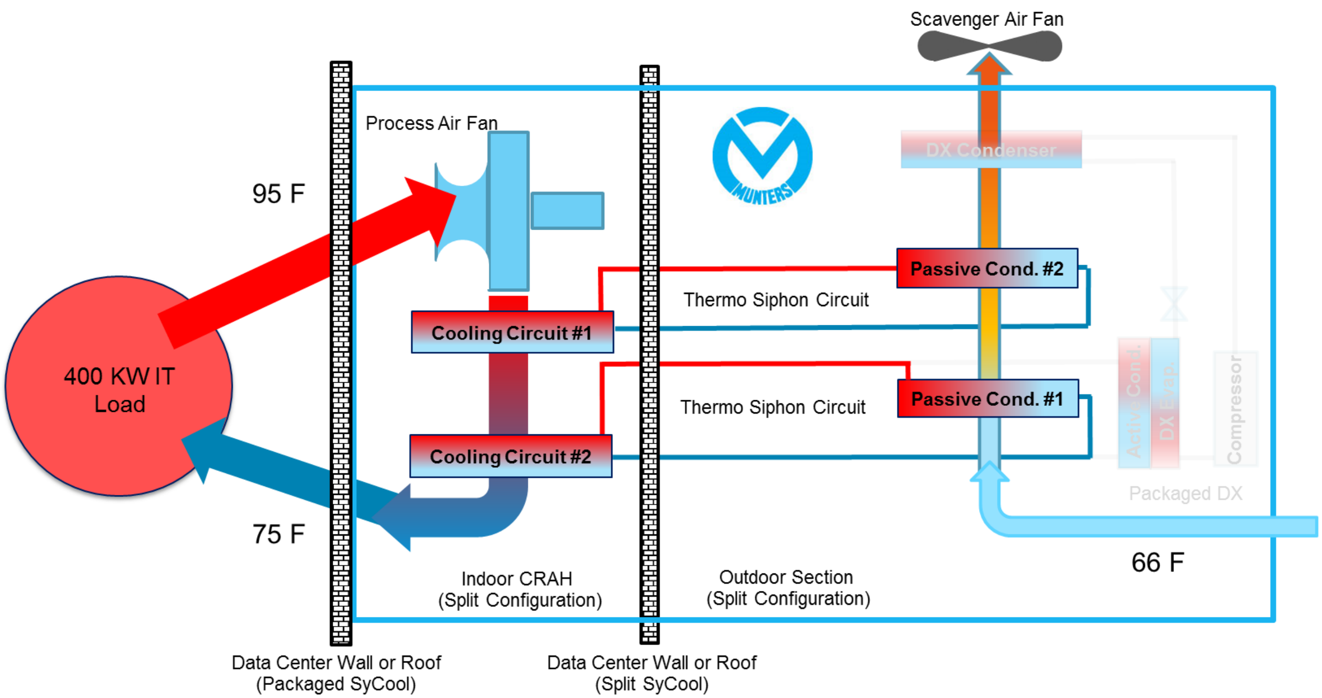
Thermosiphon - Circular Heat Pipe



- **Top of loop:** Cool scavenger ambient air condenses refrigerant that is returned to the evaporator by gravity.
- **Bottom of loop:** Warm data center air evaporates refrigerant that rises back up to the condenser.
- Circular flow of refrigerant naturally moves heat from bottom to top whenever scavenger air is cooler than process air.
- Passive, No moving parts associated with the heat rejection.

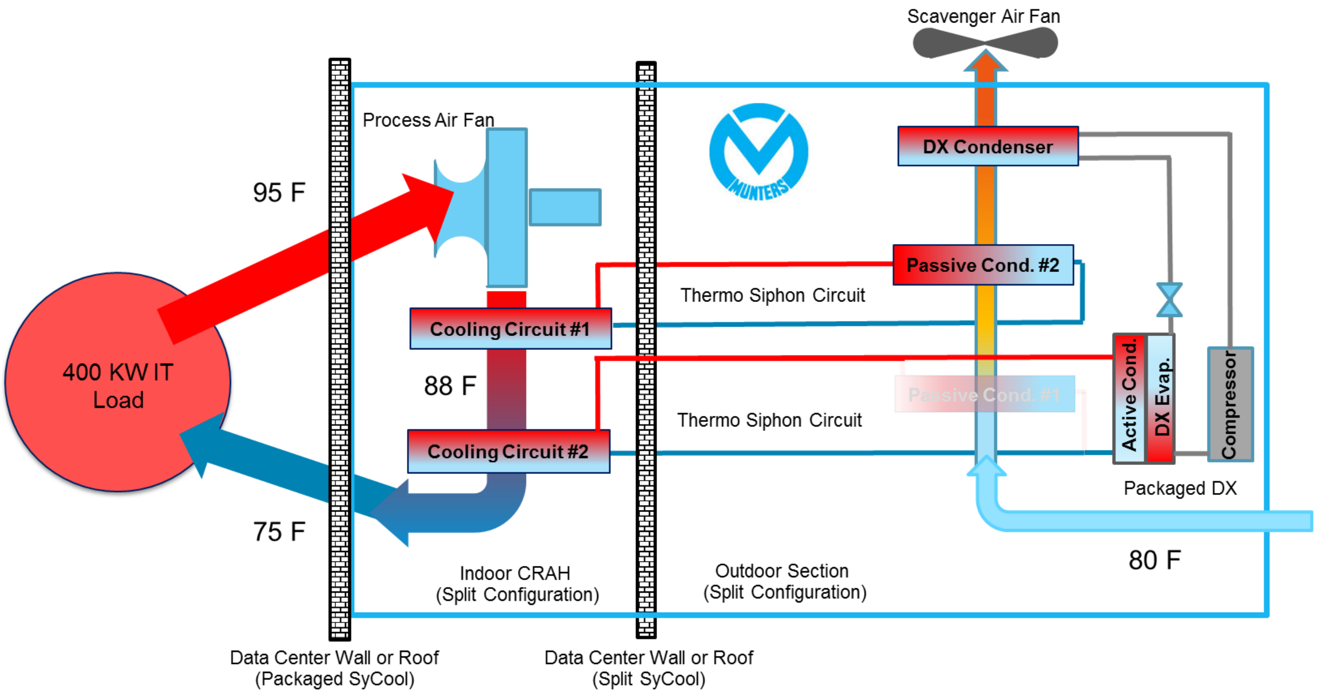


SyCool Schematic – Economizer Mode



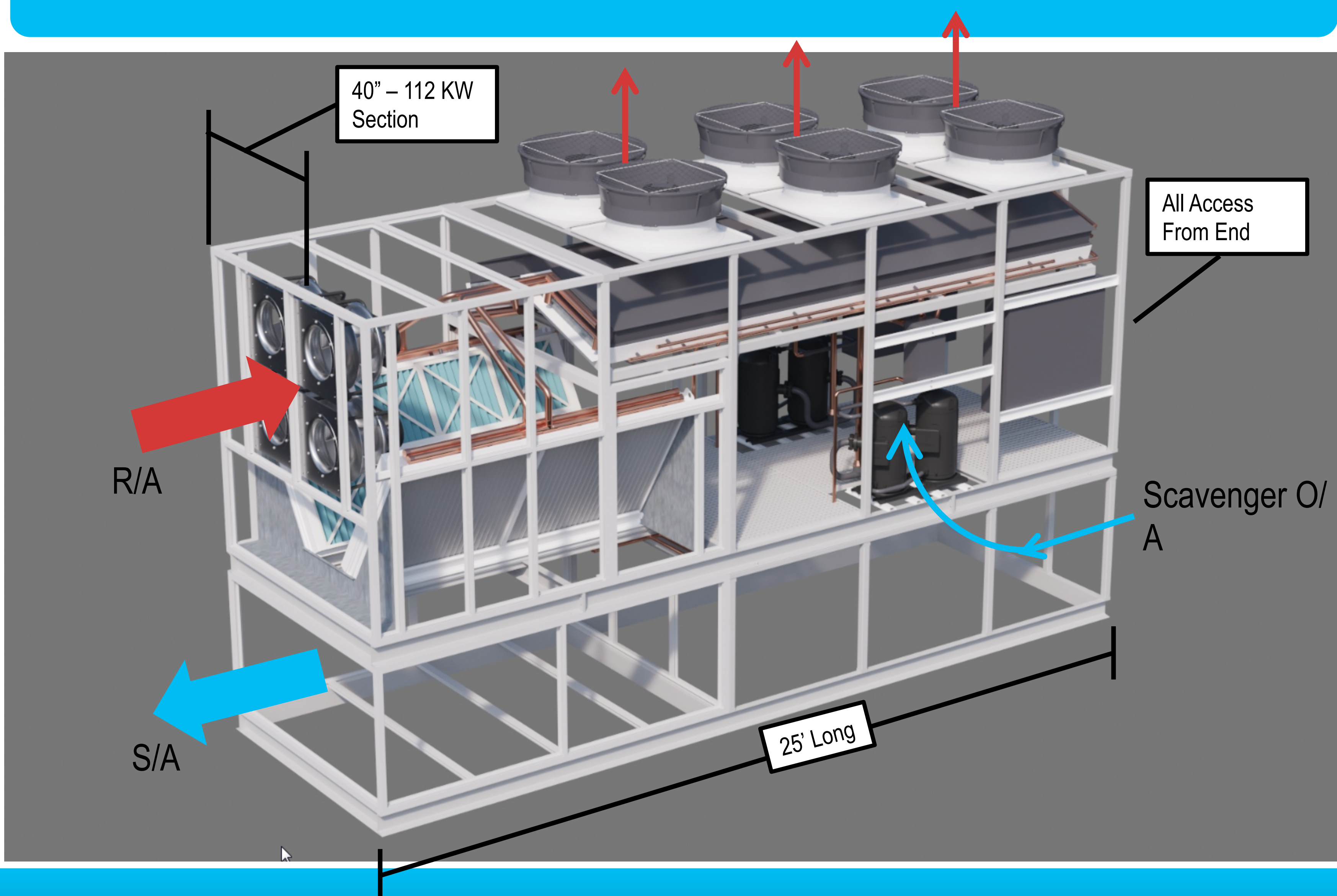
- Two Thermosiphon Circuits
- Each Circuit provides ~50% heat transfer effectiveness
- Circuits are piped counter flow (providing max Temperature Differential for Each Circuit)
- Combined Circuits provide ~70% heat transfer effectiveness
- Bottom Evaporator Circuit includes a refrigerant-to-refrigerant heat exchanger (inactive in passive mode)

SyCool Schematic – Active DX Mode



- Whenever outdoor scavenger air can not provide 100% of required cooling, compressor(s) are activated
- Compressor activation naturally moves the condensation process from the passive condenser to the active refrigerant-to-refrigerant heat exchanger
- 1st Thermosiphon remains active, providing economization throughout the active mode

SyCool System Layout



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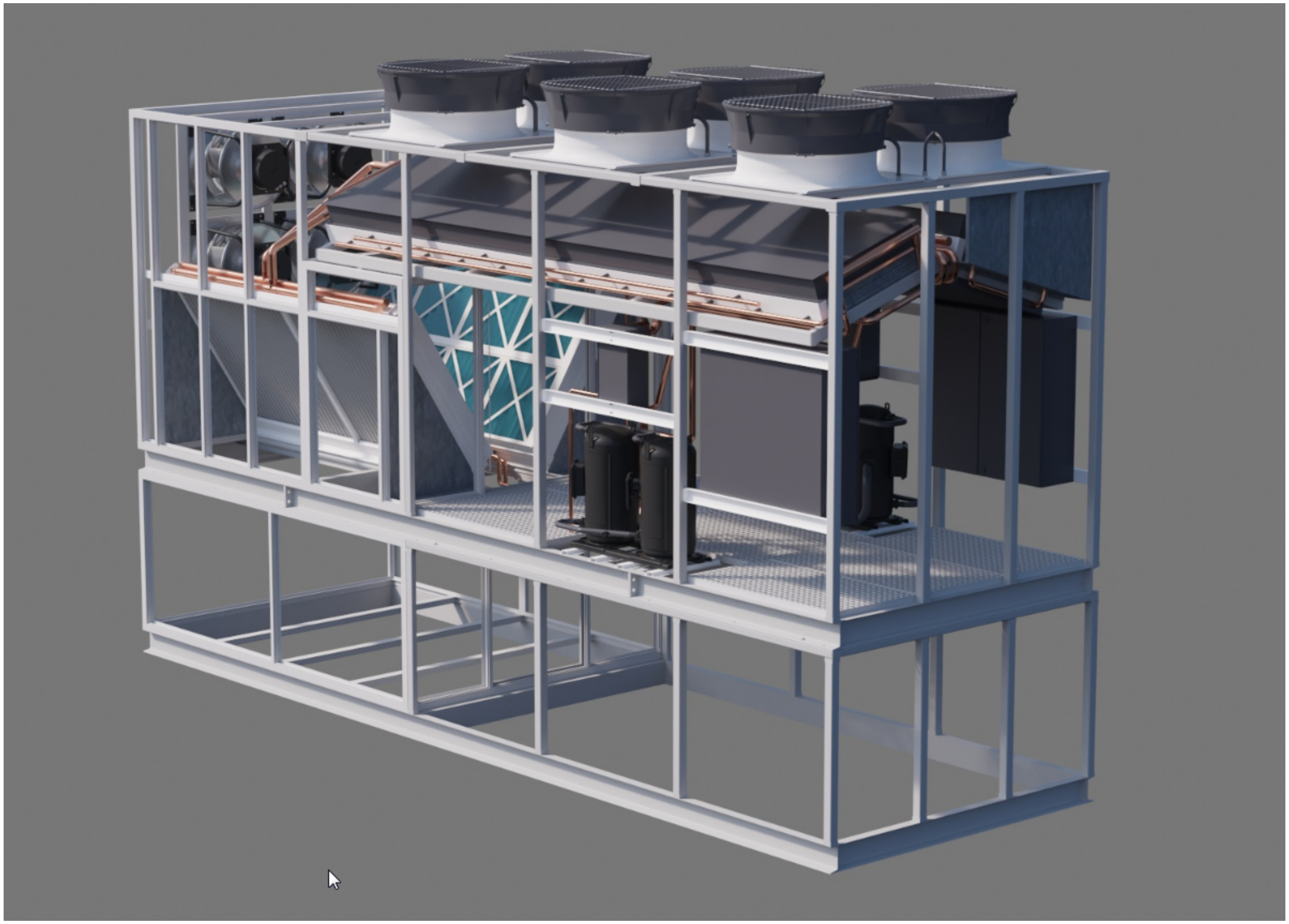
SyCool – Scavenger Air Intake View



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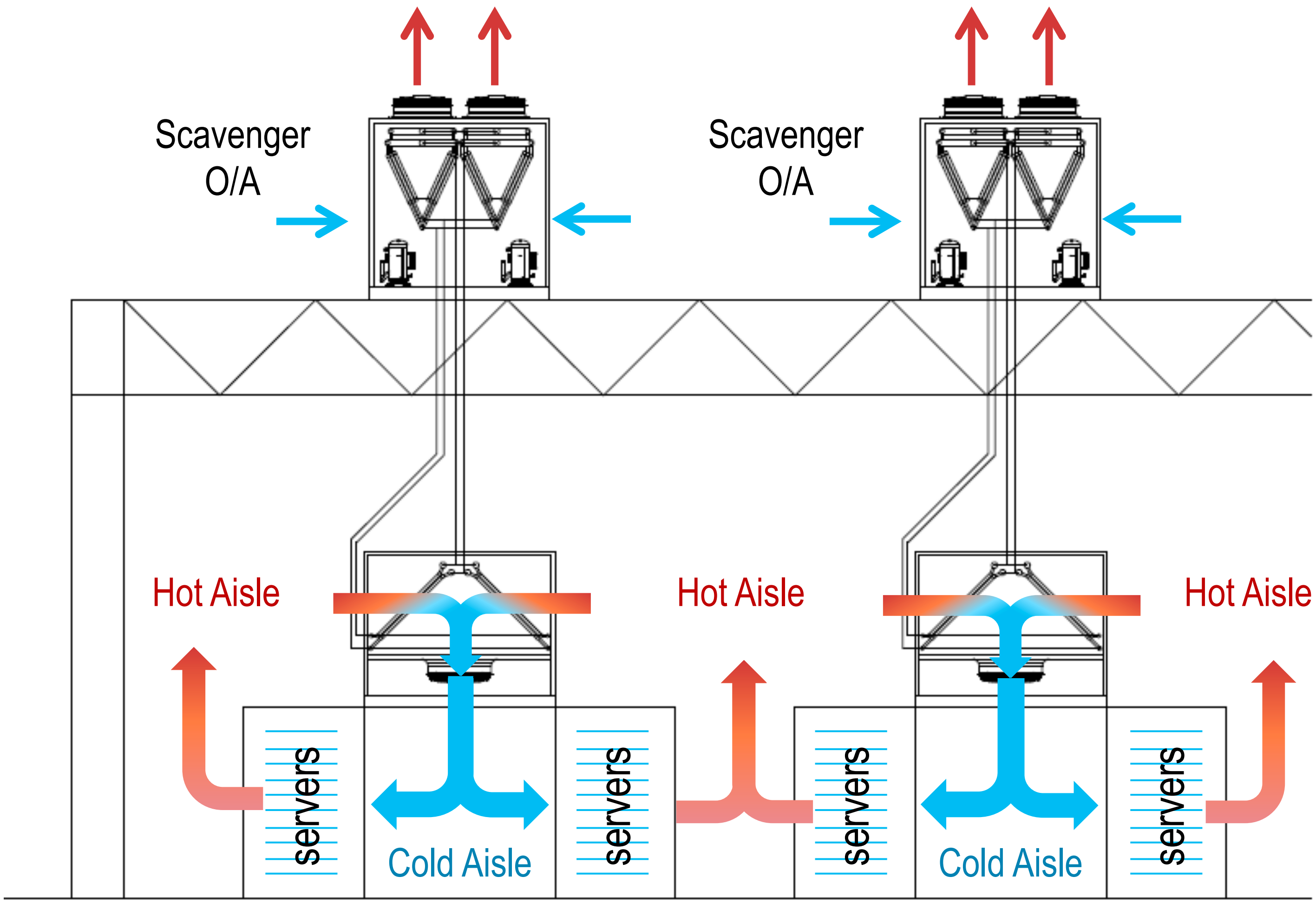
SyCool Advantage

- **Very good HX transfer effectiveness:** ~ 70% in Passive Mode
- **Passive economization** provided whenever outside air is cooler than process air
- **Low Process Side Fan Energy** (Delta P lower vs. HXR Based Systems)
- **Thermosiphon Circuit(s) are isolated** from active DX circuit
  - Refrigerant and charge can be optimized for each process
  - Line sizing can be optimized for each process
  - Thermosiphons are oil free, passive and maintenance free
  - Simple controls with smooth transition from passive to active mode
- **Compact, scalable designs**
  - 100 to ~500 KW Cooling systems
  - Configurations Side by Side with no service space between
  - Integrated package or Split systems

SyCool Installation Layout – Contained Cold Aisle Split System



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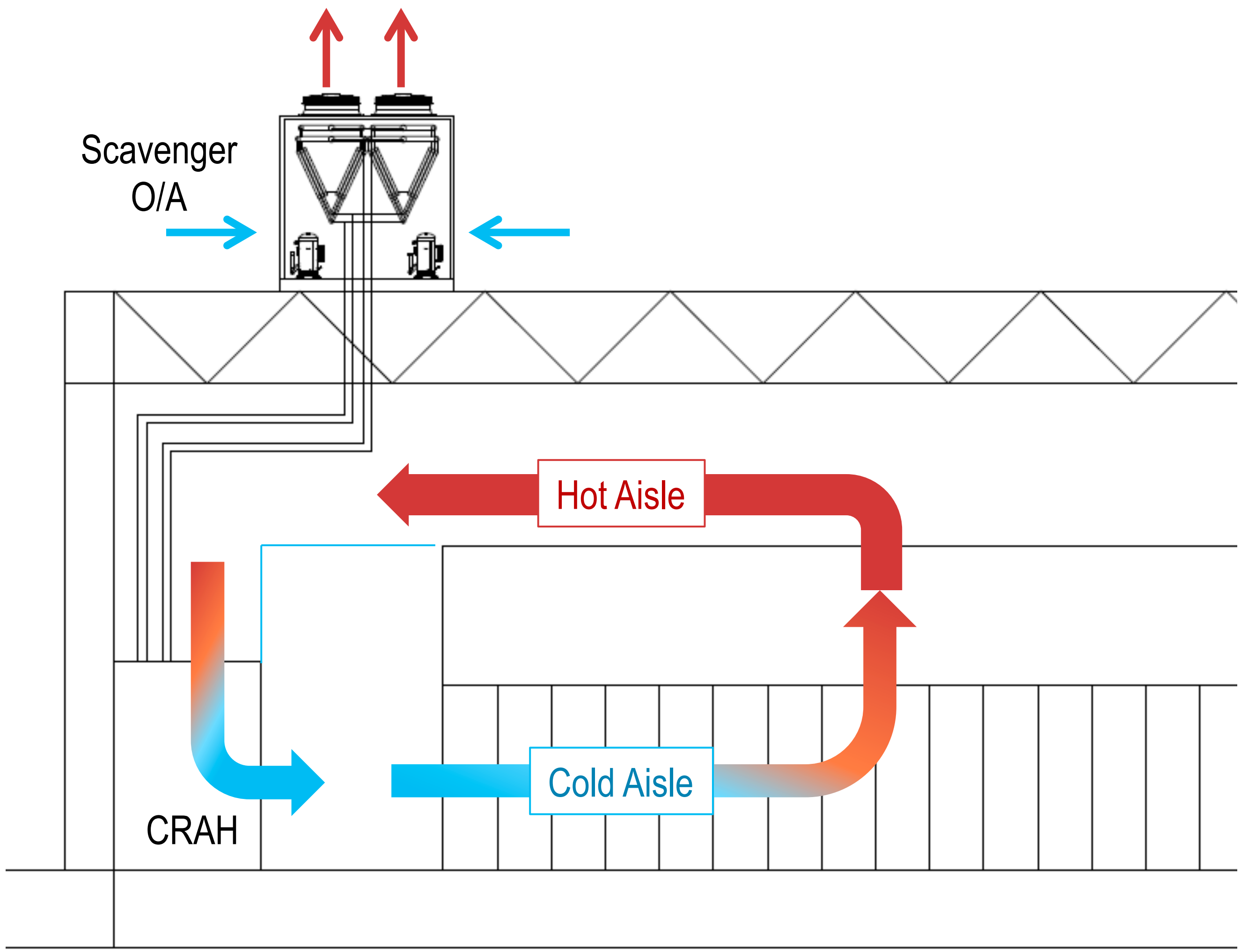
SyCool Installation Layout – Split System CRAH



Understanding Heat Recovery Effectiveness in IASE Scenario (Dry)

T1 = Cold Side or Scavenger Air Inlet Temperature
T2 = Cold Side or Scavenger Air Outlet Temperature
T3 = 95F = Hot Side or Data Center Side Inlet Temperature
T4 = 75F = Hot Side or Data Center Side Outlet Temperature
T5 = 55F = Ambient Air Temp. Where Full Economizer is First Available

(T3-T4)/(T3-T5) = Heat Exchanger Effectiveness (Data Center Side)
(95-75)/(95-55) = 50%

T3-((T3-T4)/Heat Exchanger Effectiveness)=T5
95-((95-75)/0.5) = 55

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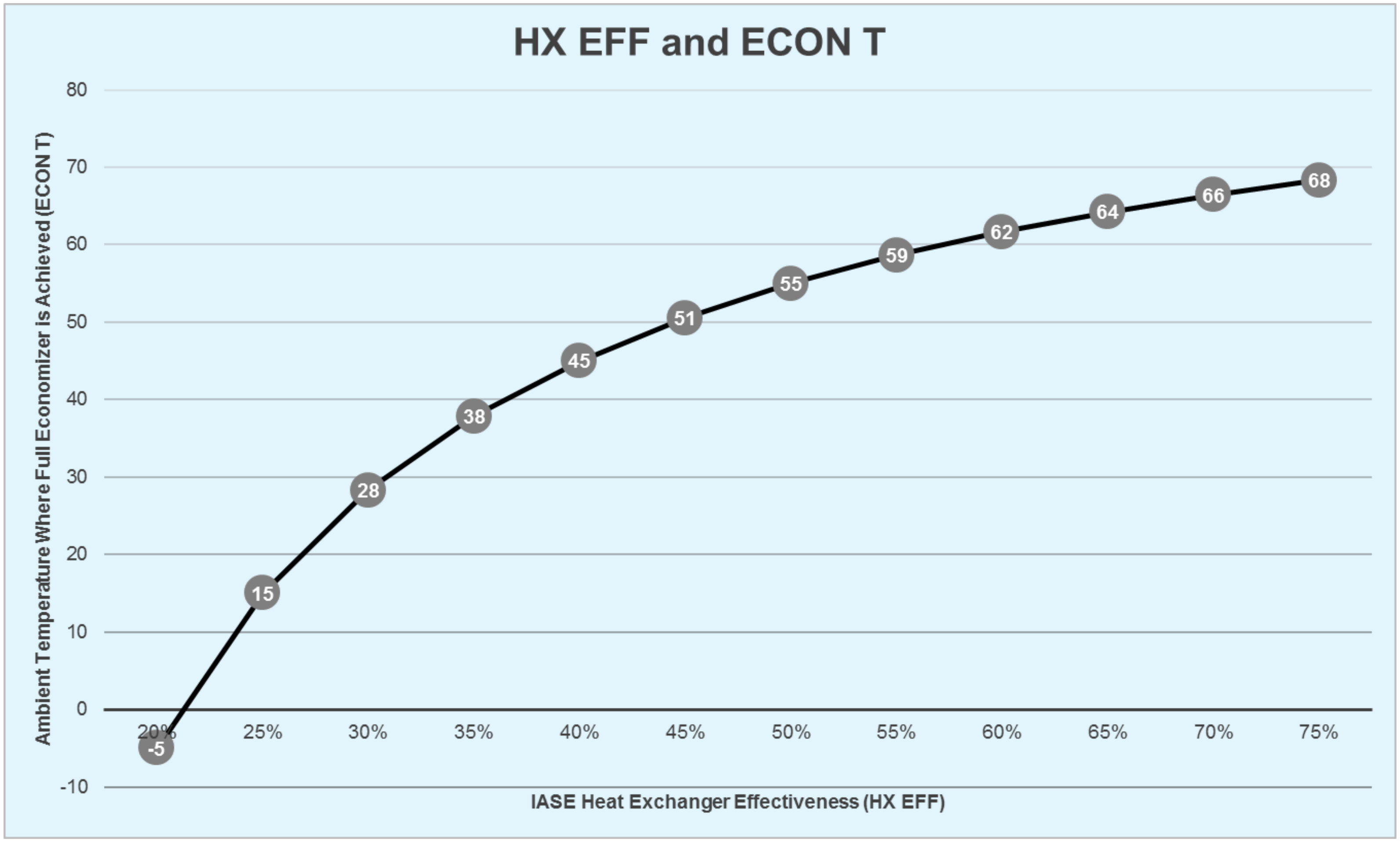
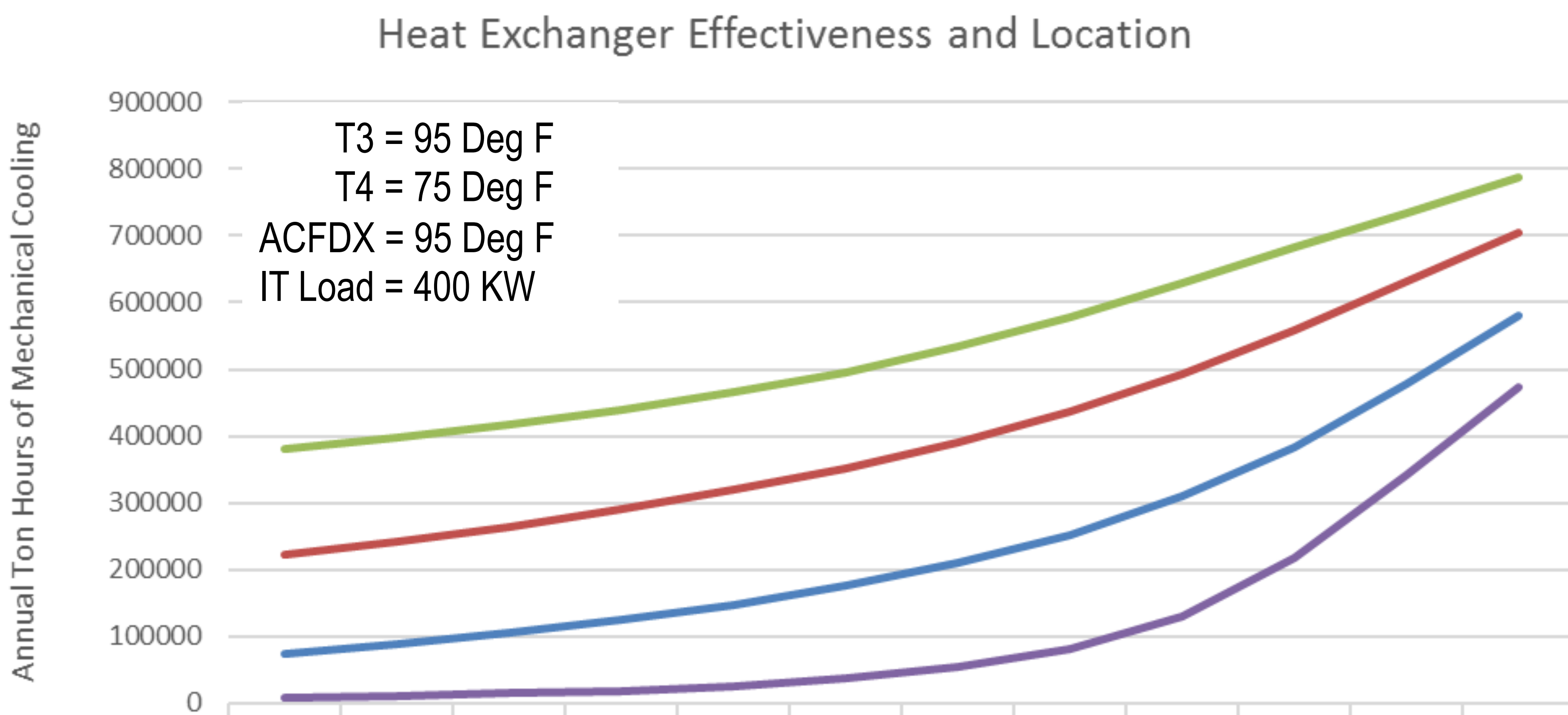


Ambient temperature (scavenger air inlet)	=	T1		
Scavenger air outlet temperature	=	T2		
Return temperature from the data center	=	T3	=	95 Deg. F
Target IASE supply temperature	=	T4	=	75 Deg. F
IASE Heat Exchanger Effectiveness	=	HX EFF		
Ambient Temperature where full economizer is Achieved	=	ECON T		

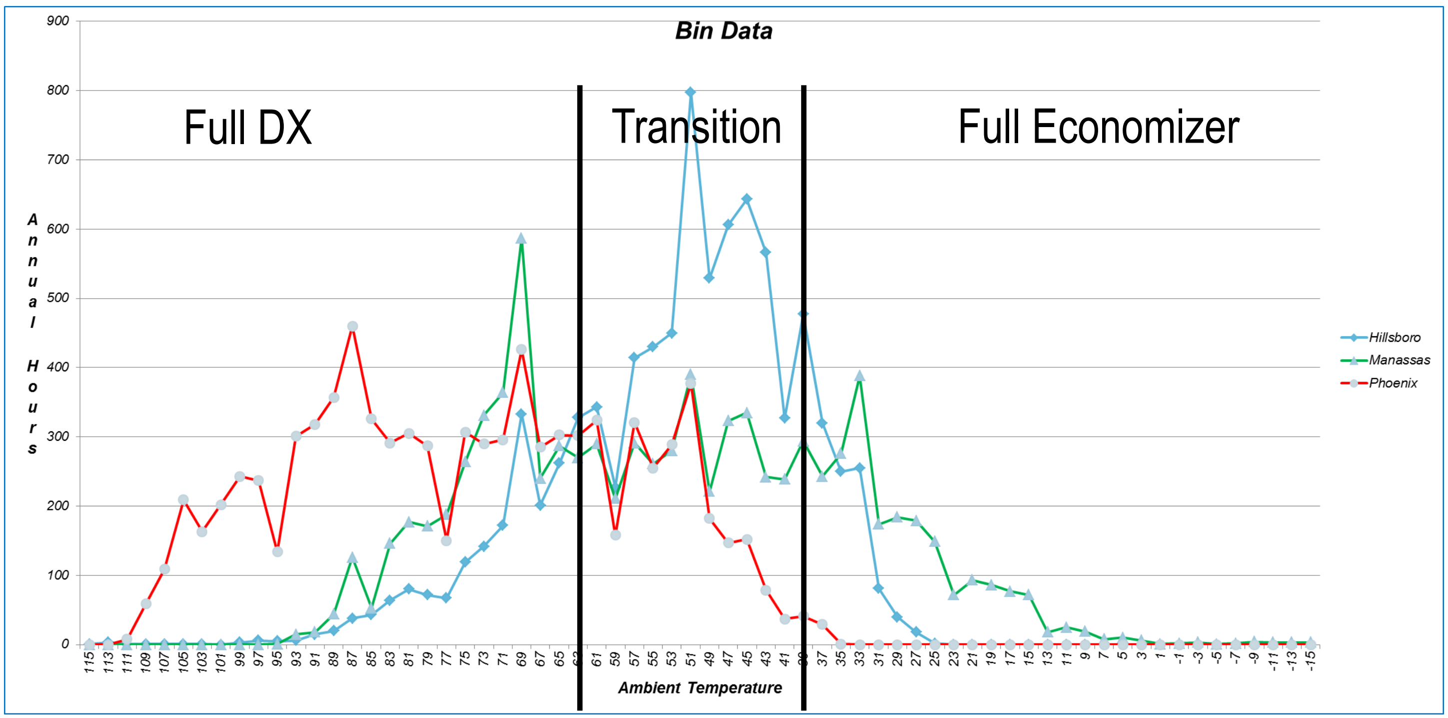


	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%
Manassas	74457	88887	105498	124970	148056	175377	209353	252840	309552	384380	478059	580736
Dallas	222402	242043	264372	289834	318747	351368	390154	436891	493115	559525	631618	704600
Phoenix	381275	398052	417313	439671	465980	496290	533381	578731	629438	681842	734301	786760
Hillsboro	9226	11502	14497	18815	25430	36610	54243	81593	130529	218804	343006	473724

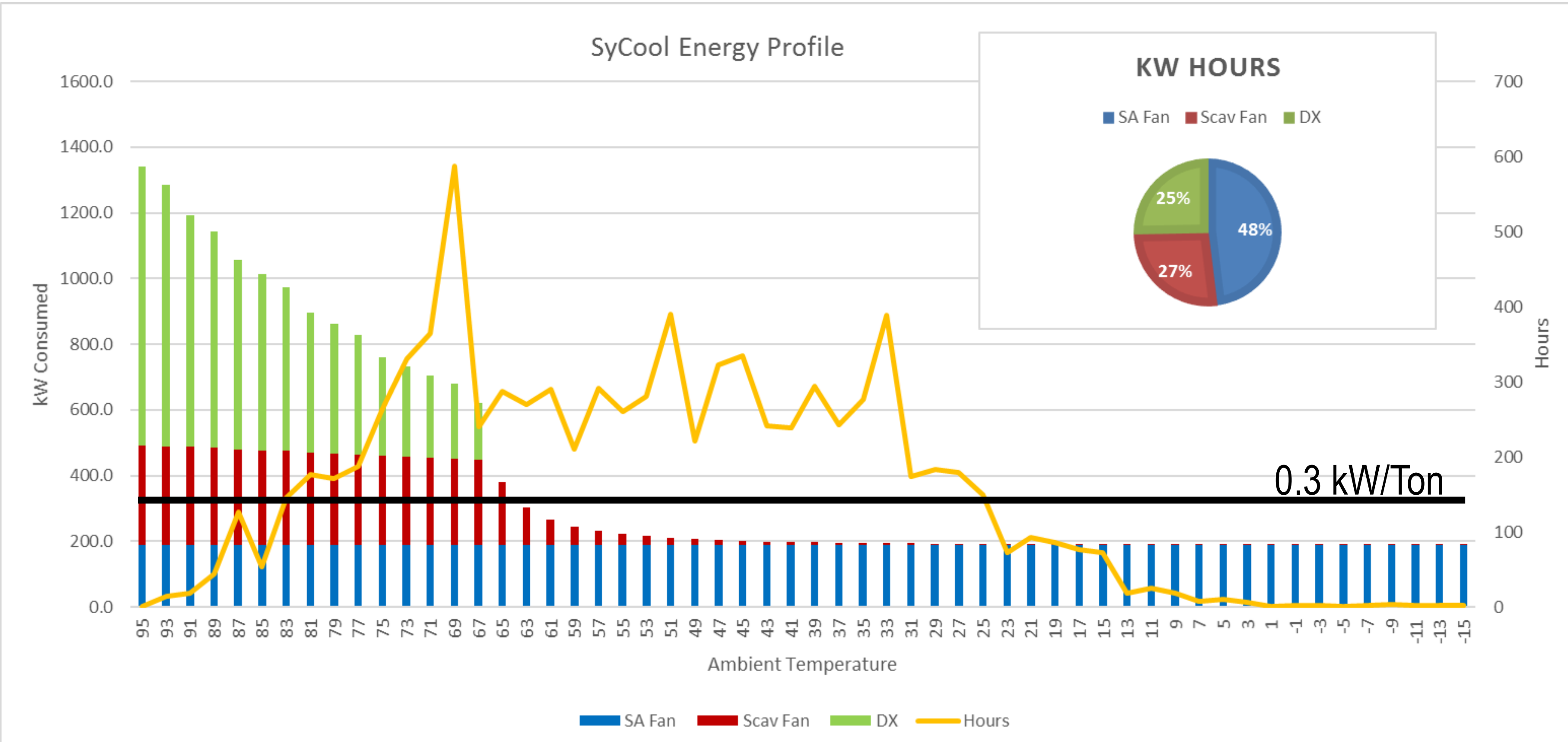
HXR EFF

Ambient Condition Full DX (ACFDX)

- Low Heat Transfer Effectiveness and Low ACFDX Hurt Efficiency Model
- Lower ACFDX Results From:
  - Cooling Circuits That Transition Between Heat Recovery and Active DX Where All Circuits Operating “Active DX” are Required to Meet Design Load
  - Chilled Water Systems (ACFDX = Water Return Temperature from CRAH Units)



SyCool Energy Profile



Manassas Va, Bin Data
3.6 MW Critical Load; N+1 Operation

0.5” ESP
95 Deg. Return; 75 Deg. Supply

pPUE = 1.112

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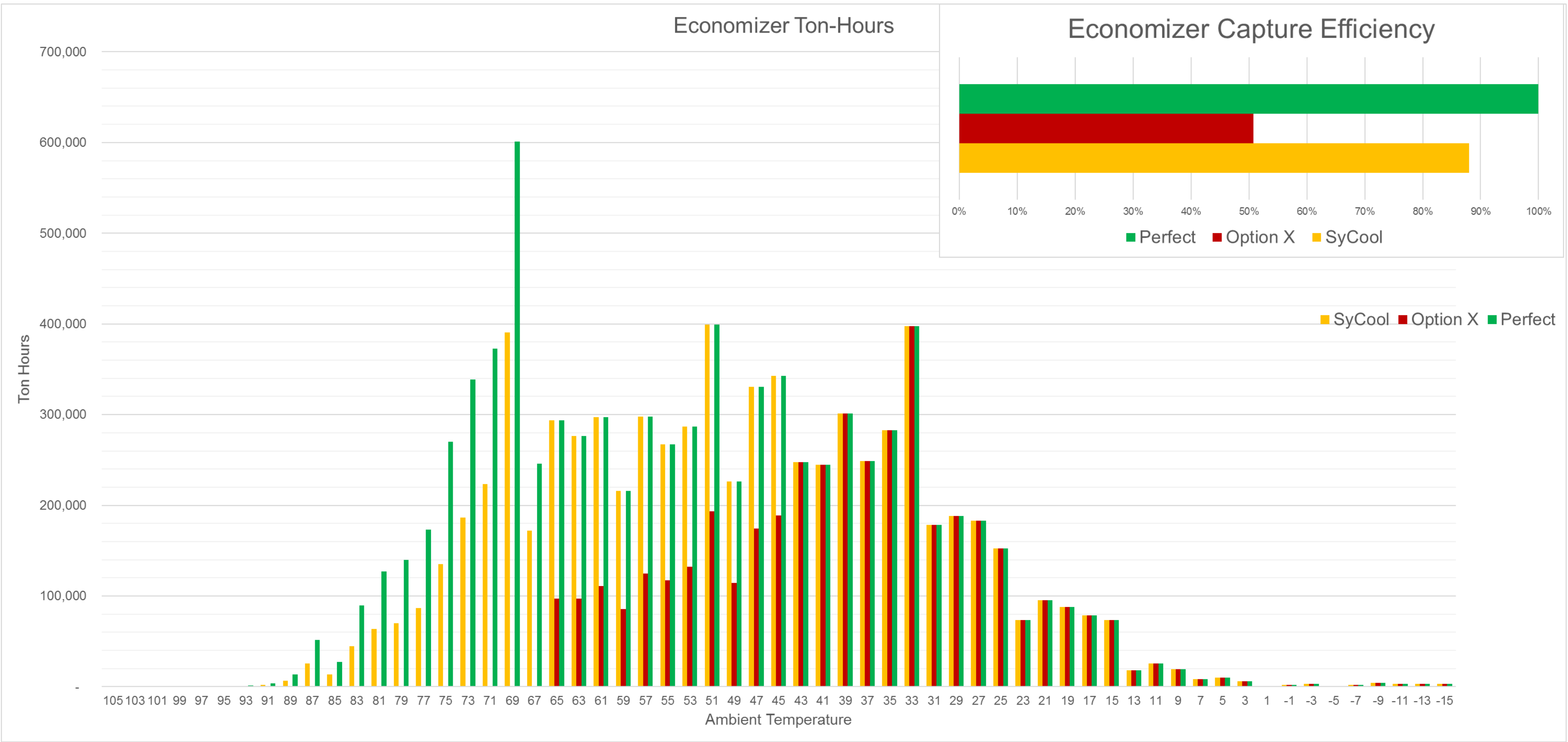
Economizer Capture Efficiency



Manassas Va, Bin Data
3.6 MW Critical Load; N+1 Operation

0.5" ESP
95 Deg. Return; 75 Deg. Supply

pPUE = 1.112

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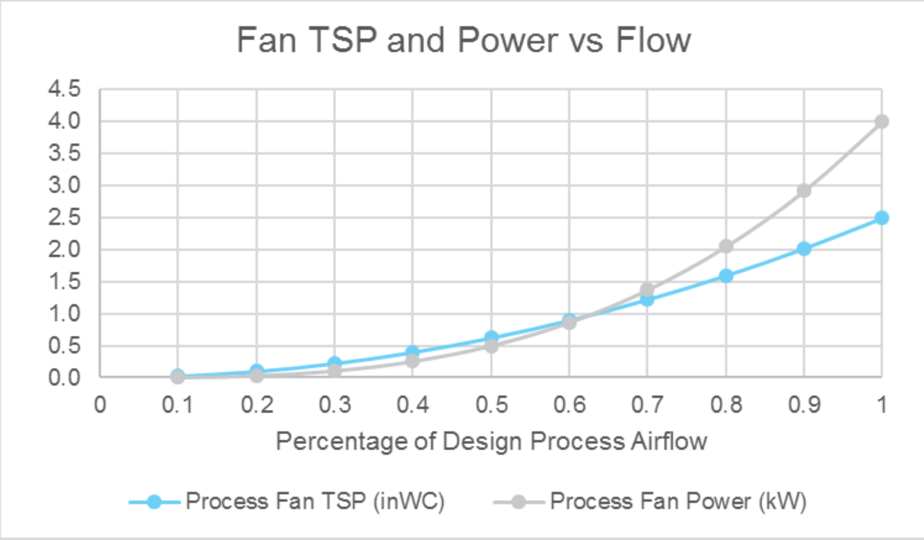
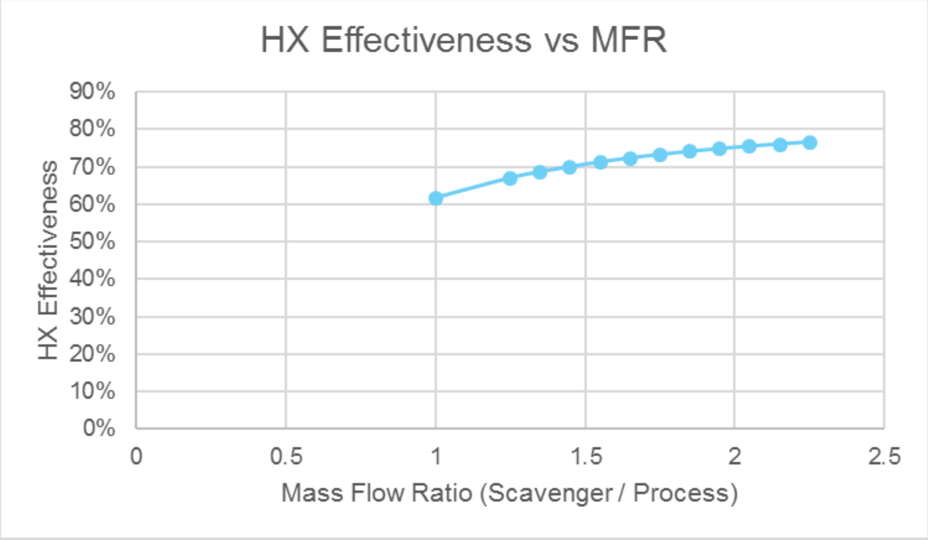
Modeling Reduced IT Load and The Impact to Energy

- Modeling Energy with 70% IT Load
  - Process Air Volume = 70% of Critical (Less with Redundancy)
  - Process Air Fan Energy Drops to 1.4/4 or 35% of Design
  - Scavenger to Process Flow Ratio Can Exceed 2:1 SIGNIFICANTLY Boosting Heat Transfer Effectiveness





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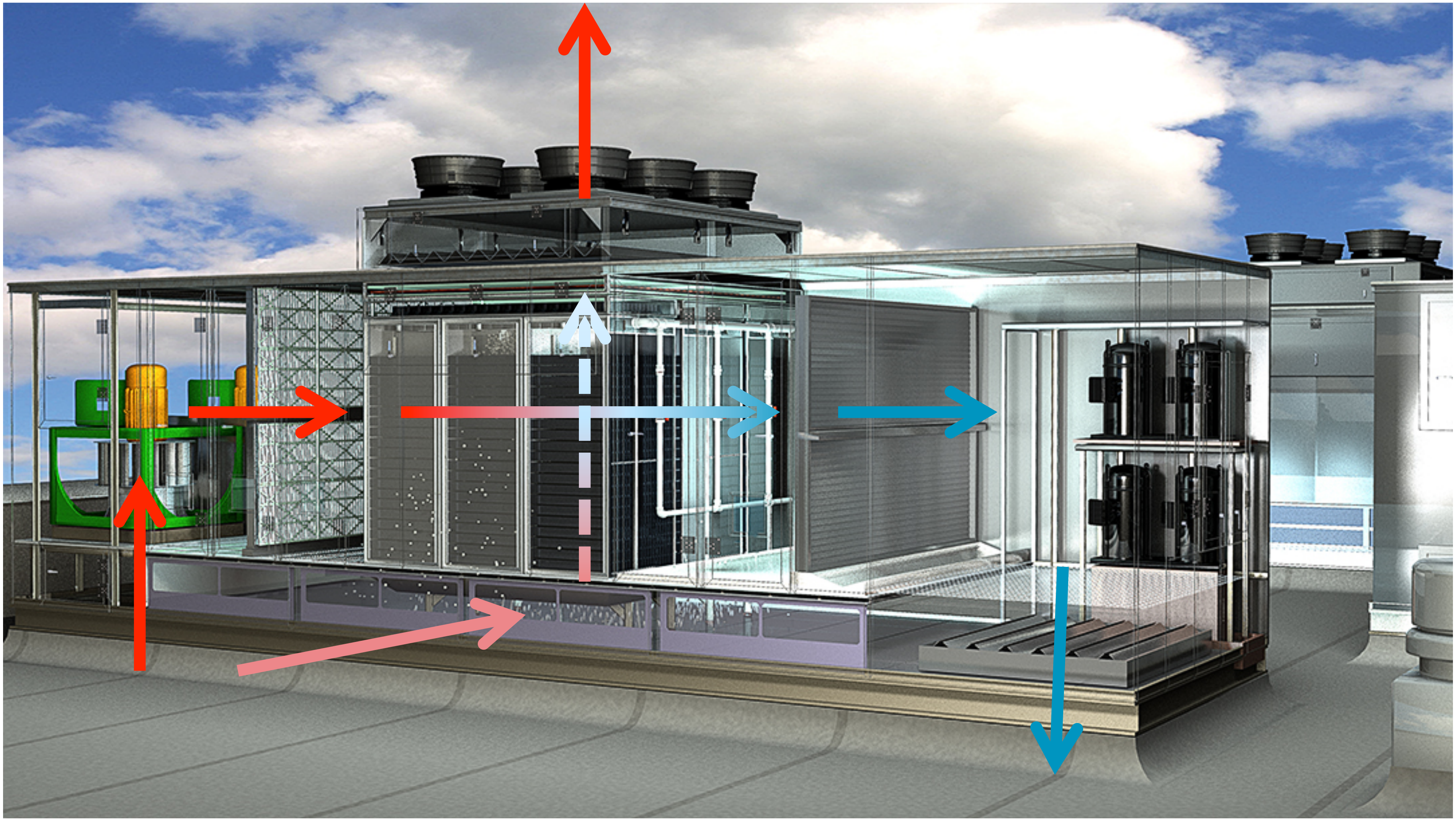
Keys to Maximizing Dry IASE Efficiency

- Maximize Heat Recovery Effectiveness
  - SyCool 60-70% Industry Best
  - SyCool ACFDX = Return Temperature for Maximum Economizer Hours
- Minimize Fan Energy
  - Heat Exchanger Based Systems Have 0.75”-1.2” W.C. Loss for Heat Exchanger (Process and Scavenger Air Side)
  - SyCool Process air Delta P < 0.6” for Heat Exchanger and DX
- Minimize Compressor Energy
  - Higher HR EFF Best Way to Minimize Compressor Energy
  - Balance SST and DX Air Side Pressure Drop. In General, Higher SST best
  - Up to 60% Higher Capacity vs. “Nameplate” (Oasis Best with High SST and Low Condensing Temperature)

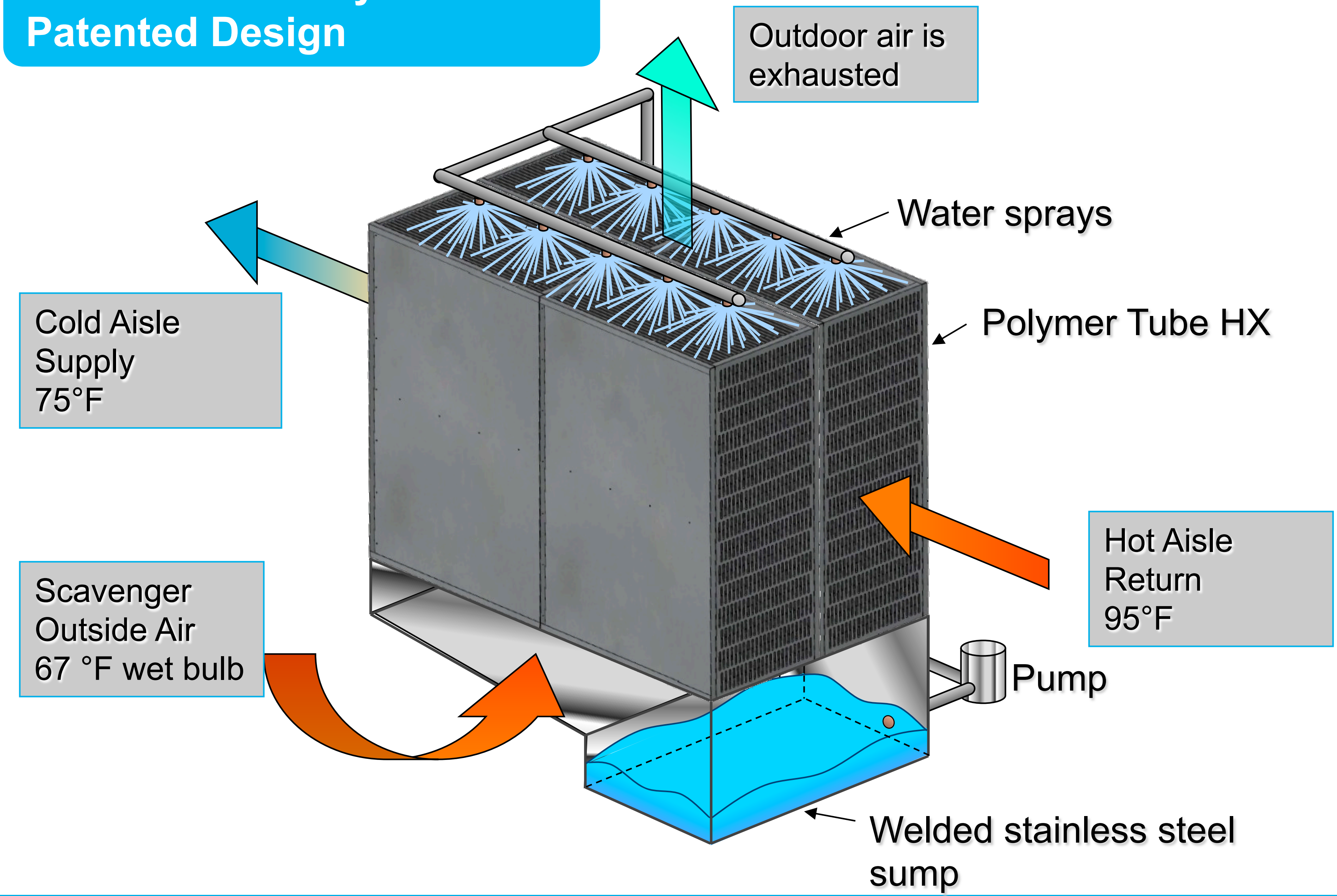
SyCool Checks Important Cooling Parameters

Data Center Cooling Vendor Options			
	SyCool	Option A	Option B
Waterless	✓		
High Heat Exchanger Effectiveness	✓		
Economizer All Hours Ambient Temp < Data Center	✓		
Low Maintenance Reliable Heat Exchanger with No Leakage	✓		
Low Process Pressure Drop	✓		
Good Unloading Capability (8 Stages per 450 KW)	✓		
Scalable Sizes 100-500 KW	✓		
Integrated and Split Configurations	✓		
Ease to Install Split Configuration	✓		
Compact Size (450 KW Machine = 25' x 13' x 13')	✓		
Standard and Validated	✓		
Full Project Management and Service	✓		
Global Foot Print	✓		
Competitive Cost	✓		

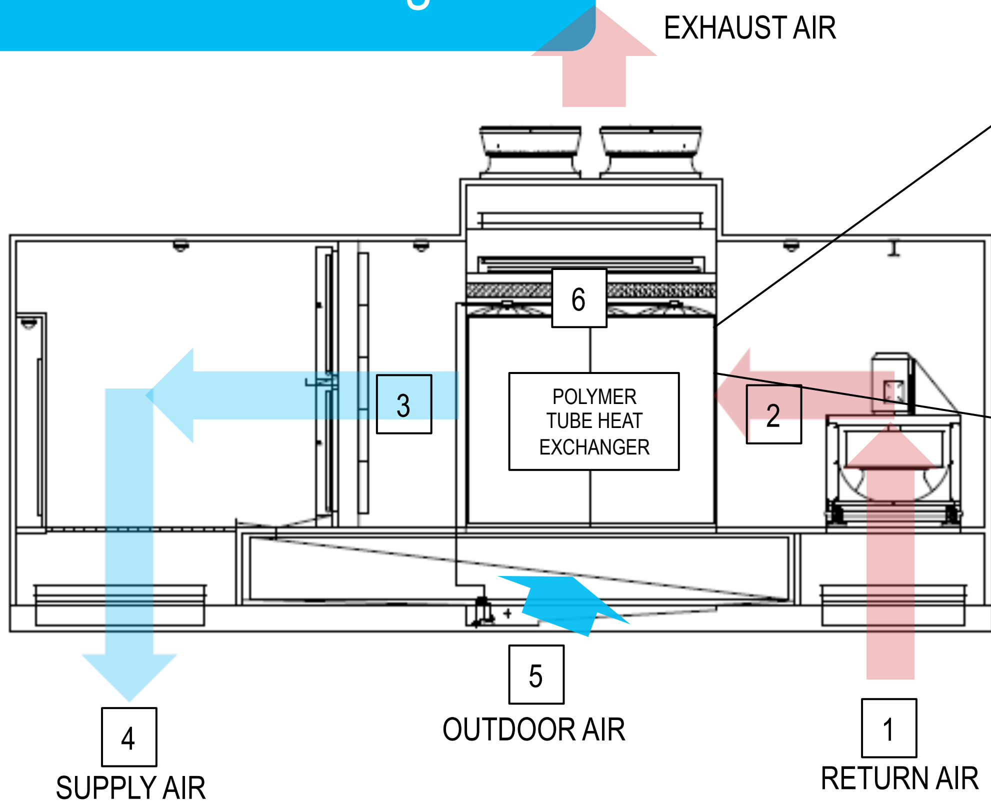
Rooftop IASE unit with Polymer Tube Heat Exchanger

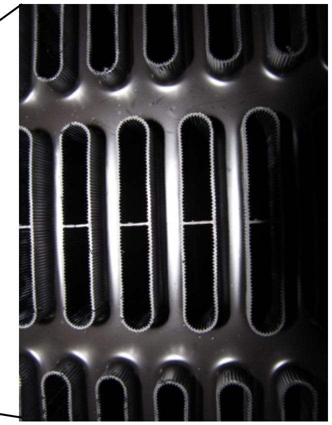


Munters EPX Polymer HX Patented Design



Oasis Wet Heat Exchanger





Hot Air From the Data Center Enters the polymer tubes that are sealed to the tube sheets with an elastomer to prevent leakage. As scavenger air and water flows over the outside of the tubes, the hot air is indirectly cooled against ambient wet bulb temperature.

State	Summer - Design			Summer - Mild			Full Economizer (Ambient WB)			Winter - Design		
Point	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM	DB (°F)	WB (°F)	ACFM
1 (R/A)	97	69.3	62,469	97	69.3	62,469	97	69.3	62,469	97	69.3	62,469
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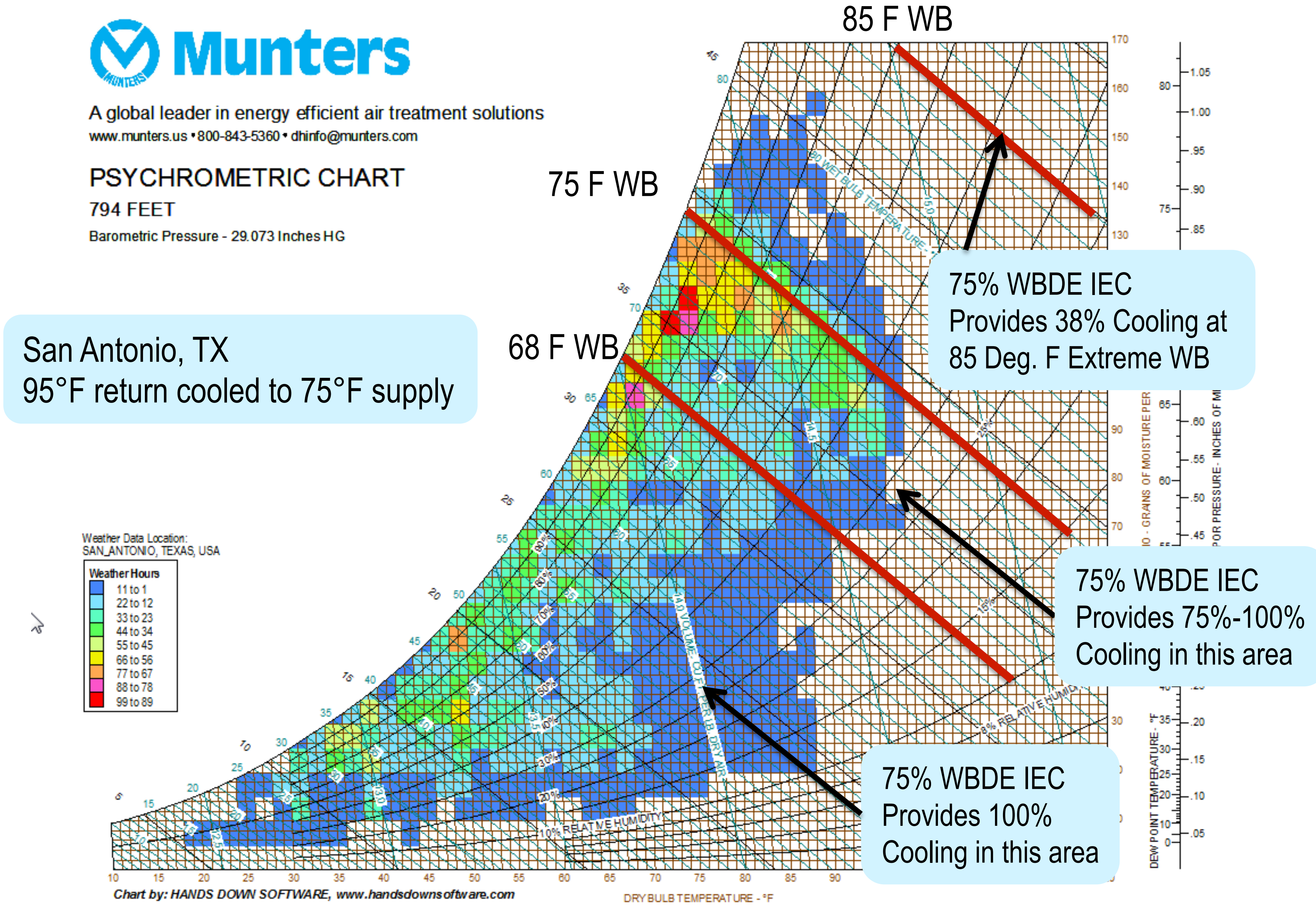
3	87.9	66.5	61,450	79.2	63.7	60,468	75	62.3	60,000	75	62.3	60,000
4 (S/A)	75	62.3	60,000	75	62.3	60,000	75	62.3	60,000	75	62.3	60,000
5 (O/A)	105	83	54,780	85	70	54,382	78	63.5	54,127	20	17	19,297
6	86.4	83.8	53,563	76.8	75.9	53,563	72.4	71.5	53,563	87.2	53.4	22,000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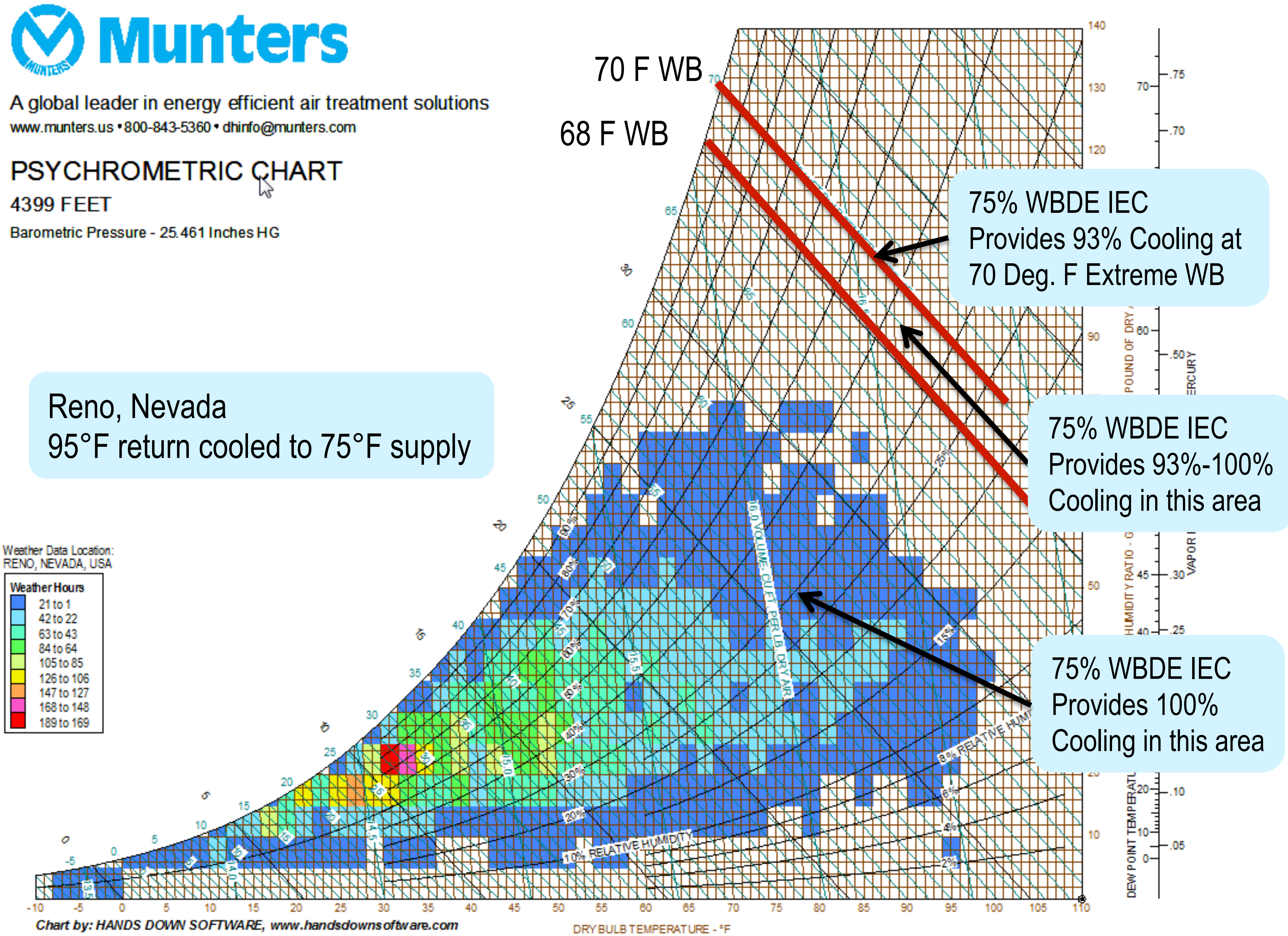
PSYCHROMETRIC CHART
794 FEET
Barometric Pressure - 29.073 Inches HG
San Antonio, TX
95°F return cooled to 75°F supply
85 F WB
75 F WB
68 F WB
75% WBDE IEC
Provides 38% Cooling at
85 Deg. F Extreme WB
75% WBDE IEC
Provides 75%-100%
Cooling in this area
75% WBDE IEC
Provides 100%
Cooling in this area
Weather Data Location:
SAN_ANTONIO, TEXAS, USA
Weather Hours
11 to 1
22 to 12
33 to 23
44 to 34
55 to 45
66 to 56
77 to 67
88 to 78
99 to 89
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com
DRY BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
WET BULB TEMPERATURE
DEW POINT TEMPERATURE - °F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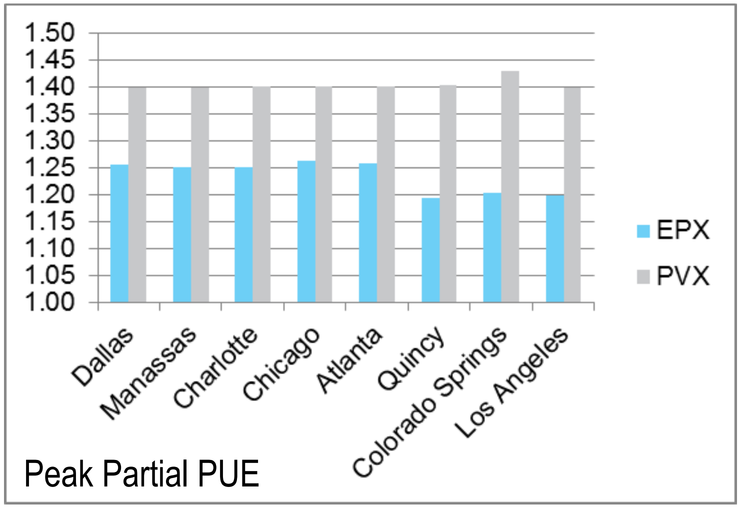
PSYCHROMETRIC CHART
4399 FEET
Barometric Pressure - 25.461 Inches HG
70 F WB
68 F WB
75% WBDE IEC Provides 93% Cooling at 70 Deg. F Extreme WB
75% WBDE IEC Provides 93%-100% Cooling in this area
75% WBDE IEC Provides 100% Cooling in this area
Reno, Nevada
95°F return cooled to 75°F supply
Weather Data Location: RENO, NEVADA, USA
Weather Hours
21 to 1
42 to 22
63 to 43
84 to 64
105 to 85
126 to 106
147 to 127
168 to 148
189 to 169
16.0 VOLUME CU.FT. PER LB. DRY AIR
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

Comparison of Indirect Air Side Economizers (At Peak Conditions)

		Peak Conditions		Peak Mechanical Cooling Load (Tons)		Peak Operating kW		Peak Partial PUE		Peak Water Consumption (gal/hr)	
		Extreme	Extreme	EPX	PVX	EPX	PVX	EPX	PVX	EPX	PVX
City	State	Max DB (20Y)	Max WB	(Wet)	(Dry)	(Wet)	(Dry)	(Wet)	(Dry)	(Wet)	(Dry)
Dallas	TX	110.4	82.9	44.3	123.1	103	160	1.257	1.400	308.9	0
Manassas	VA	101.7	82.2	43.1	123.0	101	160	1.253	1.400	247.8	0
Charlotte	NC	103.2	81.9	41.7	123.2	101	161	1.253	1.402	263.9	0
Chicago	IL	102.6	83.3	47.0	123.1	105	160	1.263	1.401	242.1	0
Atlanta	GA	102.9	82.4	43.7	123.3	104	161	1.259	1.403	255.9	0
Quincy	WA	108.3	74.1	11.5	123.4	78	162	1.195	1.404	396.3	0
Colorado Springs	CO	98.9	71.1	3.2	125.2	82	171	1.205	1.430	353.9	0
Los Angeles	CA	103.1	75.2	16.7	123.0	80	160	1.199	1.400	340.8	0

IT Load = 400 kW
Return Air Temperature = 102°F
Supply Air Temperature = 80°F
External Static Pressure = 0.5" WG
N+0 Unit operation
Annual operating data is based on TMY3 weather data in 2°F bins
EPX water consumption is based on 5 cycles of concentration



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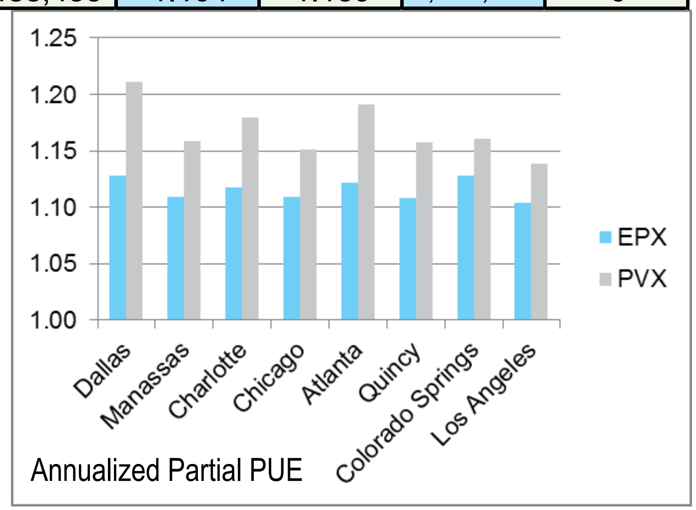
Comparison of Indirect Air Side Economizers (Annualized)

		Peak Conditions		Total Annual Mechanical Cooling (Ton-Hours)		Total Annual Energy Usage (kWH)		Annualized Partial PUE		Total Annual Water Consumption (Gal)	
City	State	Extreme Max DB (20Y)	Extreme Max WB	EPX (Wet)	PVX (Dry)	EPX (Wet)	PVX (Dry)	EPX (Wet)	PVX (Dry)	EPX (Wet)	PVX (Dry)
Dallas	TX	110.4	82.9	21,867	321,022	447,583	738,276	1.128	1.211	1,425,110	0
Manassas	VA	101.7	82.2	3,037	161,839	382,271	555,889	1.109	1.159	1,039,790	0
Charlotte	NC	103.2	81.9	11,233	219,299	412,681	632,326	1.118	1.180	1,207,353	0
Chicago	IL	102.6	83.3	3,992	139,811	381,081	527,704	1.109	1.151	902,747	0
Atlanta	GA	102.9	82.4	15,051	247,251	428,532	668,010	1.122	1.191	1,319,934	0
Quincy	WA	108.3	74.1	4	153,199	377,473	550,754	1.108	1.157	1,002,611	0
Colorado Springs	CO	98.9	71.1	0	111,296	447,333	565,541	1.128	1.161	994,383	0
Los Angeles	CA	103.1	75.2	43	106,616	364,048	488,453	1.104	1.139	1,366,388	0

IT Load = 400 kW
Return Air Temperature = 102°F
Supply Air Temperature = 80°F
External Static Pressure = 0.5" WG
N+0 Unit operation
Annual operating data is based on TMY3 weather data in 2°F bins
EPX water consumption is based on 5 cycles of concentration



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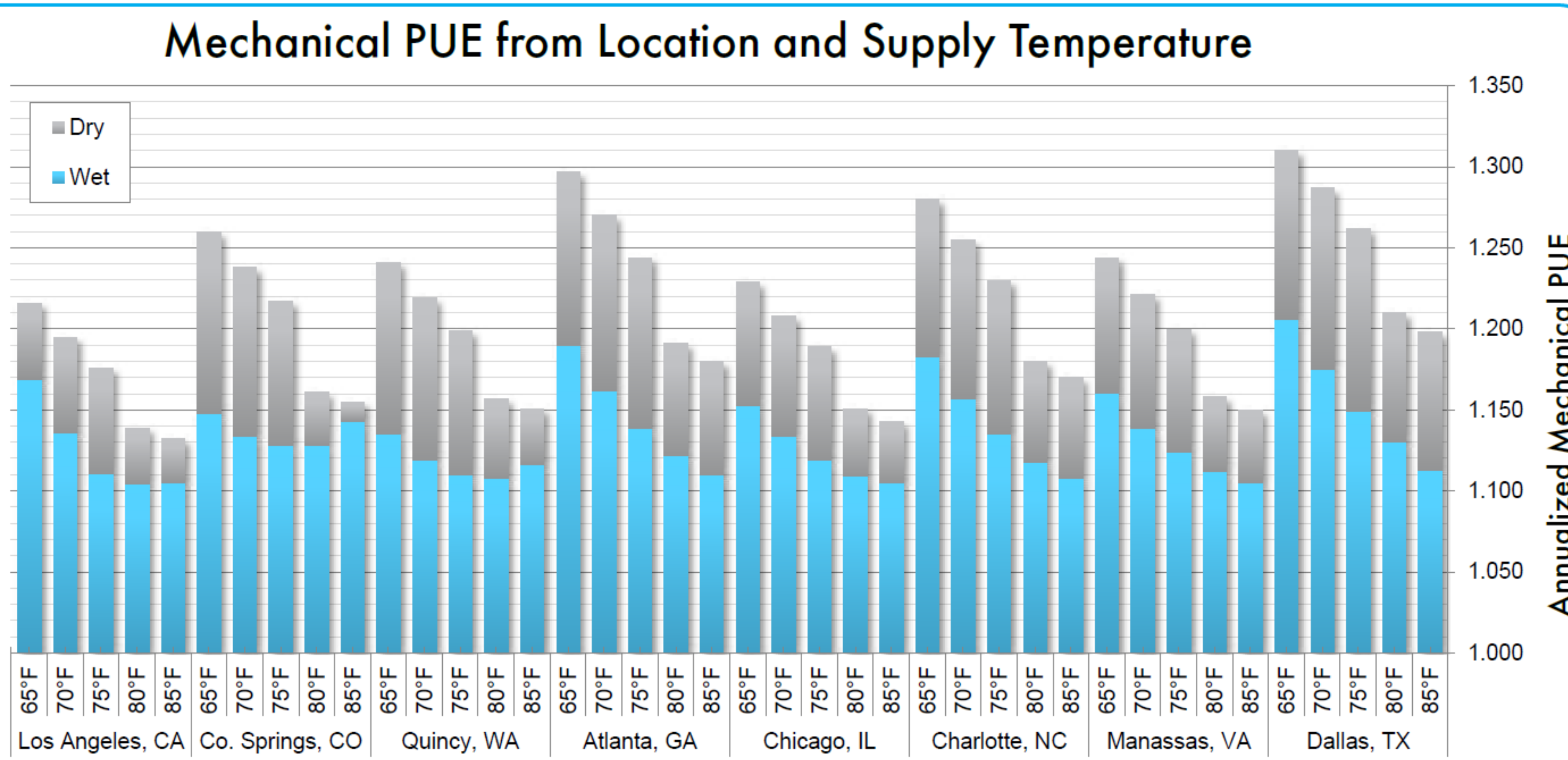
PUE Comparison of Indirect Air Side Economizers (Various Supply Temperatures)



Assumptions: • 1. ITE Temperature Rise = 22 °F, • 2. External process, air duct Static Pressure = 0.5"W.C. • 3. N+0 Unit Operation (Critical Mode) • 4. TMY3 Weather Bin Data in 2 °F Bins

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