

# ***Emerson Network Power Thermal Management – Cooling Overview***

---

Liebert Solutions for the Large Data Center

September 2013



# Agenda

---

- Thermal management customer requirements
- Liebert solutions for large data centers
  - New and expanded solutions
  - Controls and Monitoring
  - Services
- Data Center design considerations using these solutions
  - Energy and TCO tools
  - Optimizing for Capital and Efficiency
  - Controlling to deliver on the design
  - Other considerations
- Questions

# *How to get your CEU credits*

---

- You can be confident your CEUs will be recognized
  - Emerson Network Power CEUs are certified by IACET, the leading standards body in continuing education training
- We focus on delivering training outcomes, giving you substantive knowledge that helps your career and can be measured
- Post-event testing and survey now required for CEUs, by IACET
  - Testing measures your knowledge about the learning objectives discussed in the presentation
  - Those who indicated they want CEUs during webcast registration will receive an email within 5 business days of the presentation, with a link to the online 10-question test and a short presentation survey
  - You have 2 weeks after the email to take the test and do the survey
  - 60% pass rate on test – you will be apprised via email of test results and can retake the test once
  - After passing the test, you will receive your CEU certificate for download
- CEUs
  - 1 CEU = 10 content hours
  - This class is 1 hour, so you will receive 0.1 CEUs

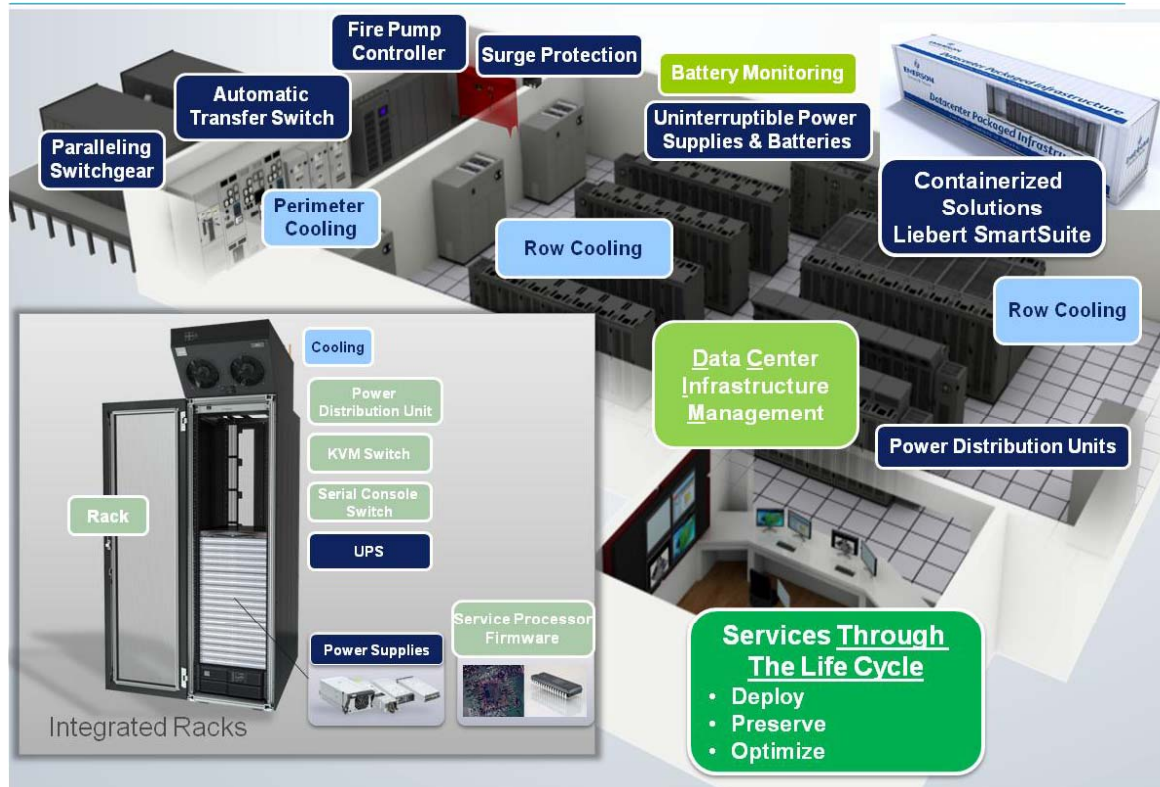
## ***What you'll learn today***

---

- Upon successful completion of this training presentation, you will know:
  1. Customer requirements for new data centers
  2. Liebert offerings for large data centers solutions
  3. Design considerations for deploying cooling technologies for optimizing efficiency and capital

# Emerson Network Power Thermal Management

*Emerson Network Power makes possible the **efficient, reliable and cost effective** management of heat in your mission critical facility through unparalleled **expertise** and the industry's most advanced **service, software and equipment** technology.*



*Achieve industry leading Efficiency levels (PUE < 1.1), Availability approaching 100% and up to 50% lower capital and operating costs.*



# ***Thermal Management Technology to Solve Customer Needs***

**Efficiency /  
Economization**

*Max Return Air Temps, Variable Capacity, Aisle Control, Max Economization Hours, Lowest Max KW*

**Efficient  
Capital/Modular/Speed**

*Solutions that will allow effective growth and use of Capital in Optimized Building Blocks*

**Solutions**

*Engineered / Optimized, Ease of Connectivity, Custom – Standard Configurations*

**Control/Intelligence**

*From the Unit, Aisle to the Whole Data Center – Visibility and Control*

**Availability**

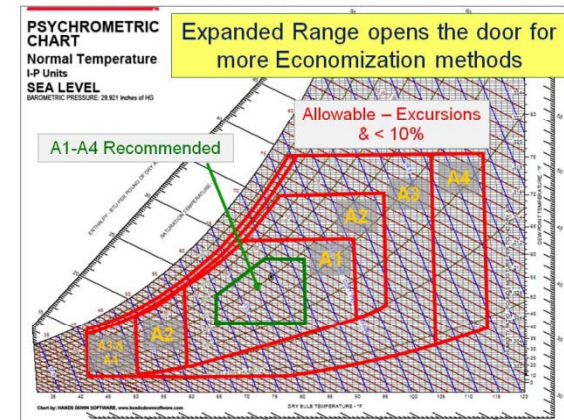
*Systems & Controls to Measure, Monitoring & Service to maintain the highest Availability*



# Focus on Economization Methods

- ASHRAE Thermal Guidelines – 2011
- Liebert Offering
  - Chillers
    - Water (cooling towers)
    - Air Cooled Chillers (available in Liebert HPC-S)
  - Pumped Refrigerant – Liebert DSE
  - Outside Air
    - Integral outside air dampers for DX and CW equipment
    - As part of the Direct Evaporative AHU solution
  - Glycool DX – Liebert DS
  - Evaporative
    - Indirect and Direct Evaporative AHU
    - Condensers

ASHRAE Thermal Guidelines - 2011





# Large Data Center Solutions

Configurable

Custom

Perimeter

Liebert DSE



Liebert CW



Liebert CWC

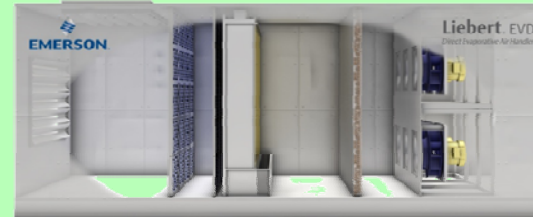


Exterior (Roof/Side)

Liebert EVI

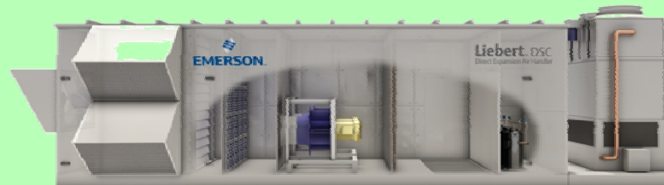


Liebert EVD



Evaporative – Indirect and Direct

Liebert DSC



Maximum Flexibility

# Liebert CRAH & Custom Air Handling Solutions

## Industry Leading Efficiency, Quality, and Service

### CRAH

- Expanding standard CRAH from CW181 (24,000 CFM, 300kW) to 35,000 CFM (400kW)
- Flexible coil sizing
- Lowest fan power strategy
  - EC Fan underfloor
- iCOM controls features



### Custom Air Handlers

- 30,000 to 80,000 CFM
- 250 – 600 kW
- Custom physical sizing / configurations
- iCOM control features



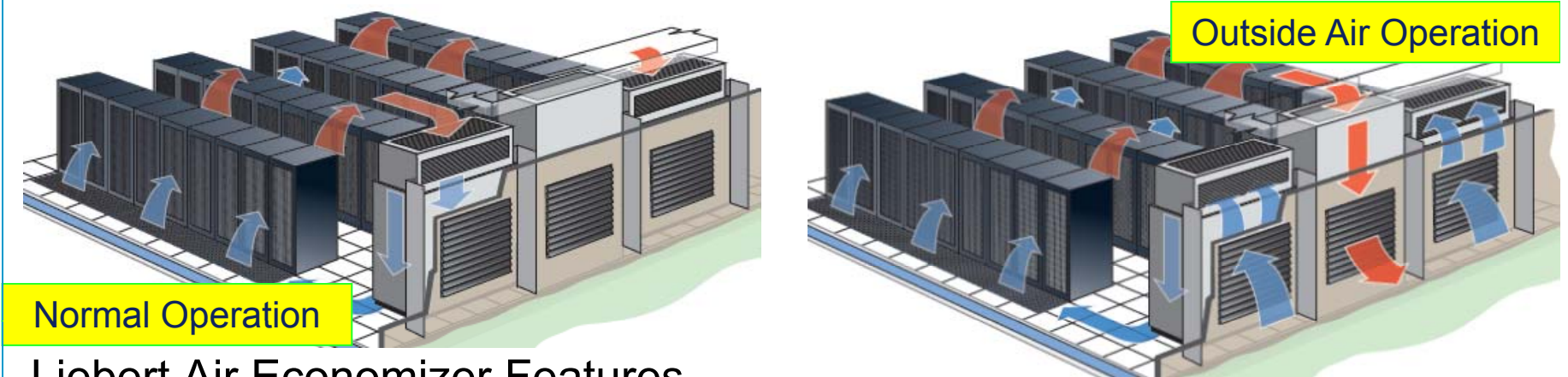
# Liebert Custom Air Handling Solutions

## Liebert CWC Chilled Water Air Handler

- Custom capacity and footprint configurations available from 200 – 600+ kW (25,000 - 80,000+ cfm)
  - Downflow, upflow or horizontal (fan array) airflow configurations
  - EC or direct drive w/ VFD fan options
  - Fans located under raised floor or in unit
  - Outside air economizer options
  - Multiple filtration options
  - Multiple casing materials available
  - Indoor or outdoor construction available



# Liebert Air Economizer System available on all Liebert DS and CW units

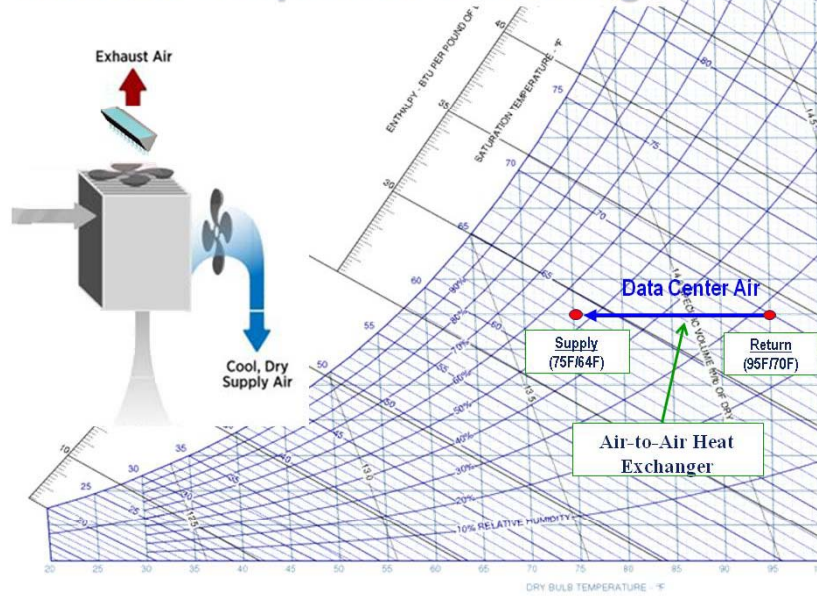


## Liebert Air Economizer Features

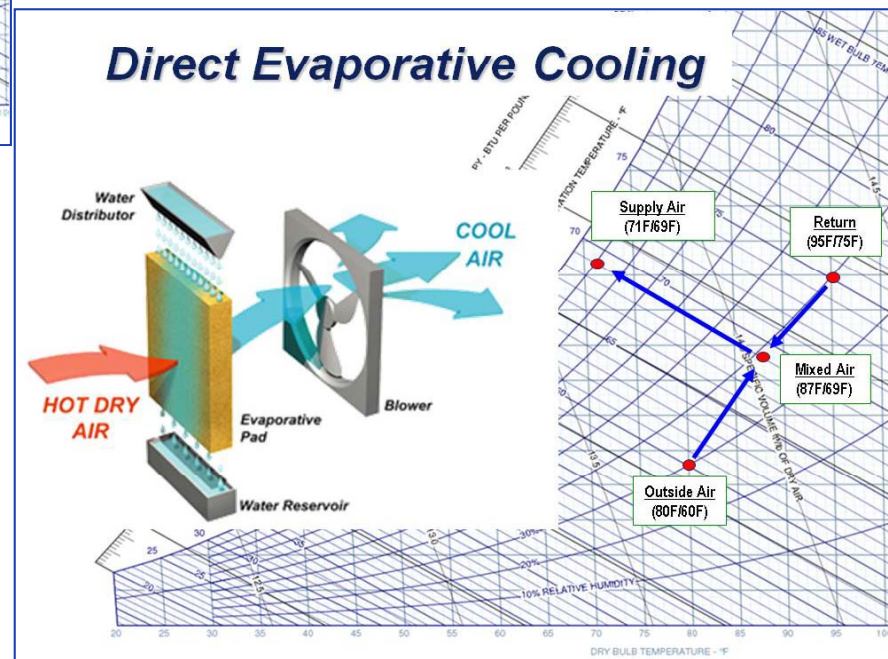
- Integrated economizer dampers with the cooling unit iCOM controller
  - 3 Stages of Cooling – 100% Outside Air, Mixed Outside Air & Cooling, 100% Cooling
  - Air Enthalpy operation with variable capacity cooling
- Sensors T/H – Outdoor Air, Return Air, Supply air
- Restricted airflow switch to detect clogged OA filters or other restrictions
- In economizer mode, unit humidification and dehumidification are inhibited
- Disable mode for emergency shut down
- Control menu to tune settings and monitor operations
- Custom operation and range capability

# Evaporative Cooling Applications

## Indirect Evaporative Cooling

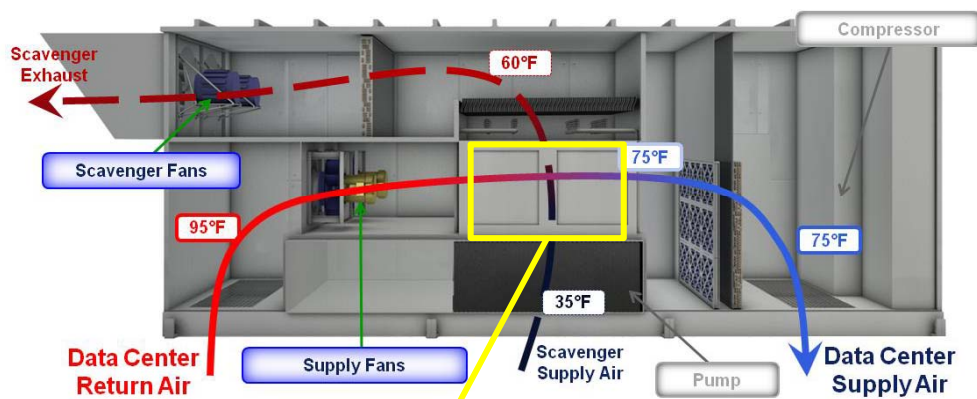


## Direct Evaporative Cooling

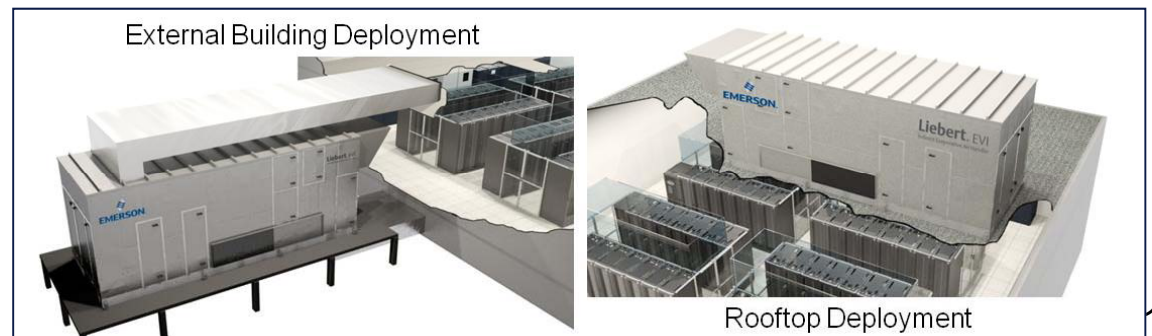
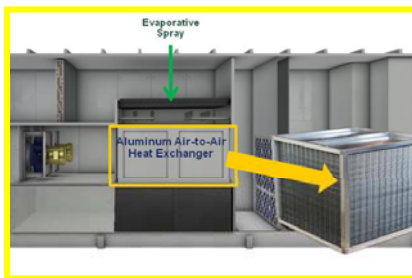


# Liebert EVI Indirect Evaporative Air Handler

- Capacities from 150 – 400+ kW with DX or CW trim
- PUE <1.20 with No Outside Air
- Performance based on climate and Operating Temperatures
- Potential for lower Max kW
- Higher Tier applications require on site water storage or larger DX/CW



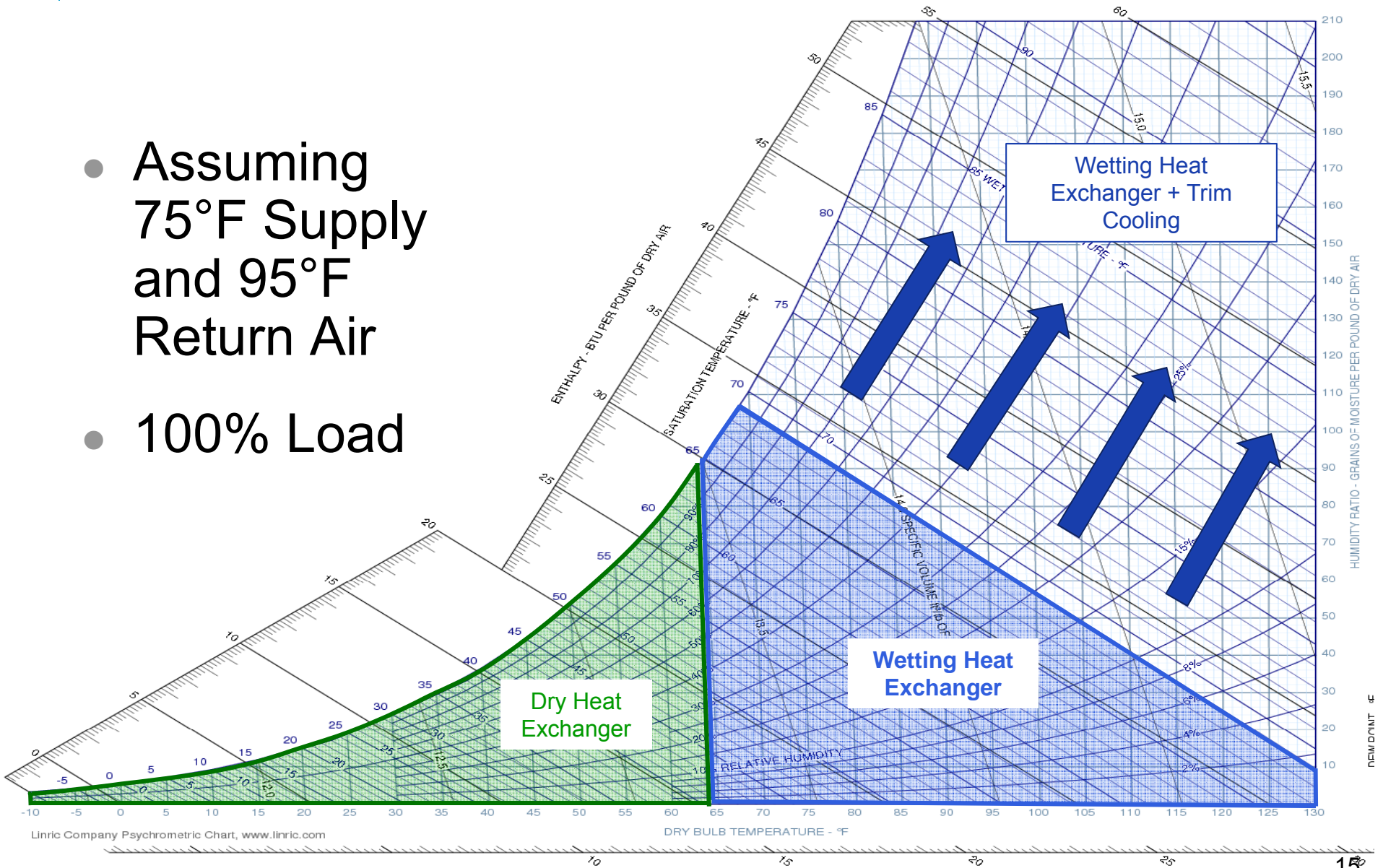
Season	Cooling Mode	Dry Bulb Temp (°F)	Wet Bulb Temp (°F)	Gallons Per Hour	Cooling PUE
Winter	Dry	35	-	-	1.10
Spring/Fall	Wet	68	57	143	1.14
Summer	Wet w/ DX	90	75	178	1.21



# Indirect Evaporative Cooling

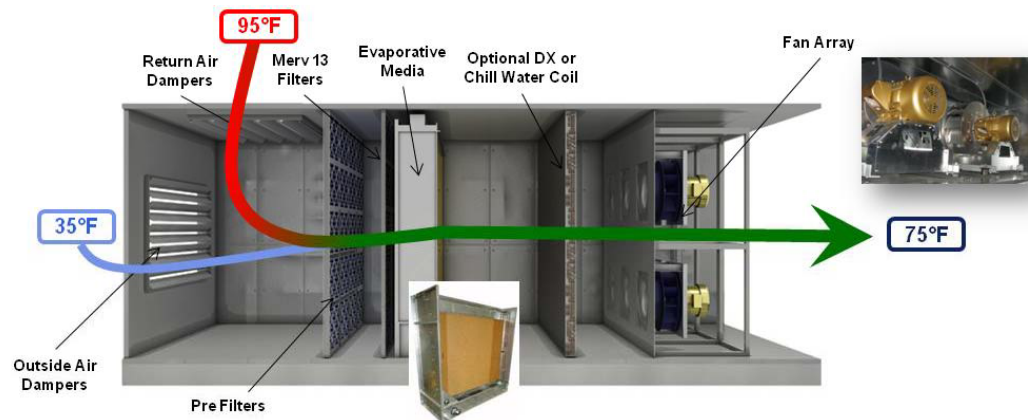
## Where it Works

- Assuming 75°F Supply and 95°F Return Air
- 100% Load



# Liebert EVD Direct Evaporative Air Handler

- Capacities from 150 – 600 kW with DX or CW trim
- PUE <1.10 requiring Outside Air (actual performance based on climate)
- Potential higher humidity and operating temperatures
- Lower Max kW
- Typically used in lower Tier applications



External Building Deployment



Data Center Gallery Deployment

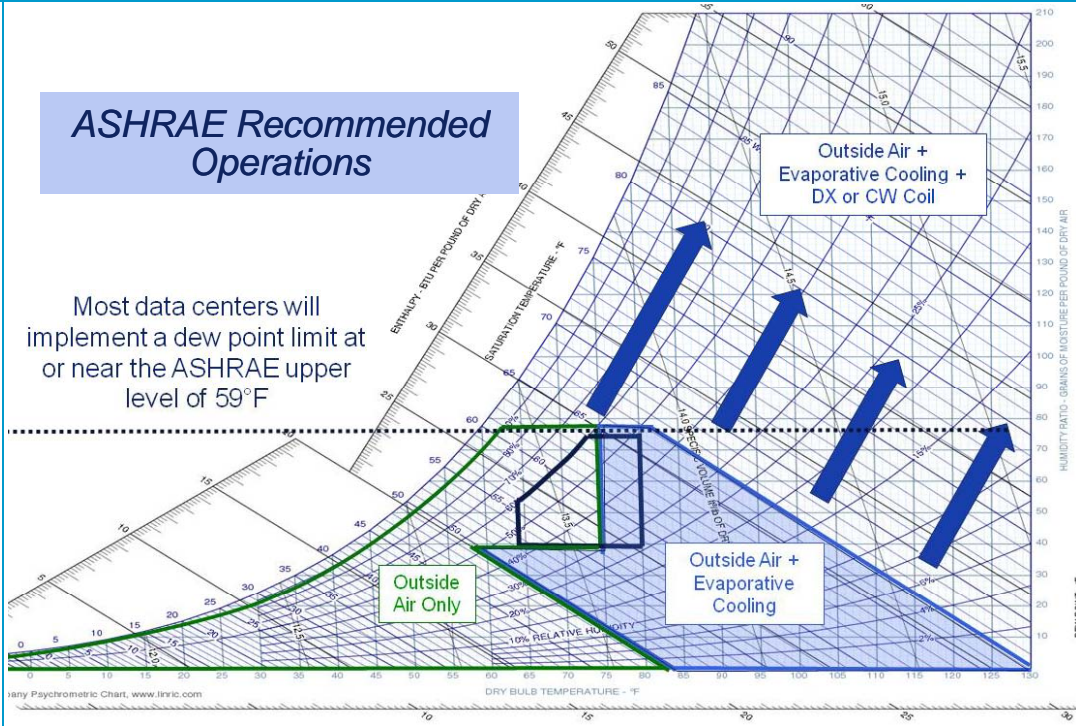


# Direct Evaporative Cooling

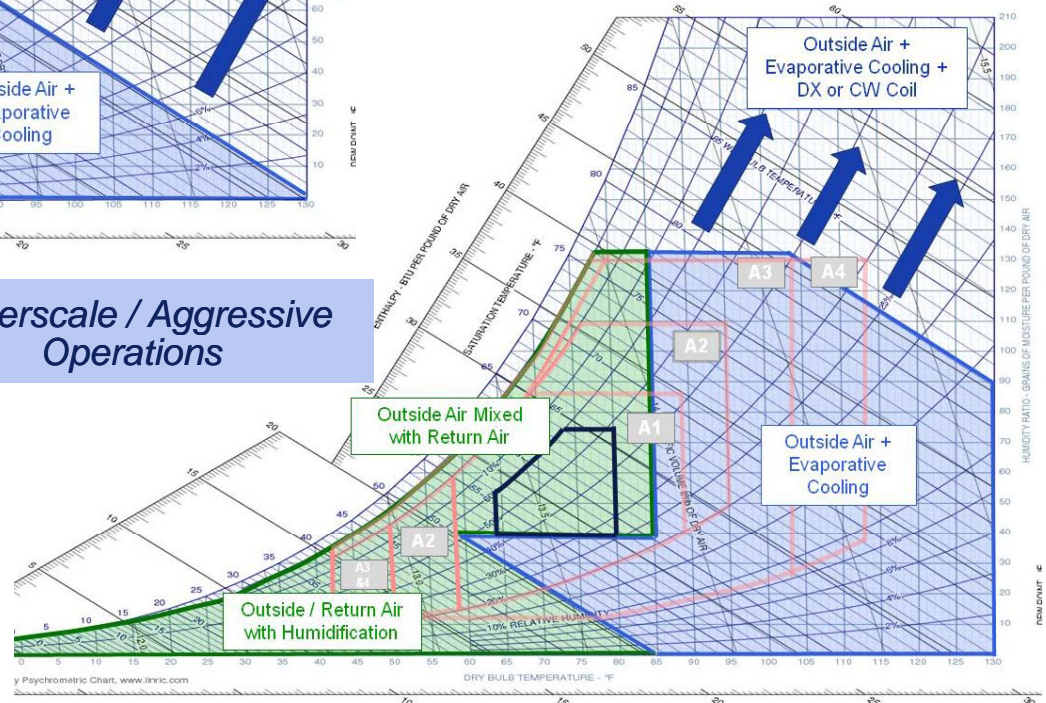
## Customers Range – Where it works

ASHRAE Recommended Operations

Most data centers will implement a dew point limit at or near the ASHRAE upper level of 59°F



Hyperscale / Aggressive Operations



# Liebert Evaporative Air Handlers

## Customization Options

- Areas of Customization include:

- Capacity and physical dimensions
- Airflow supply & discharge
- EC or direct drive w/ VFD fans arranged as single or fan arrays
- Supplemental or full cooling options using chilled water or DX
- Number and type of filters
- Unit casing materials

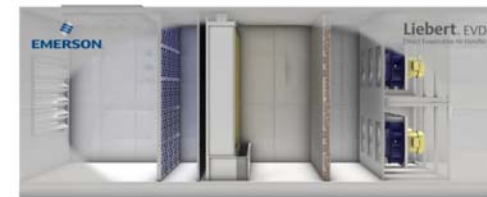
### Liebert EVI Indirect Evaporative Air Handler

- Wet/Dry efficiency, static pressure drop and size of heat exchanger
- Temperature to wet the heat exchanger



### Liebert EVD Direct Evaporative Air Handler

- Efficiency of media and the use of bypass dampers
- Exhaust air integration

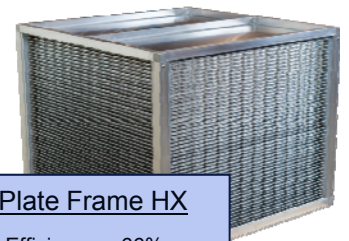


Robust 3D design tools allowing for *quick* custom designs, component performance comparisons and pricing options

# Emerson Network Power

## Liebert Custom Air Handling Solutions

- High quality construction
  - 2" foam-injected walls, doors & flooring (R-12 value)
    - Minimal deflection and leakage and energy loss
    - High durability and strength with reduced sound transmission
  - Removable panel design for easy service or component access
  - Options for high R-value, lower sound, corrosive environmental coatings and finish
- EVI (Indirect) Aluminum heat exchanger
  - Higher Efficiency – Dry +32% to 65%, Wet + 5%
  - Durable, will not break or crack (vs PVC / Polymer) and can be power washed
- Variable Capacity
  - EC and Direct Drive Fans with VFD
  - Variable Speed and Digital Compressors
- Multi Stage Direct Evaporative Media



Alum Plate Frame HX  
Dry Efficiency ~ 66%  
Wet Efficiency ~ 78%



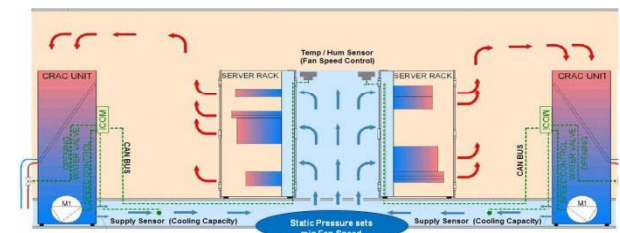
# Liebert iCOM Controls

## Datacenter Controls



- Global platform with proven and robust routines
- Choice of Control Strategies
  - Return Air, Static Pressure Control, or Supply Air
  - Optimized Aisle™
    - For Cold Aisle, Hot Aisle Containment or Overhead Distribution
  - Auto Tuning PID – adjusting gain settings
- Multi-unit teamwork
  - Fan speed coordination to minimize energy usage
  - Lead lag and cascade
  - Predetermined Sequence of Operation
- Trellis Ready Advanced Applications
  - Remote service management
  - Wireless sensors fully integrated with controls
  - Integrated flow/capacity, kW and pressure sensors
- Simple BMS Integration – Custom mapping protocols

- **10-30% Better Efficiency**
- **Availability approaching 100%**
- **10-20% Lower Deployment Costs**
- **Powerful Insight for Ongoing Improvement**

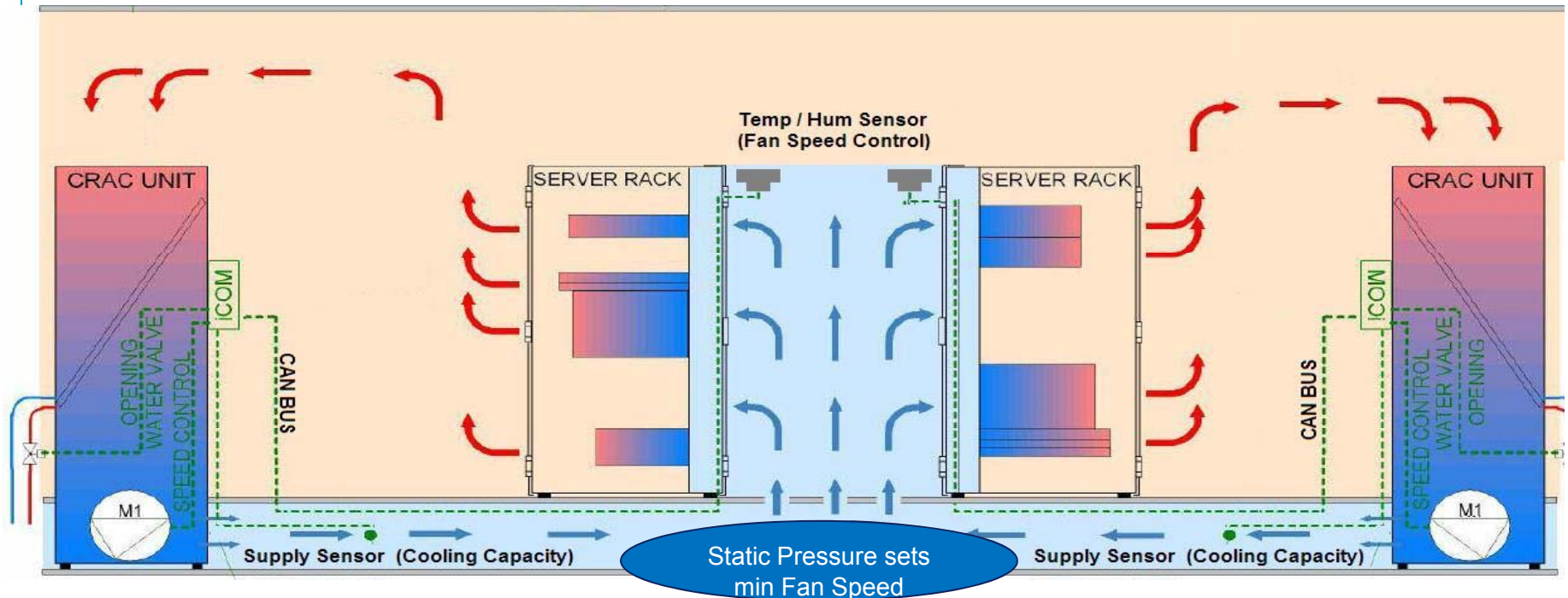


# Liebert iCOM™ Optimized Aisle™

- Optimized Aisle mode manages air flow and cooling capacity independently in cold aisle config
- Optimized Aisle is a server centric solution - focused on the inlet temperature to the servers
- Adjusts to server utilization, equipment add/changes and other outside variables
- Adapts from no to end/full containment
- Available Static Pressure to set a minimum airflow

## Delivers

- Reliable IT operation
- Cooling Efficiency
- Lowest Fan Power
- Highest return air temperature for the best Cooling unit performance
- Thermal Mapping



# Liebert iCOM™ Optimized Aisle™ Hot Aisle Containment and Overhead Distribution

Same proven algorithm applied to non-cold aisle deployments

- Airflow controlled through the differential pressure between:

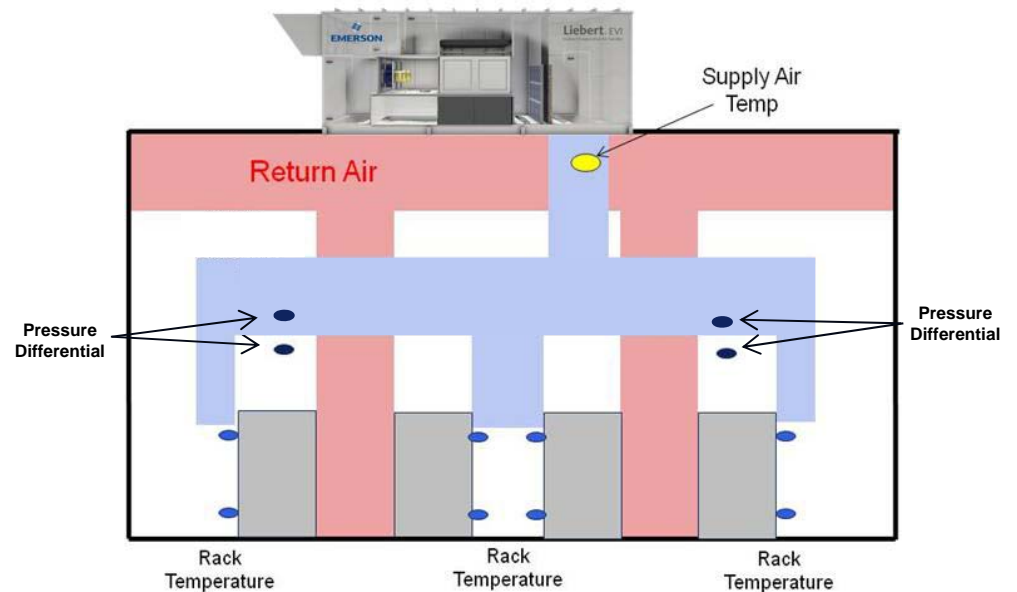
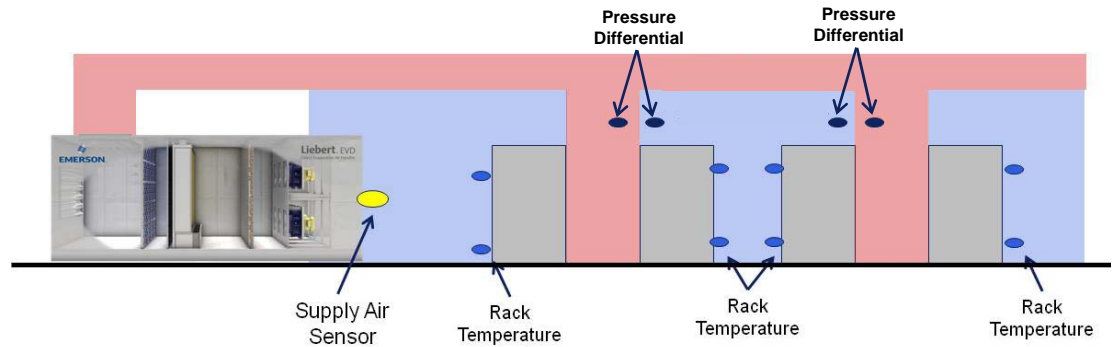
## Hot Aisle Containment

Hot aisle and Cold aisle

## Overhead Distribution

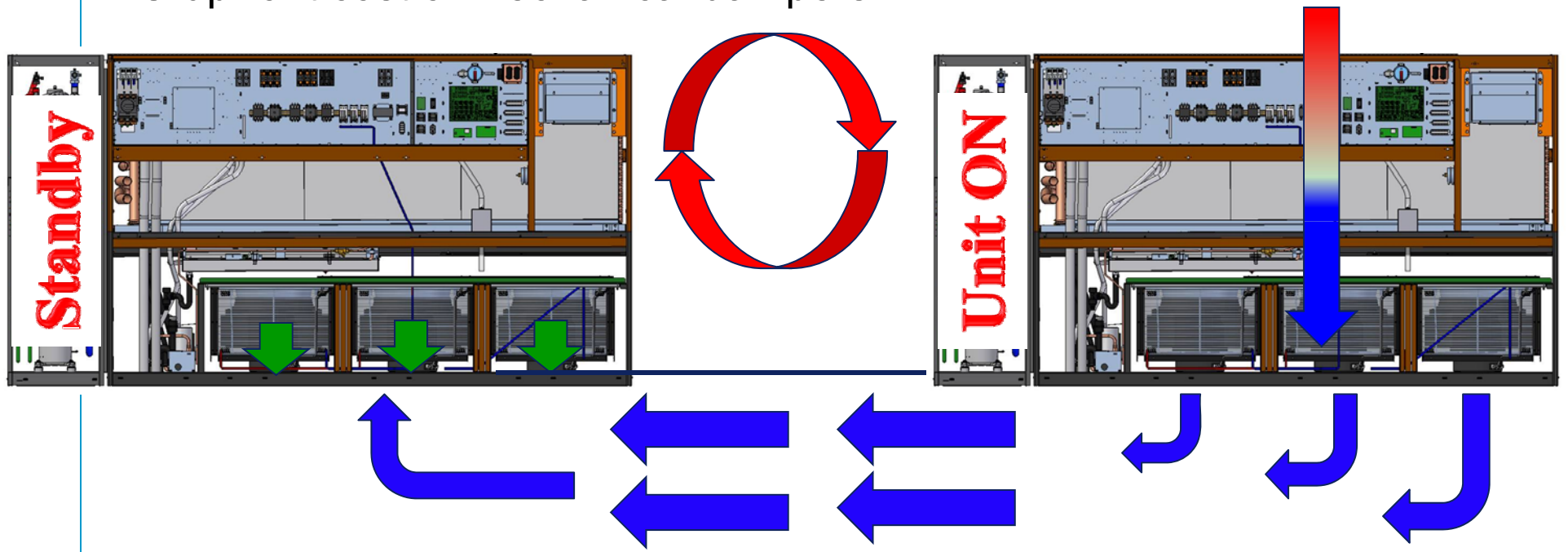
Supply duct to Room

- Supply air temperature maintains cooling capacity independently
- Monitor cold aisle temperatures for fan speed override
- Fan speed operates in parallel with other units



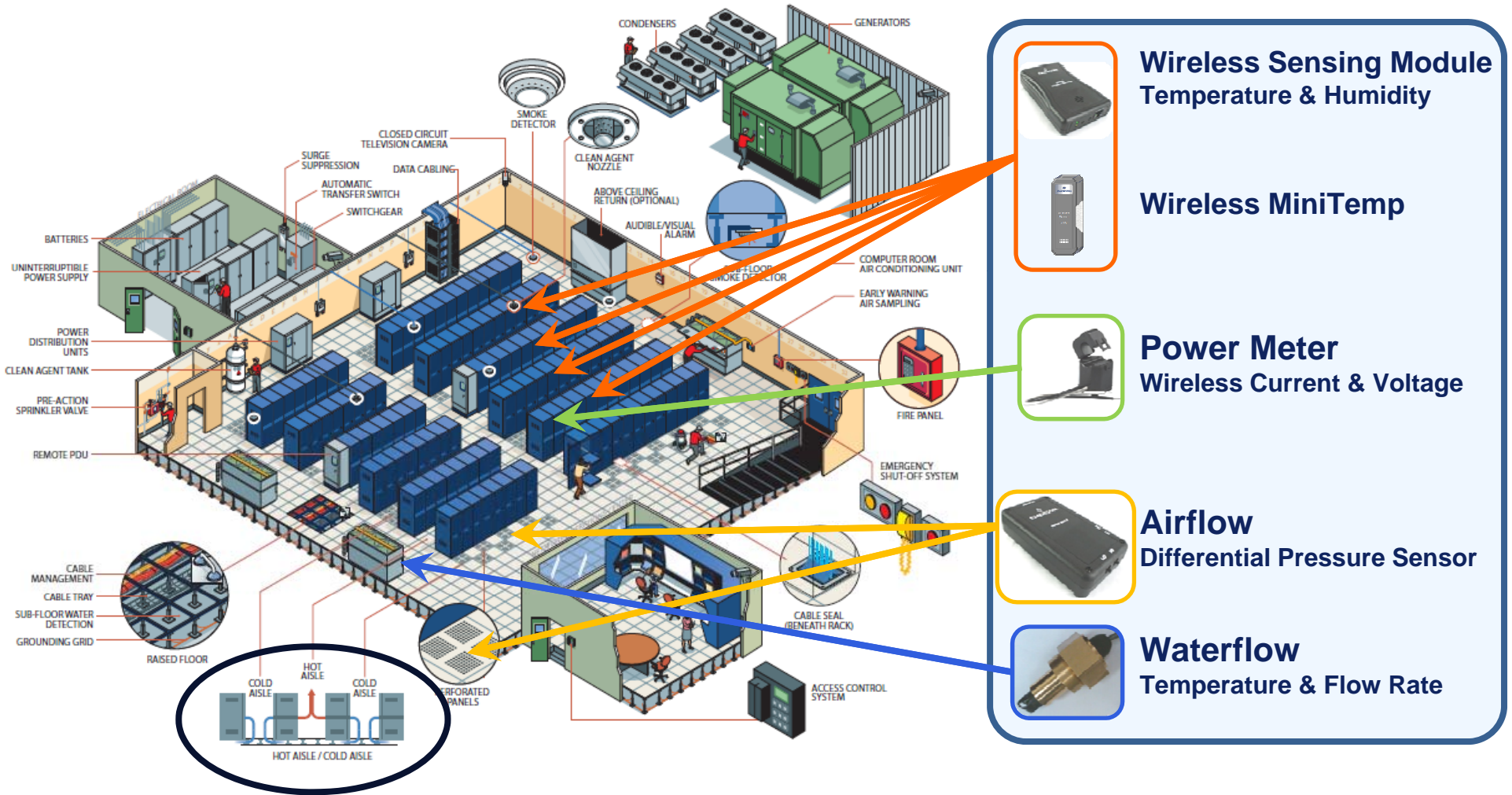
# Energy Efficiency – Virtual Damper

- Fans rotate at low speed to prevent air flow through unit
  - Adjustable based on application
- NO pressure drop during unit operation
- NO upfront cost of mechanical dampers



# Data Center Platform Landscape

## Launching Multiple Sensors in F'13

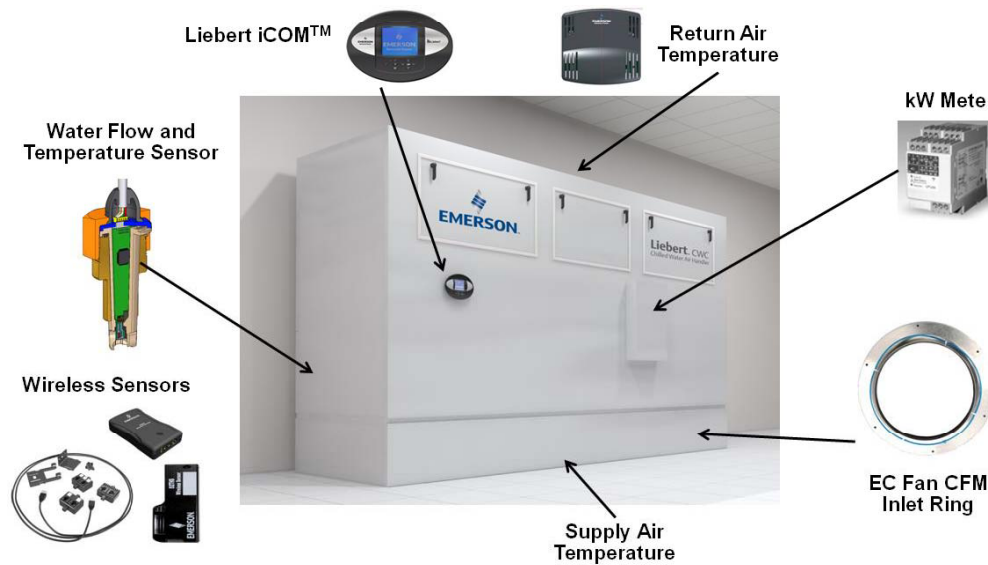


Building Intelligence around Performance, Capacity, and Diagnostics to make the right planning decisions and support SLAs



# DCIM - Trellis Installed Intelligent Sensors

- Trellis intelligent sensors provide insight to optimize efficiency and capacity with iCOM controls



## Instrumentation options provide

- Electrical power consumption
- Airflow
- Gross cooling capacity (ex CW)
- Delivered Net Sensible capacity
- Remaining Capacity
- Predictive Diagnostics

# Custom Controls Compared to Liebert iCOM Solution

Custom Controls

## Unit Control

### Basic Unit Operation

- Fan operation
- DX operation / Chilled Water valve control / Media wetting
- Damper Position
- Supply or return air control
- Generic sequence of operation
- Basic sensor deployment



## Site Level Control

### Required BMS Integration

- Data center sensors
- Unit control points
- Multi-unit coordination - Fan Speed, Standby rotation, Lead/Lag operation, Cascade
- Failover procedures
- BMS control screens and points

## Outcome

- High total implementation cost
- Greater system complexity
- Lengthy deployment with limited field testing and validation
- Significant risk to project timeline
- Generic, one-off controls with expensive / inconsistent long term support

Liebert iCOM Controls

## Liebert iCOM Solution

- Coordination with data center operation
- Optimized unit performance
- Predefined configurable sequence of operation
- Factory equipped sensors
- Defined staging and valve routines



- Predefined configurable failover routines
- Built-in multi-unit Teamwork
- Optimized Aisle Operation
- Sensor connection back to units
- Sharing of sensor data between units
- Wireless rack sensor integration
- Simple BMS integration

- Low total implementation cost
- Algorithms developed specifically for data centers
- Extensive reliability testing and robust algorithms
- Reduced system complexity
- Quick deployment
- Limited risk

# Liebert DSE

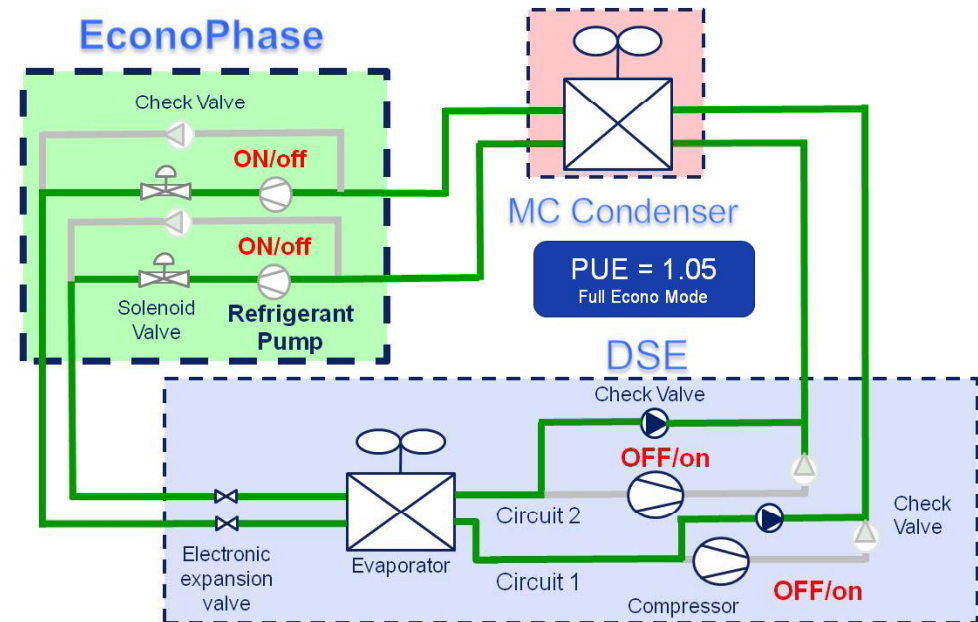
## World's Most Efficient DX System

- Efficiencies of 1.5x ASHRAE standards with annual PUE<1.2
- Pumped Refrigerant Economizer (EconoPhase) mode with operation down to 1.05 PUE
- Designed for return air temperature up to 105°F
- Standard iCOM control with Optimized Aisle
- Capacities of 80 to 165 kW
- Ideal for sites up to 3 MW
- Simple and reliable part and full economizer mode

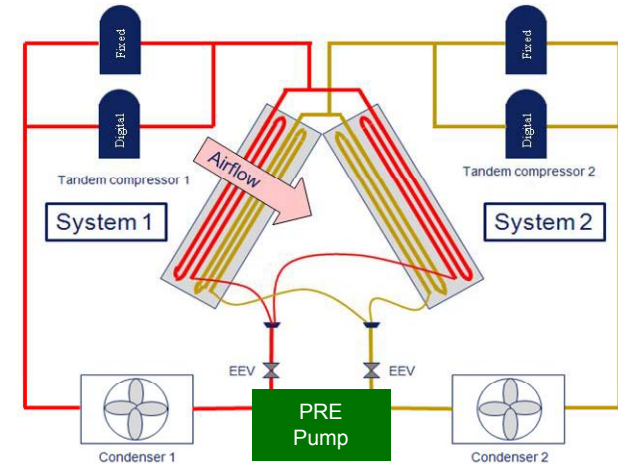
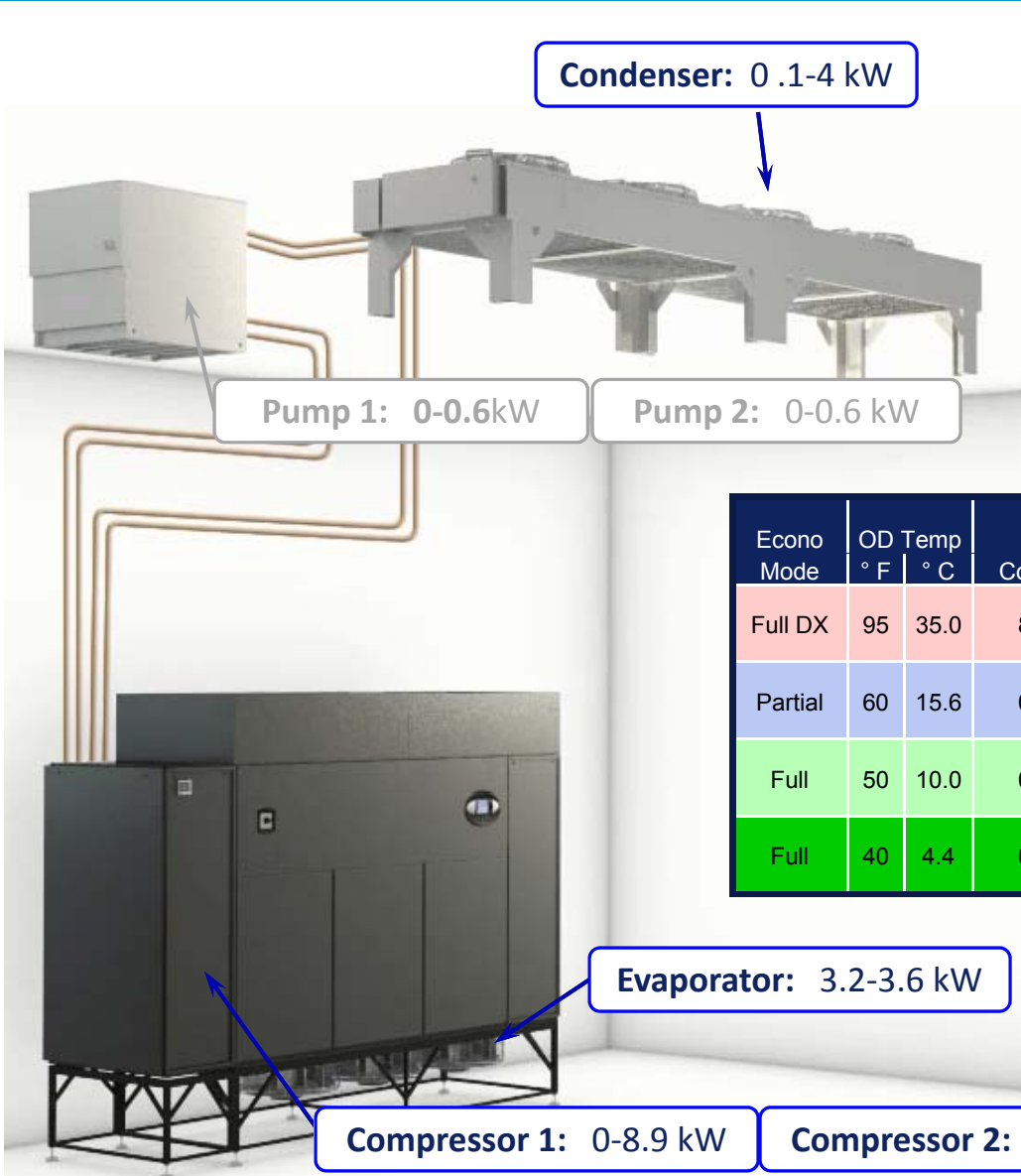


Mode	OD Temp	Total Power
Full DX	95 °F	24.1 kw
Partial Econo	65 °F	15.1 kW
Full Econo	25 °F	3.7 kW

For 125 kW of Cooling



# Most Efficient System: DX, Partial and Full Econo Operation Modes



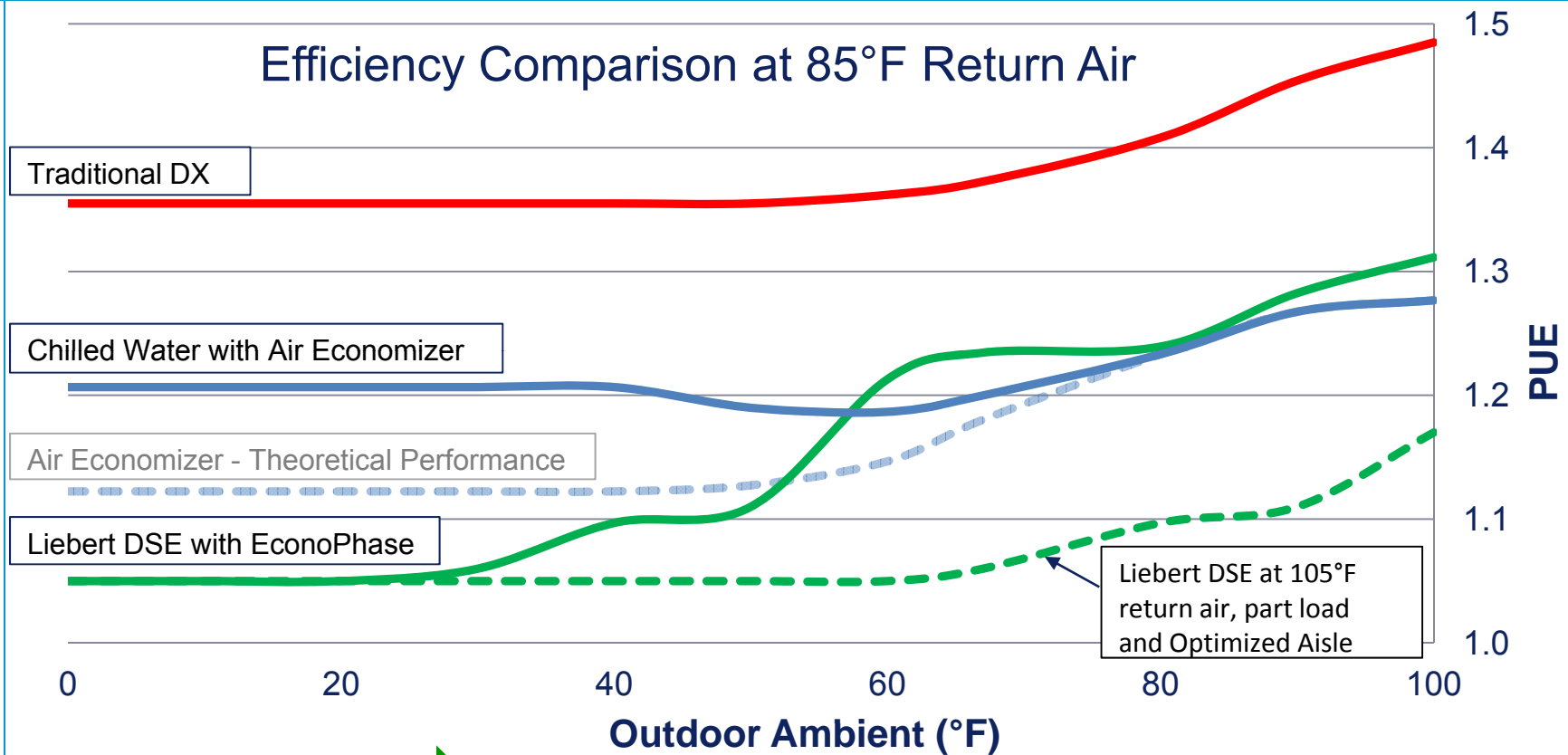
Econo Mode	OD Temp		System 1		System 2		Cond Fan	Evap Fan	Total Power	Mech PUE
	° F	° C	Compr	Pump	Compr	Pump				
Full DX	95	35.0	8.9	0.0	8.9	0.0	4.1	3.5	25.4	1.24
Partial	60	15.6	0.0	0.4	8.9	0.0	2.4	3.5	15.2	1.15
Full	50	10.0	0.0	0.5	0.0	0.5	4.8	3.6	9.4	1.09
Full	40	4.4	0.0	0.6	0.0	0.6	0.5	3.6	5.3	1.05

Performance for DA125 @  
80% load, 95 deg F RAT

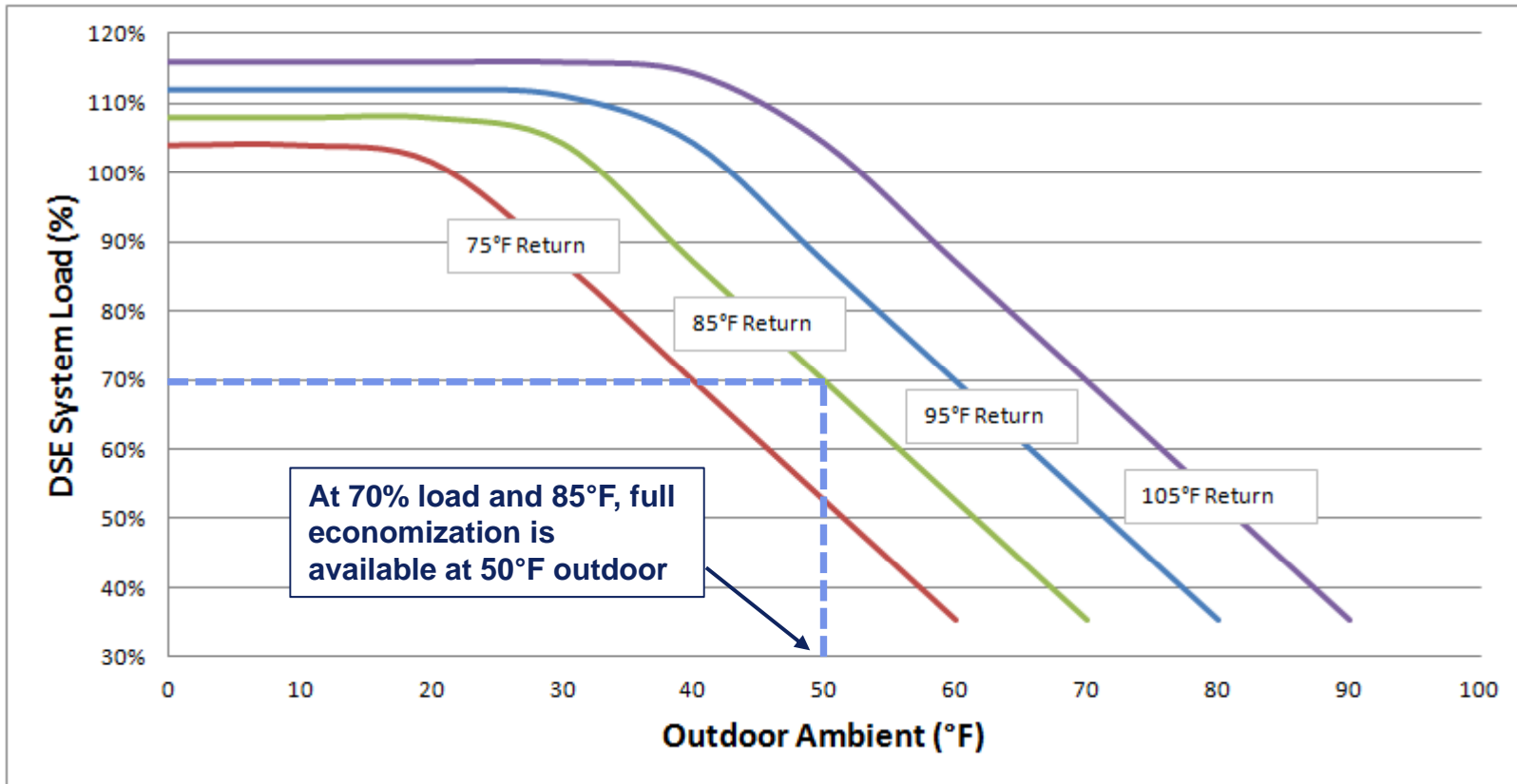


# Unmatched Efficiency with Hassle-Free Economization

Efficiency Comparison at 85°F Return Air



# Most Efficient System: Liebert EconoPhase 100% Free-Cooling Capability



Annual free-cooling hours increase at higher return air conditions and lower unit loads:

Percentage of Annual Hours with 100% Free-Cooling Available		
Location	85°F Return Air	95°F Return Air
San Francisco, CA	42%	70%
Philadelphia, PA	32%	48%
Charlotte, NC	36%	45%



# ***Down Flow Front Discharge Configuration***

---

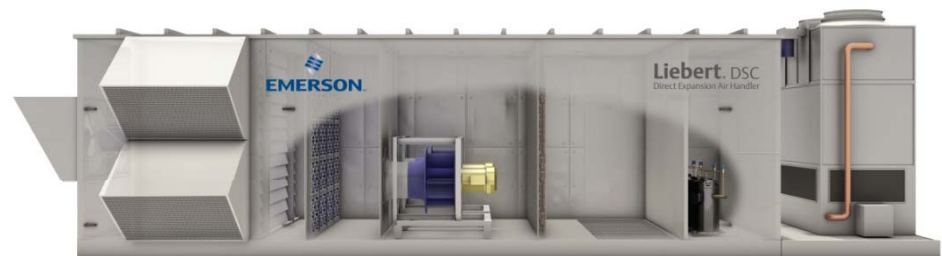
- Primarily used for battery, mechanical, or electrical rooms
- Full airflow rating compared to bottom discharge with fans in the unit
- No Floor stand required / additional front grill available
- Disconnect and Controls at normal height to meet NEC and User interface requirements
- Available in Chilled Water (CW) and DX (DS/DSE) product lines



# **Liebert Custom Air Handling Solutions**

## **Liebert DSC Direct Expansion Air Handler**

- For customers seeking low installation costs and zero footprint in or along side the data center
- Unit capacities ranging from 150 – 600 kW per unit
- Liebert DSC Direct Expansion Air Handler configurations combine premium quality construction with high efficiency options
  - Outside air economizer with integrated by pass dampers
  - Variable speed or digital compressors with optional evaporative condenser
- Low noise options available





# Liebert Data Center Thermal Management Solutions

	Liebert DSE	Liebert CW Chilled Water Unit	Liebert CWC Chill Water AHU	Liebert EVI Indirect Evap AHU	Liebert EVD Direct Evap AHU	Liebert DSC Direct Expansion AHU
<b>Financial Attributes</b>						
Equipment Cost	✓				✓	
Efficiency	✓ +	✓	✓	✓ +	✓ +	✓
Availability	✓	✓	✓	✓	✓	✓
Install Cost				✓	✓	✓
Infrastructure Cost				✓	✓	
<b>Operating Conditions</b>	ASHRAE Recommended	ASHRAE Recommended	ASHRAE Recommended	ASHRAE Recommended	ASHRAE Allowable	ASHRAE Recommended
<b>Outside Air</b>	None	Optional	Optional	None	Required	Optional
<b>Data Center Location</b>				Best in Dry Climate	Best in Dry Climate	
<b>Low Water Costs</b>	✓					✓
<b>Location</b>						
Roof				✓	✓	✓
External Side			✓	✓	✓	
Gallery	✓	✓	✓		✓	
DC Perimeter	✓	✓	✓			
<b>Modular System</b>	✓	✓		✓	✓	✓

# Emerson Network Power Service and Support

## Our Message → Service Value Proposition

- Nationwide service through regionally based Factory Trained Technicians
- Guaranteed 4 hours response time for contract customers
- 24-hour customer and tech support
  - Local Parts Stocking
- Remote Monitoring delivered by data center experts
- Energy Optimization Services
  - CFD modeling services
  - Energy Efficiency Assessments
  - Reduce energy costs 15-40%



- **Availability approaching 100%**
- **Lower Service & Maintenance Costs**
- **15% Energy Savings**



# ***Designing in These Technologies***

---

- Liebert Energy and TCO tools
- Customer Operating Requirements
- Designs for high efficiency
  - Return air / Supply air temperatures
  - Maximize economization hours
- Redundancy / Cautions
- Other factors
  - Max KW rating
  - Utility ride through

# Liebert Energy & TCO Tool – Energy and Performance Calculation for Any System Type

Rev 12.3

Pennsylvania - PHILADELPHIA

Job Name

Customer Presentation

Print

Exit

IT Load 1,200 kW  
 Minimum Cooling Redundancy 0%  
 Altitude above 3000 ft No

Electric Utility rate \$ 0.060 per kw-h  
 Water utility rate \$ 3.25 per k gal  
 \$ - Override

Humidity control NO  
 Control Limit 42 ° F  
 Vapor Barrier Effectiveness 80%

Financial Analysis Requirements  
 15 # Years for Analysis  
 10% Discount Rate  
 20% Equipment discount

Option 1  
 Liebert DA125\_P w/EconoPhase

Air Cooled unit digital with Free Cooling (2)MCL165 Premium Condensers			
Fan Type	EC		
Optimized Aisle	YES		
@ Return Air Conditions	95 ° F	18% RH	
CRAC Unit Capacity each	152 kW		
Operating CRAC Capacity each	133 kW		
@ Supply Air Conditions	70 ° F		
Economizer Utilization	100%		
Units required	9	N+1	9
Actual Redundancy	12%		
UPS & Distribution Efficiency	100%		
Water usage per year (k gal)	0		
Cooling Equipment	\$ 64,953		
UPS & Distribution Equipment	\$ -		
<b>Energy Costs per year</b>	<b>\$ 64,953</b>		
Water Costs per year	\$ -		
Unit ASCOP	9.18		
PUE	1.10		
Maximum System kW	244		
<b>Budgetary Equipment Costs</b>			
Air Cooled unit digital with Free Cool	\$ 475,248	-	
(2)MCL165 Premium Condensers	\$ 231,984	-	
Free Cooling package	\$ 144,000	-	
Installation	\$ 764,832	-	
<b>Total</b>	<b>\$ 1,616,063</b>		
Maintenance cost (annual)	\$ 18,040	-	
Life Time NPV Cost \$K	\$ 2,247		
Payback (yrs) vs lowest option:	Negative		

Option 2  
 Liebert DA150\_P w/EconoPhase

Air Cooled unit digital with Free Cooling (2)MCL165 Premium Condensers			
Fan Type	EC		
Optimized Aisle	Yes		
@ Return Air Conditions	95 ° F	18% RH	
CRAC Unit Capacity each	180 kW		
Operating CRAC Capacity each	150 kW		
@ Supply Air Conditions	70 ° F		
Economizer Utilization	100%		
Units required	8	N+1	8
Actual Redundancy	17%		
UPS & Distribution Efficiency	100%		
Water usage per year (k gal)	0		
Cooling Equipment	\$ 62,752		
UPS & Distribution Equipment	\$ -		
<b>Energy Costs per year</b>	<b>\$ 62,752</b>		
Water Costs per year	\$ -		
Unit ASCOP	9.54		
PUE	1.10		
Maximum System kW	271		
<b>Budgetary Equipment Costs</b>			
Air Cooled unit digital with Free Cool	\$ 441,644	-	
(2)MCL165 Premium Condensers	\$ 206,208	-	
Free Cooling package	\$ 128,000	-	
Installation	\$ 664,099	664,099	
<b>Total</b>	<b>\$ 1,439,951</b>		
Maintenance cost (annual)	\$ 16,515	-	
Life Time NPV Cost \$K	\$ 2,043		
Payback (yrs) vs lowest option:	Lowest Capital Cost		

Option 3  
 Liebert CW181 & Screw Chiller w/ Series Econo

250 T Water Cooled Screw Chiller - Series economizer			
Chiller output temp	52 ° F		
Chiller delta t	12 ° F		
Chiller Capacity	895 kW		
CRAH Fan Type	EC		
Optimized Aisle	Yes		
@ CRAH Return Air Conditions	95 ° F	18% RH	
CRAH Unit Capacity each	272 kW		
@ Supply Air Conditions	67 ° F		
Economizer Utilization	95%		
Chillers Required	2	N+1	-
CRAH units Required	6		6
Actual Chiller Redundancy	33%		
Actual CRAH Redundancy	26%		
UPS & Distribution Efficiency	100%		
Water usage per year (k gal)	13,281		
Cooling Equipment	\$ 57,903		
UPS & Distribution Equipment	\$ -		
<b>Energy Costs per year</b>	<b>\$ 57,903</b>		
Water Costs per year	\$ 43,208		
Unit ASCOP	10.90		
PUE	1.09		
Maximum System kW	248		
<b>Budgetary Equipment Costs</b>			
250 T Water Cooled Screw Chiller -	\$ 196,220	-	
Cooling Tower	\$ 50,120	-	
Condenser Pump kW	\$ 32,997	-	
CW Loop Pumps	\$ 105,077	-	
CRAH units	\$ 177,624	-	
Installation & piping	\$ 1,138,035	-	
<b>Total</b>	<b>\$ 1,700,073</b>		
Maintenance cost (annual)	\$ 38,378	-	
Life Time NPV Cost \$K	\$ 2,761		
Payback (yrs) vs lowest option:	Negative		

Option 4  
 Liebert CW181 & Screw Chiller w/ Air Economizer

250 T Water Cooled Screw Chiller - Air economizer			
Chiller output temp	52 ° F		
Chiller delta t	12 ° F		
Chiller Capacity	895 kW		
CRAH Fan Type	EC		
Optimized Aisle	Yes		
@ CRAH Return Air Conditions	95 ° F	18% RH	
CRAH Unit Capacity each	272 kW		
@ Supply Air Conditions	67 ° F		
Economizer Utilization	90%		
Chillers Required	2	N+1	-
CRAH units Required	6		6
Actual Chiller Redundancy	33%		
Actual CRAH Redundancy	26%		
UPS & Distribution Efficiency	100%		
Water usage per year (k gal)	2,757		
Cooling Equipment	\$ 43,498		
UPS & Distribution Equipment	\$ -		
<b>Energy Costs per year</b>	<b>\$ 43,498</b>		
Water Costs per year	\$ 8,969		
Unit ASCOP	14.51		
PUE	1.07		
Maximum System kW	248		
<b>Budgetary Equipment Costs</b>			
250 T Water Cooled Screw Chiller -	\$ 181,685	-	
Cooling Tower	\$ 50,120	-	
Condenser Pump kW	\$ 32,997	-	
CW Loop Pumps	\$ 105,077	-	
CRAH units & Exhaust fans	\$ 307,829	-	
Installation & piping	\$ 1,381,807	-	
<b>Total</b>	<b>\$ 2,059,515</b>		
Maintenance cost (annual)	\$ 38,601	-	
Life Time NPV Cost \$K	\$ 2,752		
Payback (yrs) vs lowest option:	Negative		



Pennsylvania - PHILADELPHIA

Job Name

# Energy//TCO Report

IT Load 1,200 kW  
 Minimum Cooling Redundancy 0%  
 Altitude above 3000 ft No

Electric Utility rate \$ 0.060 per kw-h  
 Water utility rate \$ 3.25 per k gal  
 Humidity cont  
 Vapor Barrier €

Option 2

Liebert DA150\_P w/EconoPhase

Air Cooled unit digital with Free Cooling  
 (2)MCL165 Premium Condensers

Fan Type EC  
 Optimized Aisle YES  
 @ Return Air Conditions 95 ° F 18% RH  
 CRAC Unit Capacity each 180 kW  
 Operating CRAC Capacity each 150 kW  
 @ Supply Air Conditions 70 ° F  
 Economizer Utilization 100%  
 Units required 8 N+1 8  
 Actual Redundancy 17%

UPS & Distribution Efficiency 100%

Water usage per year (k gal) 0

Cooling Equipment \$ 62,752  
 UPS & Distribution Equipment \$ -  
**Energy Costs per year \$ 62,752**  
 Water Costs per year \$ -

Unit ASCOP 9.54  
**PUE 1.10**  
 Maximum System kW 271

**Budgetary Equipment Costs**

Air Cooled unit digital with Free Cool \$ 441,644 -  
 (2)MCL165 Premium Condensers \$ 206,208 -  
 Free Cooling package \$ 128,000 -  
 Installation \$ 699,052 -  
 Total \$ 1,474,904

Maintenance cost (annual) \$ 16,515 -

**Life Time NPV Cost \$K \$ 2,078**

Payback (yrs) vs lowest option: **Lowest Capital Cost**

## Page 2 Details by Bin

Dry Bulb Bin Data					
Temp bins	below 5	5-9	90-94	above 95	
Dry bulb hrs	9	17	88	18	
WB @ DB bin	6	6	75	75	
Ave Dew point	2	2	62	62	
<b>Option 1 9 Liebert DA125_P w/EconoPhase</b>					
<b>System kW load</b>					<b>Total MW-Hr</b>
Compressor kW	0.0	0.0	178.0	187.2	718.3
Evap Fan kW	22.7	22.7	20.2	20.2	186.0
Condenser kW	0.3	0.3	36.6	36.6	122.5
Humidifier kW	0.0	0.0	0.0	0.0	0.0
Free cooling pump kW	12.0	12.0	0.0	0.0	55.8
UPS & Distribution	0.0	0.0	0.0	0.0	0.0
Total power consumed kW	35.1	35.1	234.7	243.9	1082.5
Energy consumed MW-Hr	0.3	0.6	20.7	4.4	
<b>Option 2 8 Liebert DA150_P w/EconoPhase</b>					
<b>System kW load</b>					
Compressor kW	0.0	0.0	192.8	195.2	584.2
Evap Fan kW	27.4	27.4	27.4	27.4	240.3
Condenser kW	0.1	0.1	48.0	48.0	151.5
Humidifier kW	0.0	0.0	0.0	0.0	0.0
Free cooling pump kW	12.0	12.0	0.0	0.0	69.9
UPS & Distribution	0.0	0.0	0.0	0.0	0.0
Total power consumed kW	39.6	39.6	268.3	270.6	1045.9
Energy consumed MW-Hr	0.4	0.7	23.6	4.9	



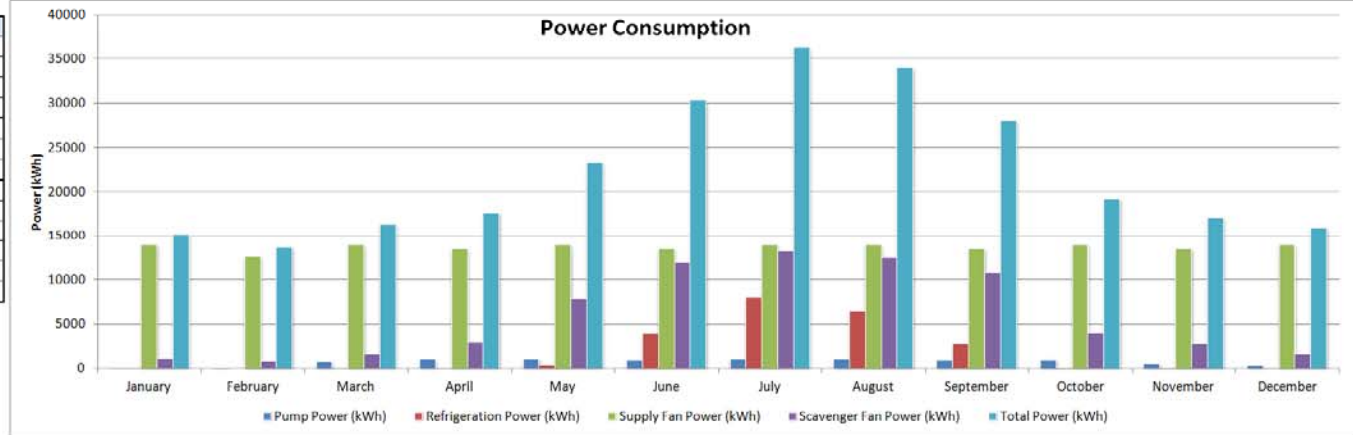
# Indirect Evaporative Energy Model - EVI

## Data Center Economic Energy Analysis



Energy Model Inputs:			
Process Airflow (SCFM):	31667	Max Scavenger Airflow (ACFM):	54000
Process Air ESP ("):	1	Unit Design Capacity (kW):	201
Process Entering Air (deg F):	85	Altitude (feet):	0
Process Supply Air Temp (deg F):	65	Sump Cycles of Concentration:	3
Electrical Cost (\$/kWh):	0.06	Sump Flushes Per Week:	2
Water Cost (\$/hundred cubic feet):	2	Weather Location:	PHILADELPHIA INTERNATIONAL AP
		Hour-by-hour energy model based on:	TMY 3 Weather Data

Energy Model Outputs:	
Annual Operating Cost	\$17,757
Mechanical PUE	1.15
Annual Energy Usage (kWh)	267250
Annual Water Usage/1,000 (Gallons):	644
Evap + DX cooling hours	2165
Evap cooling only hours	3168
Dry cooling hours	2617
Peak Power Usage (kW):	75.0
HX Max Cooling Capability (kW):	223.3
Refrigeration Max Cooling Requirement (tons):	50.2
Max HX Dry Efficiency:	70.8%
Max Wetbulb Depression Efficiency:	83.3%
Max Unit EER:	38.5



Operating Cost Breakdown									
Month:	Hours:	Supply Fan	Scavenger Fan	Refrigeration Section	Water	Pump	Total Operating Cost	Average Unit EER	Average Unit kW/ton
January	744	\$836.79	\$69.74	\$0.06	\$9.44	\$3.70	\$919.74	37	0.325
February	672	\$755.81	\$52.81	\$0.00	\$39.06	\$11.73	\$859.42	37	0.325
March	744	\$836.79	\$98.92	\$0.42	\$124.07	\$46.62	\$1,106.82	35	0.350
April	720	\$809.80	\$179.05	\$7.64	\$178.40	\$62.26	\$1,237.15	32	0.389
May	744	\$836.79	\$470.36	\$26.25	\$223.01	\$64.93	\$1,621.35	26	0.495
June	720	\$809.80	\$715.92	\$238.45	\$202.86	\$57.83	\$2,024.86	19	0.663
July	744	\$836.79	\$795.74	\$480.91	\$215.94	\$64.63	\$2,394.01	16	0.766
August	744	\$836.79	\$753.72	\$389.12	\$210.89	\$62.67	\$2,253.19	18	0.719
September	720	\$809.80	\$648.87	\$166.04	\$201.48	\$57.01	\$1,883.20	21	0.613
October	744	\$836.79	\$245.50	\$12.86	\$165.09	\$61.44	\$1,321.68	31	0.411
November	720	\$809.80	\$169.46	\$12.98	\$91.17	\$35.09	\$1,118.50	33	0.378
December	744	\$836.79	\$96.59	\$2.21	\$60.19	\$20.89	\$1,016.68	36	0.342
<b>Totals</b>	<b>8760</b>	<b>\$9,852.57</b>	<b>\$4,296.69</b>	<b>\$1,336.94</b>	<b>\$1,721.59</b>	<b>\$548.80</b>	<b>\$17,756.59</b>	<b>NA</b>	<b>NA</b>

\*The information provided in this document is for comparative purposes only and is not a guarantee of savings or actual energy performance.

# Liebert TCO / Energy Performance Tools for Direct & Indirect Evap Coolers

**Direct Evaporative Cooler**

**Location**

Country: USA, Algeria, Argentina, Australia, Austria, Azores, Bahamas

State: Antigua

City: COOLIDGE

Altitude (ft): 1000

Load (kW): 80 (39.3 kW)

Utility Rate

CFM Required: 80,000

Supply Air Set Point (°F)

Mid Bin DB (°F)	5	7	12	17	22	27	32	37	42	47	52	57	62	67	72	77	82	87	92	97	
Ambient DB (°F)	Below 5	6.0	10.14	15.16	20.24	25.28	30.54	36.19	40.44	45.49	50.54	56.60	60.64	65.69	70.74	75.79	80.84	85.88	90.94	above 95	
Ambient WB (°F)	0	0	0	0	0	0	0	0	0	0	0	0	63.1	66.4	70.3	72.9	75.8	78	79.5	79.5	
Hours	0	0	0	0	0	0	0	0	0	0	0	0	2	34	408	3,232	4,112	948	24	0	
<b>Total</b>																					<b>8,760</b>

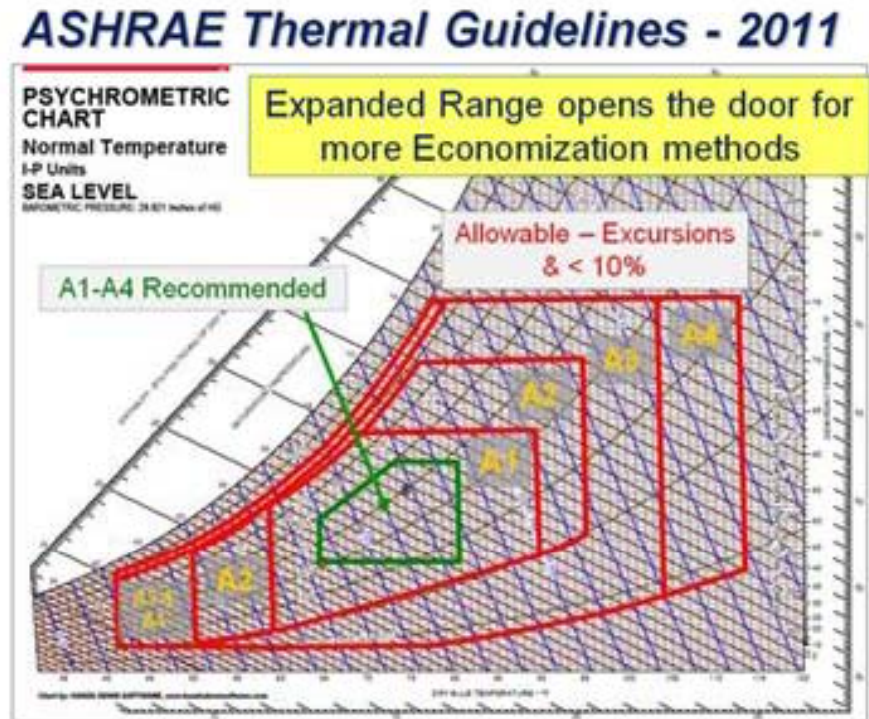
State	CFM	DB (°F)	Filtered DB (°F)	RH (%)	WB (°F)	Enthalpy (BTU/lb)
1	40,000	40,000	40,000	40,000	40,000	40,000
2	40,000	40,000	40,000	40,000	40,000	40,000

- Reference Models for Custom Air Handlers
- 35,000, 42,000 and 48,000 CFM
  - Raised floor / non-raised floor
  - Downflow, Horizontal and Vertical



# Customer Requirements

- Supply Temperature Operating point – will drive RAT (~20 to 25 deg dT depending on load)
- Build plans and IT deployment plans – modular builds
- Tier requirements
- Outside Air acceptability
- Controls and Monitoring





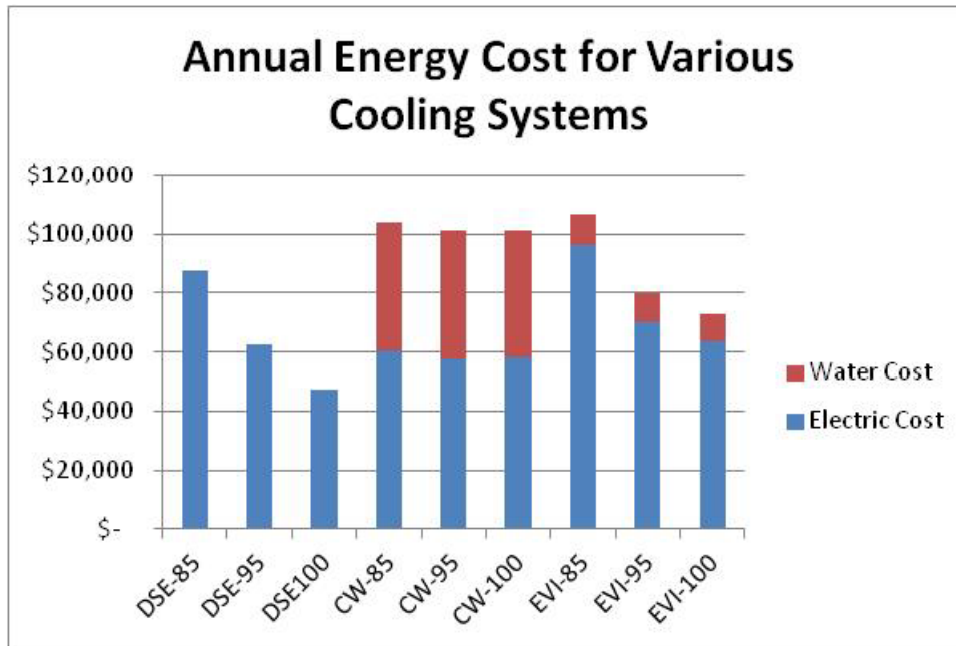
# Benefits of Higher Return Air Temperatures

- Capital
  - Cooling Equipment
  - Electrical Gear
- Operating Expense
  - Energy
  - Maintenance
- Control is on the Supply – a 95 deg F Return Air Temperature is about 70 deg F supply but depends on unit loading

		Performance					Capital		Operating Expense	
		Capacity per unit	Unit ASCOP	Hours of Econo Mode	Mech PUE	Max kw	Cooling Units	Electrical Gear	Annual Energy	Annual Maintenance
RAT <sup>1</sup>	85° F	154	5.78	2791	1.17	397	11		\$ 113,948	\$ 22,708
	95° F	180	8.71	4196	1.11	301	10		\$ 74,807	\$ 20,644
Improvement		17%	51%	50%	-5%	-24%	-9%	-24%	-34%	-9%
Oper Redundant Units		180	10.34	4898	1.09	299	10		\$ 61,639	\$ 20,644
Improvement			19%	17%	-2%	-1%			-18%	
<b>Total Benefits</b>		17%	79%	75%	-7%	-25%	-9%	-25%	-46%	-9%

example: Location - Philadelphia  
 Critical load 1,295 kW  
 Electric \$0.06 / kwh

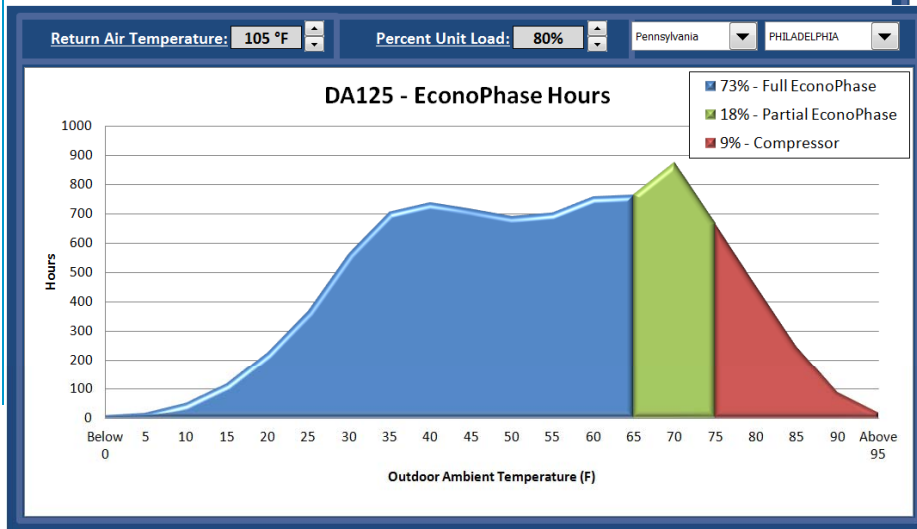
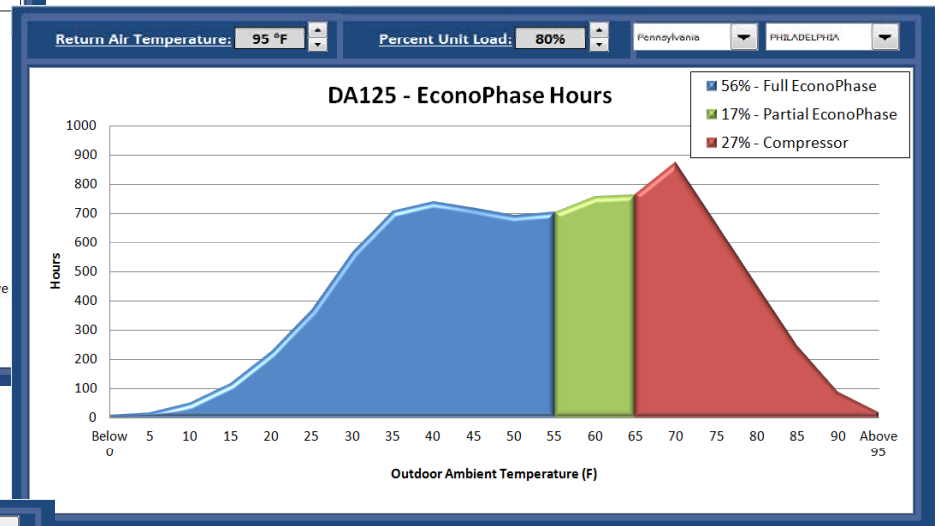
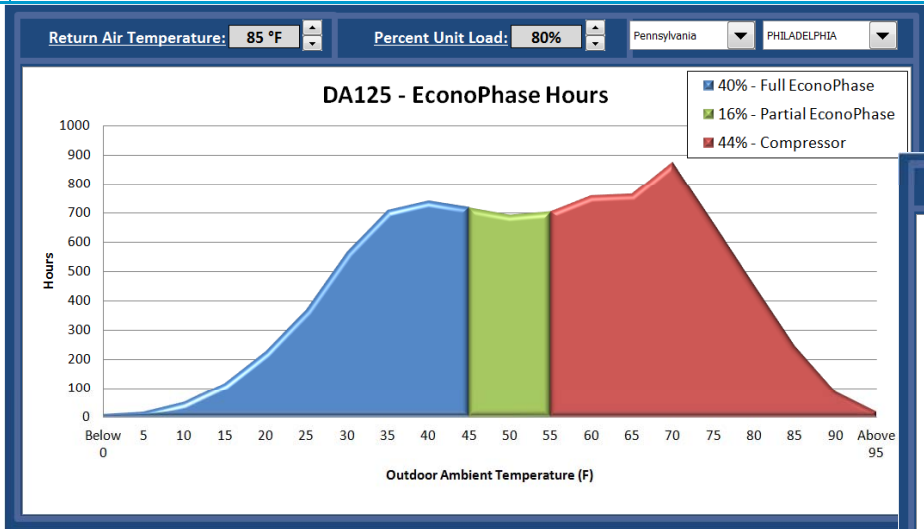
# Cooling Technology Solutions



- Location – Philadelphia
- Critical load – 1,200kW
- RAT of 85, 95, 100
- Electric - \$0.06 / kwh,
- Water - \$3.25 / 1000 gal
- LCWT – 52 deg F / 12 dT
- Chiller – series economizer

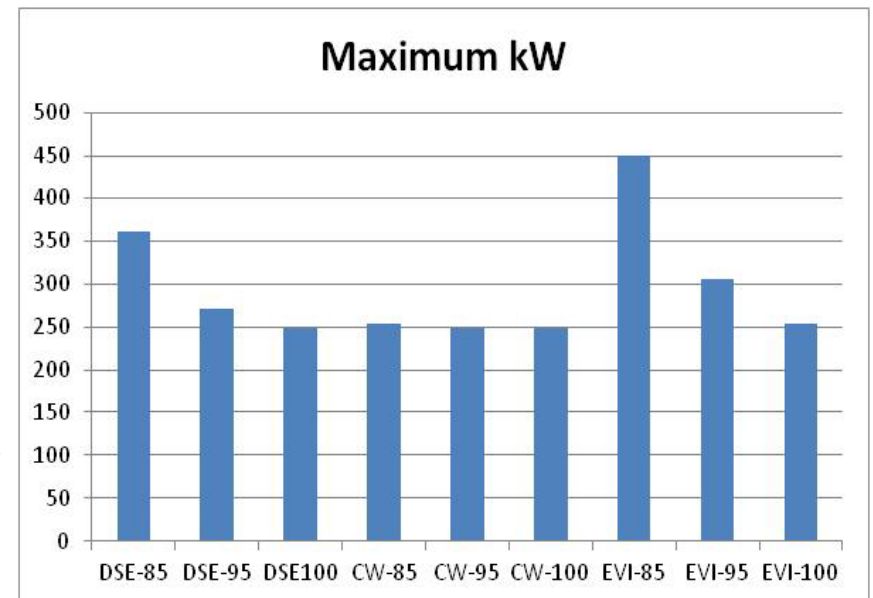
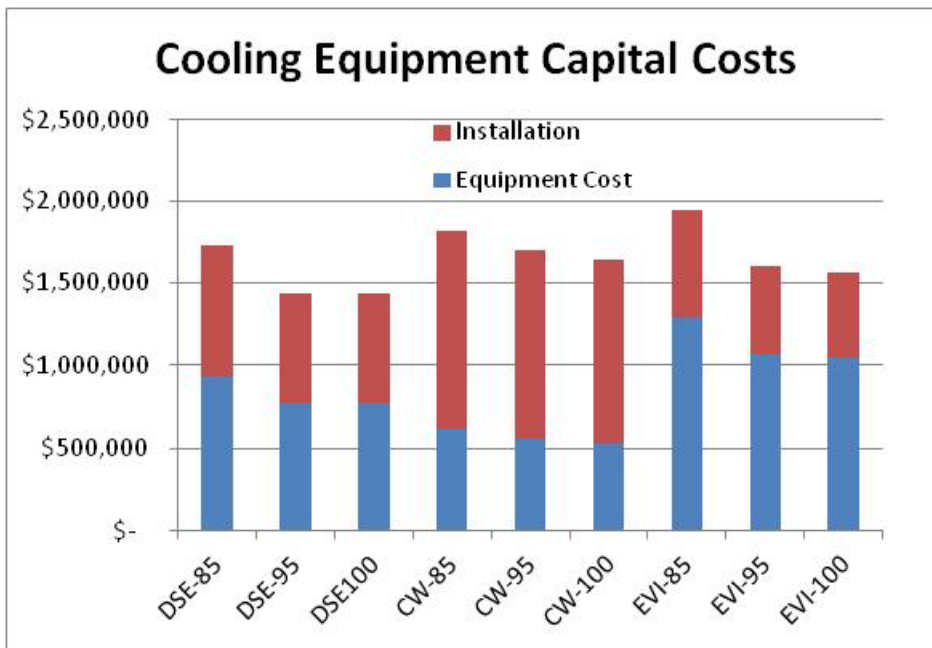
- To get the advantages of higher RAT, Chilled water systems need to raise the LCWT
- Indirect Evaporative systems are impacted by the higher supply air ESP (~1")

# Bin Hours Economization Representation for Liebert DSE



- Dry Bulb economizer solutions get in the peak of available bin hours

# Capital Costs



- Cooling Capital
  - Driven by installation costs
- Max kW – impacts Generator sizing and switch gear
- Consider Water storage requirements for ride through

# Impact of Designing for Higher RAT Temperatures but Not Operating

- Reduced Redundancy
- Higher Operating Costs
- Higher Max kW

	<u>Design</u>	<u>Operating at lower RAT</u>	
IT load (kW)	<u>1,200</u>	<u>1,000</u>	<u>1,200</u>
RAT/SAT	100 / 74	85 / 64	85/60
N+ x	1	1.5	0.24
# units	8	8	8
Capacity per unit (kw)	193	154	154
Electric Cost	\$ 47,497	\$ 74,723	\$ 111,301
Water Cost	\$ -	\$ -	\$ -
<b>Total</b>	\$ 47,497	\$ 74,723	\$ 111,301
PUE	1.07	1.14	1.18
Max Kw	249	302	369

# ***Data Center Design and Control***

---

- Key to achieving and maintaining design objectives
  - Control
    - iCOM controls to the Supply air but with Optimized Aisle maintains the maximum Return Air Temperature
    - Maintains capacity for 100% Availability
  - Variable capacity (cooling and airflow)
  - Measuring and Monitoring a tighter environment
  - Some level of containment

# Building for Modularity / Staged Build

	<u>DA150 P</u>	<u>CW (Centrifugal)</u>	<u>Indirect Evap</u>
<u>5000 kW</u>			
Capital	\$6,119,794	\$8,224,292	\$5,816,571
Redundancy	N+6	N+5 (CRAH)	N+2
Energy			
Electric	\$254,097	\$216,239	\$323,470
Water	<u>\$0</u>	<u>\$180,033</u>	<u>\$39,411</u>
Total	\$254,097	\$396,272	\$362,881
<u>1200 kW</u>			
Capital	\$1,474,904	\$4,928,282	\$1,605,000
Redundancy	N+1	N+1 (CRAH)	N+1
Energy			
Electric	\$62,752	\$113,333	\$70,036
Water	<u>\$0</u>	<u>\$43,208</u>	<u>\$9,755</u>
Total	\$62,752	\$156,541	\$79,791

- The Energy / TCO tool can run the different scenarios

# ***Other Design Factors***

---

- **Liebert DSE**
  - Simple, low maintenance and all Controls can be self contained with iCOM and does not required a separate BMS
  - Generally requires roof space for condensers
  - Works best in climates with more than 35% of the dry bulb bin hours temperatures at about 35 deg F below the RAT
- **Chilled Water**
  - Generally requires a BMS system for the chiller plant. Added cost?
  - Economizer hours driven by adjusting the Leaving CW temperature
  - Cost of water and treatment
- **Indirect Evaporative**
  - Cost of water and treatment/ Availability
  - Does not take IT space – can be on the Roof or Side of building
  - Cooling support rooms may require other cooling solutions
  - Best in dry climates and higher RAT applications
  - Installation requires duct work – mostly operate in HAC config

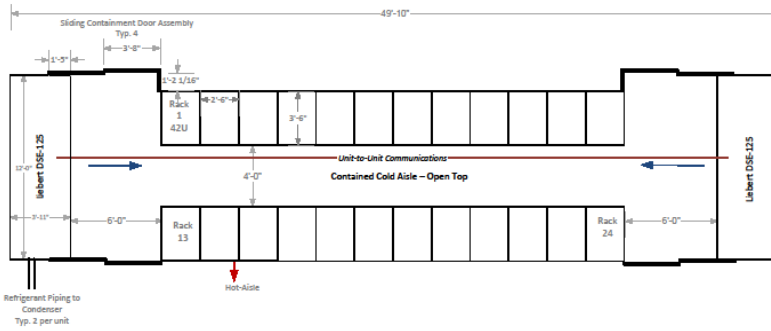
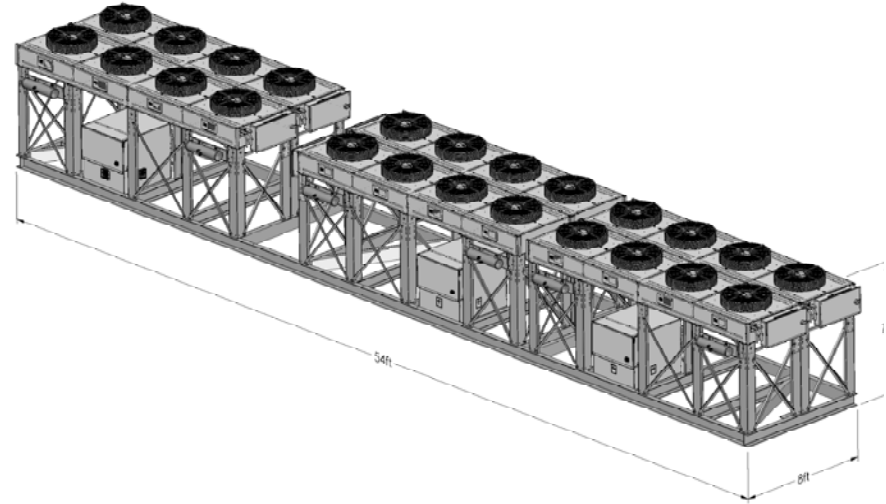


## ***Other Considerations***

---

- Installation costs
  - As energy cost come down, the first cost is the major driver of the TCO
  - Finding creative ways to bring down the installation costs – factory built modules – eliminate on site uncertainties
- SCCR
- White space use
  - Cooling equipment in Galleries
  - External to the building
- BMS / Monitoring
- Controlling to a Supply Air Temperature – means to design to the Return Air Temperature

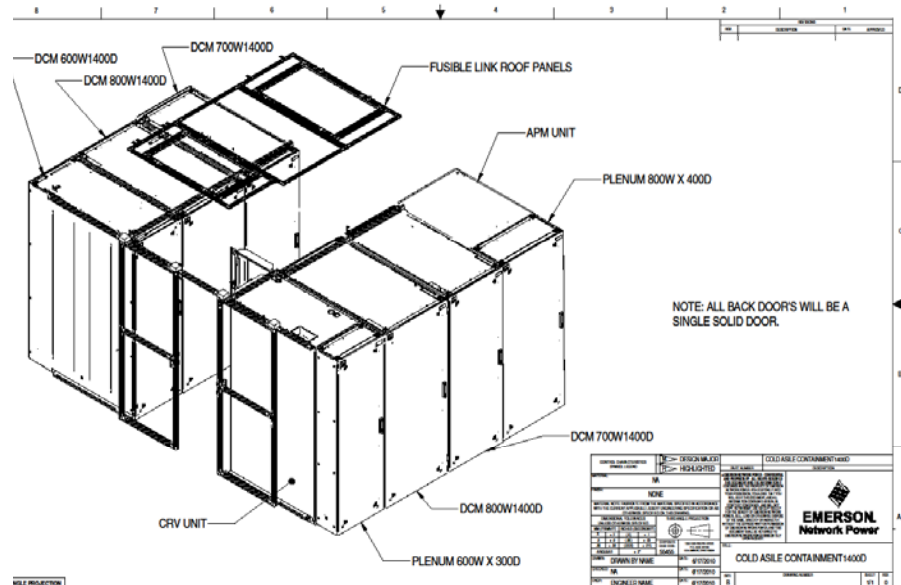
# Creative Solutions



Model		DSE125
Load	kW	100
Cabinets	Qty	24
Cabinet Load	kW	4.2
Unit Net Capacity	kW	115
Units	Qty	2
Total Capacity	kW	230
Required Units		1
Spare Capacity	kW	15
	%	15.00%
Redundant Capacity	kW	115

**Operation:** DSE units are linked with unit-to-unit communication. This enables the load to be balanced across both units. Supply air will vary based on rack inlet temperatures. Cooling capacity will vary based on supply air temperature.

Each DSE contains EC fans and scroll compressors independently controlled by the iCom microprocessor. The DSE also has a refrigerant econo-phase mode of operation whereby cooling is provided without compressor operation whenever the ambient temperature is below 50 DegF.



# Liebert Thermal Management Solutions

## Maximizing Customer Value

- iCOM Controls
  - Reliable to meet all SLAs
  - Ensures maximum efficiency all the time
  - Intelligence for managing change and reliability



- Breadth of solutions for all Data Centers from small to large
- Efficiency options with Economization with PUEs from 1.05 to 1.25
- Flexibility with Custom or Configured Solutions

- Tools for selecting the right solution
- Unmatched Service and Support for all products and applications

# Summary

---

- Thermal management customer requirements are evolving
- Liebert's new solutions for large data centers are the broadest offering to meet the application requirement with:
  - New and expanded solutions
  - Controls and Monitoring
  - Energy and TCO tools to help select the best solution
- Data Center design considerations using these solutions
  - Optimizing for Capital and Efficiency
  - Controlling to deliver on the design
  - Other considerations
- Questions

# *Thank You*

Website for More Information

Liebert DSE - <http://www.emersonnetworkpower.com/en-US/Products/PrecisionCooling/LargeRoomCooling/Pages/LiebertDSEPrecisionCoolingSystem-125kw.aspx>

Liebert CW - <http://www.emersonnetworkpower.com/en-US/Products/PrecisionCooling/LargeRoomCooling/Pages/LiebertCWChilledWater-basedPrecisionCooling26-181kW.aspx>

Liebert Air Handling Solutions - [http://www.emersonnetworkpower.com/en-US/Products/PrecisionCooling/air\\_handlers/Pages/Liebert Custom Air Handling Units.aspx](http://www.emersonnetworkpower.com/en-US/Products/PrecisionCooling/air_handlers/Pages/Liebert_Custom_Air_Handling_Units.aspx)



# Liebert DSE Technical Information

## Technical data

		Model			
		DA080	DA085	DA125	DA150
<b>95 °F DB, 52.3 DP</b>	Total Capacity kW (net)	88	100	146	170
	Sensible Capacity kW (net)	84	94	146	170
	Full-load SCOP @ 95 °F ambient	3.2	3.1	3.8	3.2
	SCOP @ 35 °F ambient (kW/kW)*	10.5	10.1	17.5	13.0
<b>85 °F DB, 52.3 DP</b>	Total Capacity kW (net)	85	92	130	153
	Sensible Capacity kW (net)	77	83	130	153
	Full-load SCOP @ 95 °F ambient	3	2.7	3.4	2.9
	SCOP @ 35 °F ambient (kW/kW)*	9.1	8.7	12.2	12.0

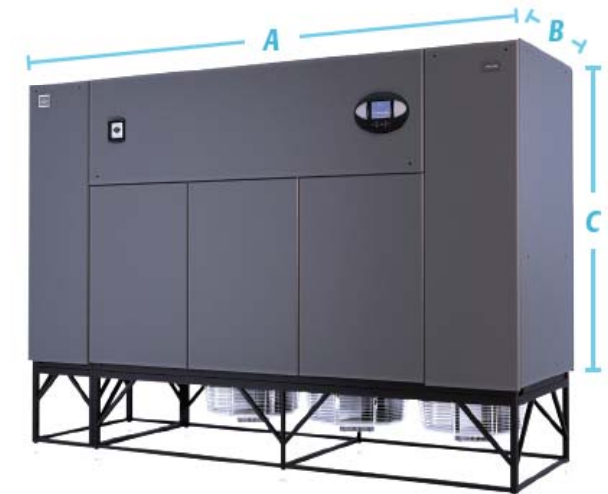
\*Economizer mode operating at 100% of DX capacity

Note: Capacity data is rated and factory-certified per ASHRAE 127-2012 with a 5% tolerance

## Basic dimensions

Model	Length (A)	Width (B)	Height (C)
DA080	100"	35"	76"
DA085	100"	35"	76"
DA125	144"	47"	76"*
DA150	144"	47"	76"*

\*Add minimum 18" height for separate filter plenum, plus floorstand height



## Condenser Line Lengths

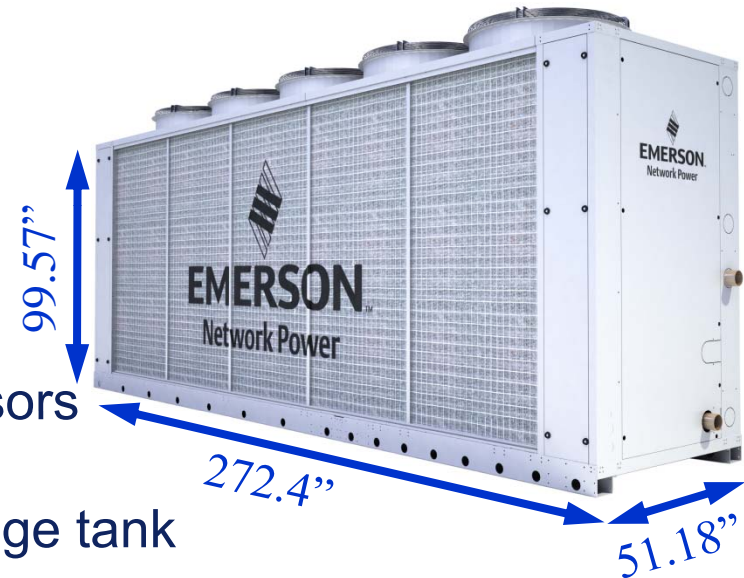
- Linear length - 300 ft (92 m)
- Vertical lift \* - 60 ft (18.5m)
- Equivalent length - 450 ft (137 m)

\* Higher lifts consult Factory

# Liebert Offering: Liebert HPC Chiller

Models:	FG0052, FG0080, FB0110
Capacities:	50, 75, and 100 tons
Power Supply:	460/3/60
Glycol percentage:	10% - 50%
Ambient Temperatures:	-20 °F to 110 °F
Water $\Delta T$ Ranges:	8 – 14 °F

FB0110 shown



## Features:

- Integral economizer, iCOM controls
- R-410a with Copeland Scroll Compressors
- Low noise, EC condenser fans
- Optional on-board pumps & water storage tank
- Robust, continuous duty design

## Benefits:

- End-to-end solutions for SMB market with CRV, XDP, DCD
  - iCOM controls networked with indoor units for complete control
- Integrated economizing function to reduce compressor power consumption at low ambient conditions

