A New Construction Energy Efficient Lab Building: Funding the Project & Performance After Occupancy

University of Denver
Daniel Felix Ritchie School of Engineering & Computer Science

Presented By:
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Overview

- Energy Efficiency Goals
- Carbon Footprint Implications
- How are we DU'ing?
- High Performance Energy Recovery System
- Performance Monitoring
- Performance After Occupancy
- Questions

Learning Objectives

- What elements can be incorporated into a building to enhance sustainability
- How to finance a project with energy efficient equipment that increases first cost
- How to effectively measure actual performance after occupancy
- How to secure continuous pay-back on energy efficient equipment

Energy Conservation - Goals

- Save Utility Dollars
- Leverage Xcel's Utility Rebates
- Lower our Carbon Footprint

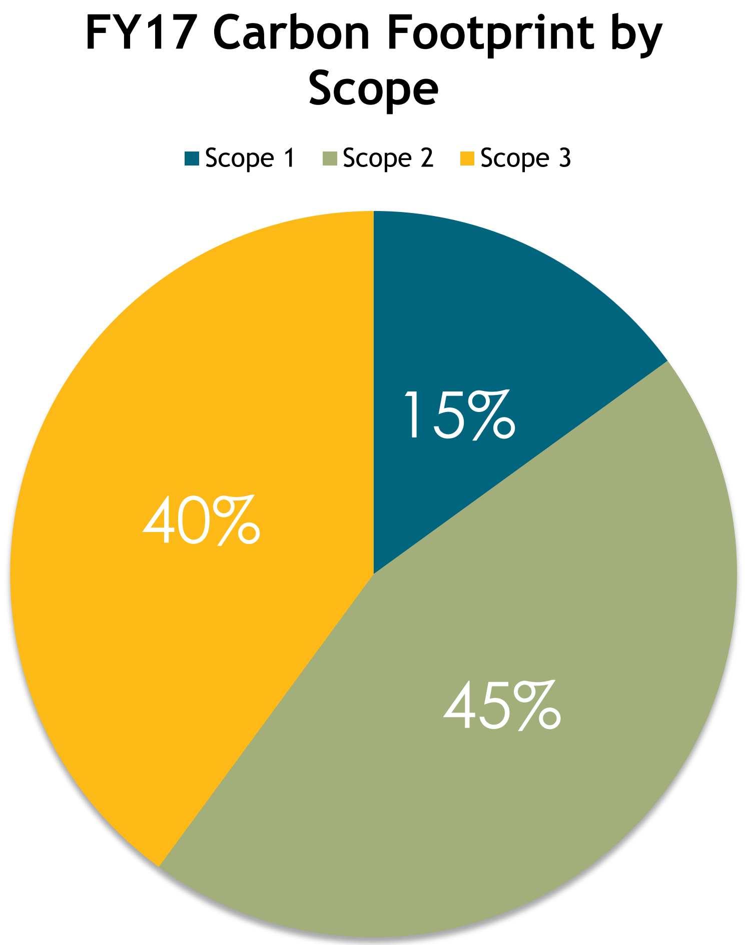
Climate Action Plan for University of Denver

"The University of Denver is committed to seeking carbon neutrality by the year 2050 through conservation, reduced consumption, and pursuing appropriate and responsible alternative energy sources. To achieve this goal, the University is working toward a **24%** carbon reduction by the year **2020**."

25X25 Sustainability Goals

1. Reduce carbon emissions by 24% by 2020 and 45% by 2025 from 2006 levels.
2. Produce 5% of DU's energy needs on-site through renewable sources.
3. Continue reduction of on-campus electrical consumption by 500,000 kWh/yr.
4. Investigate a 20-year PPA for 20% of DU's total energy needs.
5. Achieve an Energy Use Intensity (EUI) better than the national average by building type.

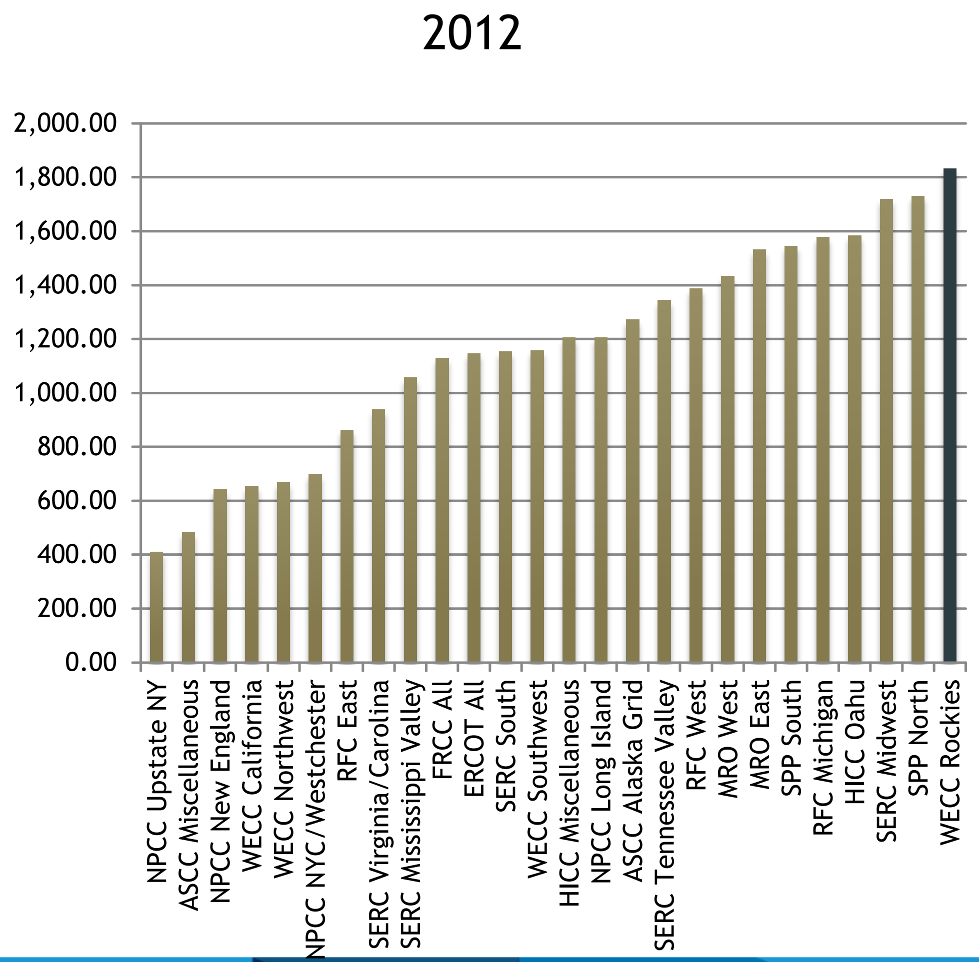
Emissions Source Overview

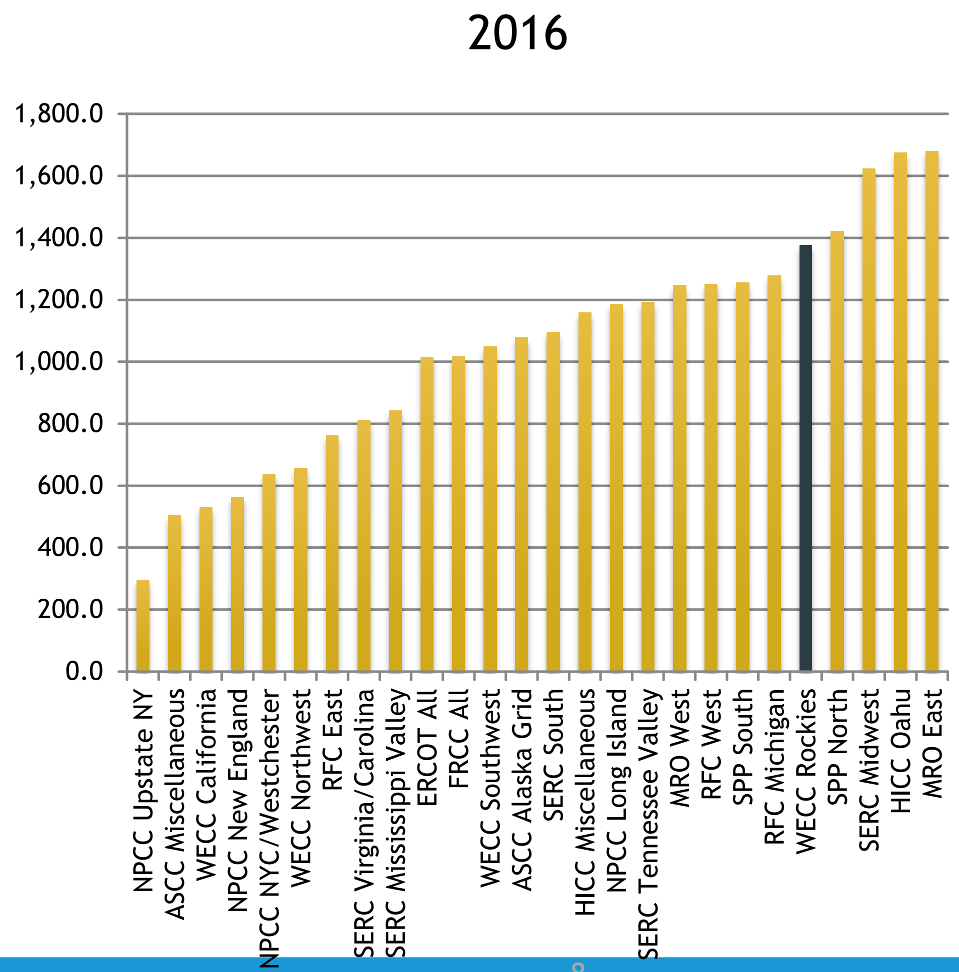


Source	MTCDE	Percentage of total
On Campus Stationary	8,504	14%
Direct financed travel	7,971	13%
Study abroad	3,900	7%
Employee commuting	4,969	8%
Student commuting	4,048	7%
Purchased electricity	34,102	45%

Scope 2 eGrid emissions

DU within one of the most carbon intense regions (but improving)





sightlines

How are we DU'ing?

Energy Conservation - Goals

- Save Utility Dollars
- Leverage Xcel's Utility Rebates
- Lower our Carbon Footprint

Energy Reserve/Green Fund Funded Projects

Energy Saving Projects - Cumulative Q2 FY18

FY17 and Prior - Completed								
		Construction	Less	Net	Annual Savings (@Prior Rates)			Average
Type	#	Cost	Rebates	Investment	Therms	Kwh	Amount	Payback (yrs)
Controls	15	$ 406,687	$ (126,882)	$ 279,805	30,650	2,020,433	$ 204,615	1.37
Lighting	30	$ 784,474	$ (275,480)	$ 508,994		3,118,252	$ 278,559	1.83
Mechanical	24	$ 1,168,857	$ (365,246)	$ 803,611	88,318	2,337,517	$ 252,086	3.19
Survey	12	$ 280,556	$ (158,013)	$ 122,543				
Totals	81	$ 2,640,574	$ (925,622)	$ 1,714,952	118,968	7,476,202	$ 735,260	2.33

FY18 - Completed or In Progess								
		Construction	Less	Net	Annual Savings (FY17 Rates)			Average
Type	#	Cost	Rebates	Investment	Therms	Kwh	Amount	Payback (yrs)
Controls	0							
Lighting	2	$ 491,415	$ (69,880)	$ 421,535		2,034,730	$ 220,952	1.91
Mechanical	0							
Survey	0							
Totals	2	$ 491,415	$ (69,880)	$ 421,535		2,034,730	$ 220,952	1.91
Cumulative	**83**	**$ 3,131,989**	**$ (995,502)**	**$2,136,487**	**118,968**	**9,510,932**	**$ 956,212**	**2.23**

Energy Reserve Funded Projects

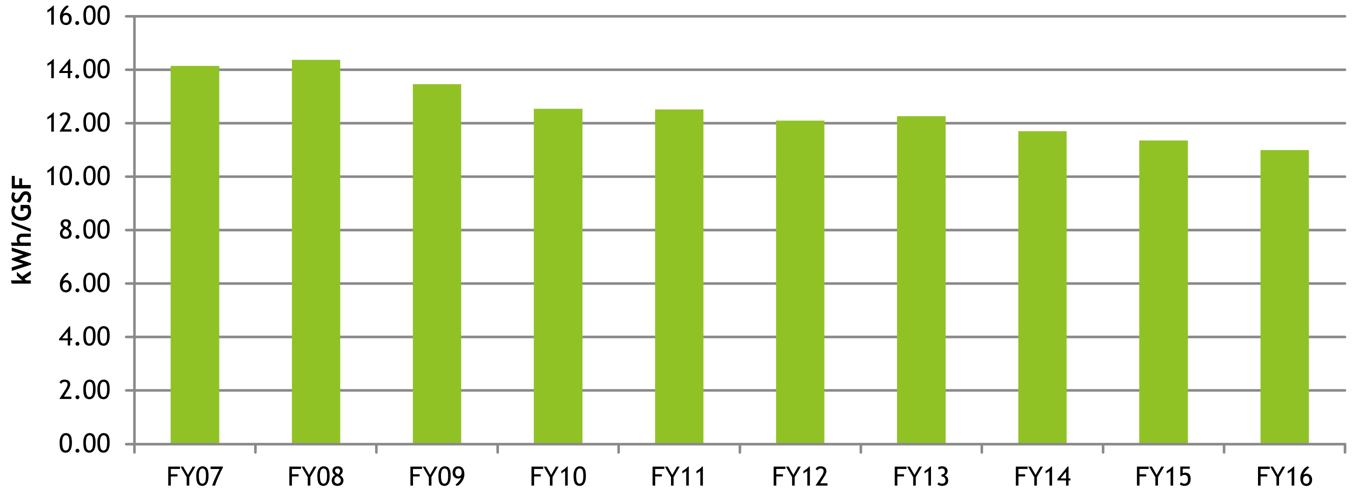
- Facilities identifies potential projects having relatively short pay back periods.
- Investments are often off-set by Xcel rebates.
- The projects are funded from an Institutional Utility Savings Reserve which has been built up from year end savings in the Utility budgets.

SECS

Type	#	Construction Cost	Less Rebates	Net Investment	Annual Savings (FY15 Rates)			Average Payback (yrs)
					Therms	Kwh	Amount	
Controls	0	$ -	$ -	$ -	-	-	$ -	-
Lighting	6	$ 131,366	$ (25,250)	$ 106,116	-	269,100	$ 26,868	3.95
Mechanical	1	$ 385,179	$ (220,000)	$ 165,179	63,343	599,866	$ 81,159	2.04

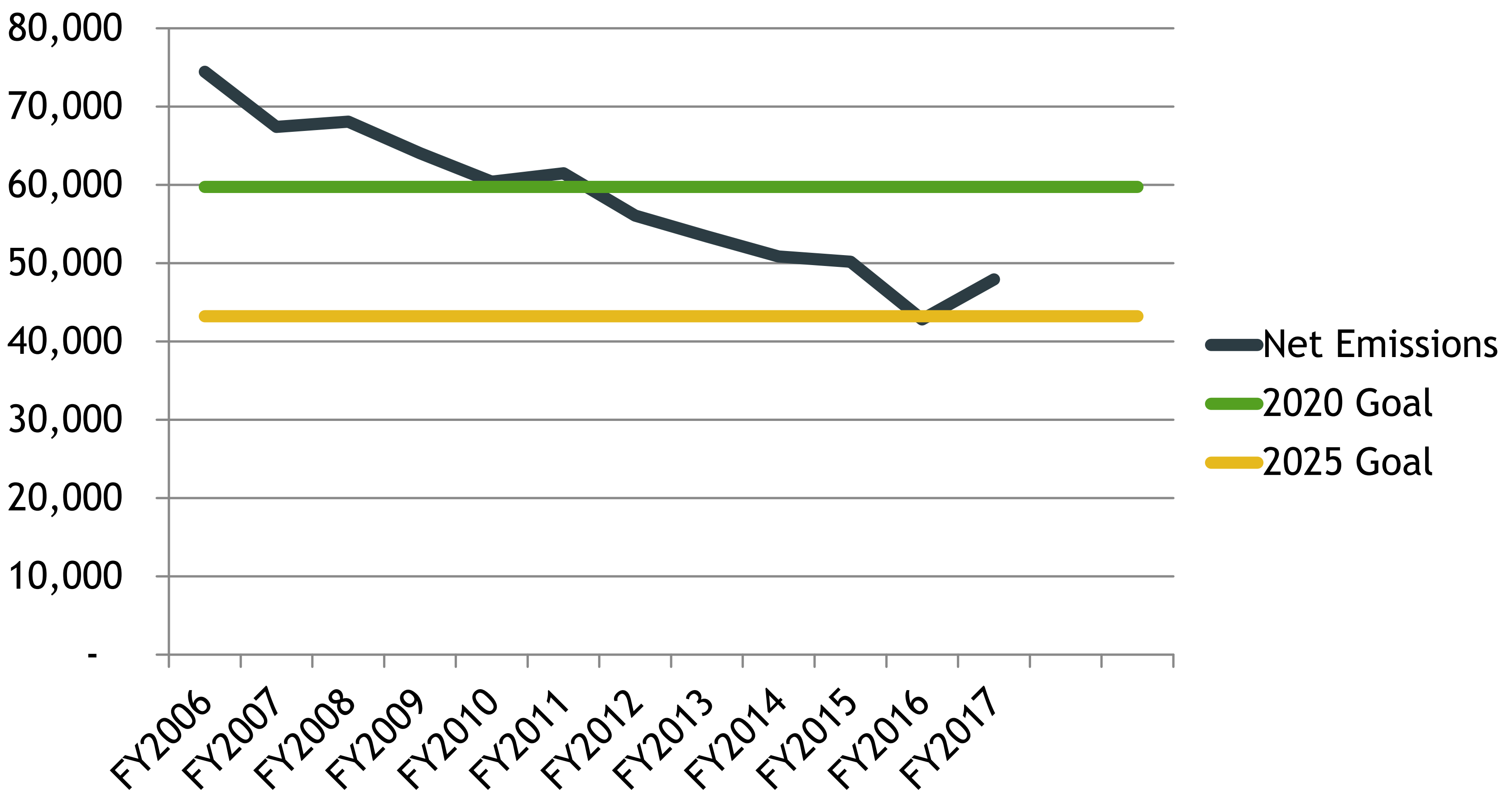
Electric Utility Savings - FY09 thru FY16

$5,376,306



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16
kWh/GSF	14.37	13.46	12.54	12.52	12.10	12.27	11.70	11.36	11.00
KWH	44,927,569	45,433,486	43,964,329	41,374,022	42,144,346	39,534,746	40,436,453	40,232,957	39,454,235

Progress towards our CARBON goal



Gross emissions, does not include emissions reductions associated with the purchase of offsets

School of Engineering – EDA Efficiency Enhancements & **Results**

- High Efficiency Heat Recovery Systems
- Magnetic Bearing Chillers
- High Efficiency Condensing Boilers
- Occupancy Sensors – to automatically setback Labs from 6 to 4 air changes per hour
- **Leveraged a $220,000 rebate from Xcel Energy**
- **Modeled building energy efficiency is 21.6% greater than required by building codes**
- **$140,000 of annual utility savings vs. base model**

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High Efficiency
Run Around Energy Recovery System

Most Critical Elements of High Performance Run Around Energy Recovery System

High-performance Heat Exchangers (Coils)

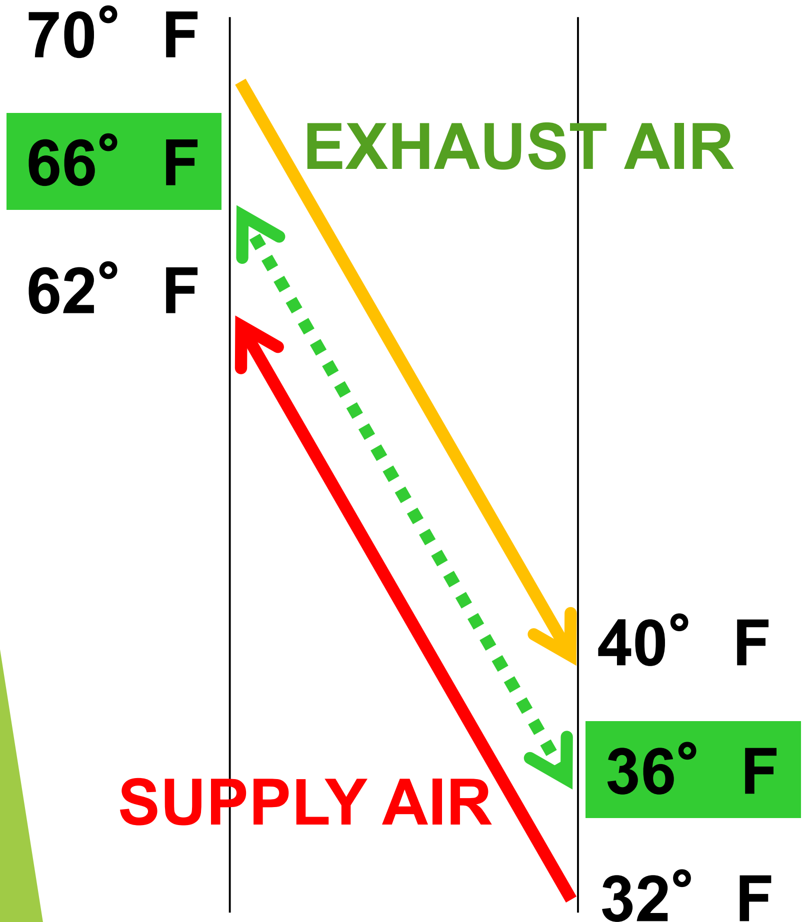
Demand-dependent Automatic Controls

- → mechanical ability to adjust the operating parameters
- → optimum performance at all operating conditions

Failure-free Operation (Monitoring)

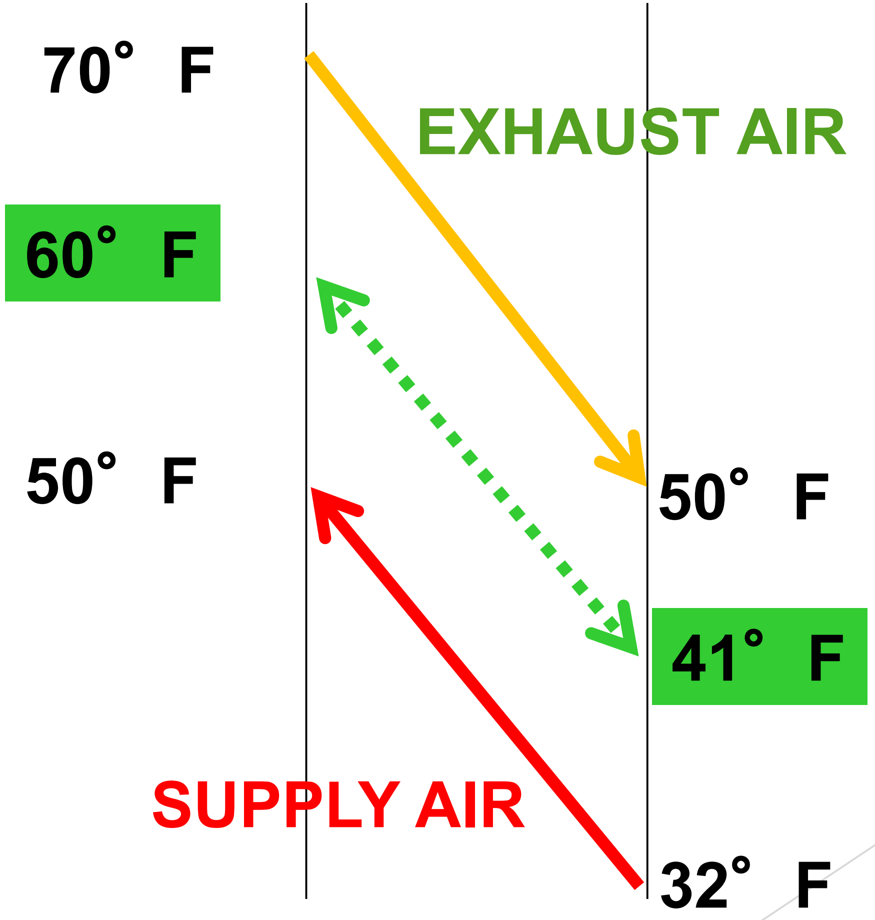
High Performance Coils

High-Efficiency System
4 degree approach temps



$\mu_T = 79\%$

Traditional System
9 – 10 degree approach temps



$\mu_T = 47\%$

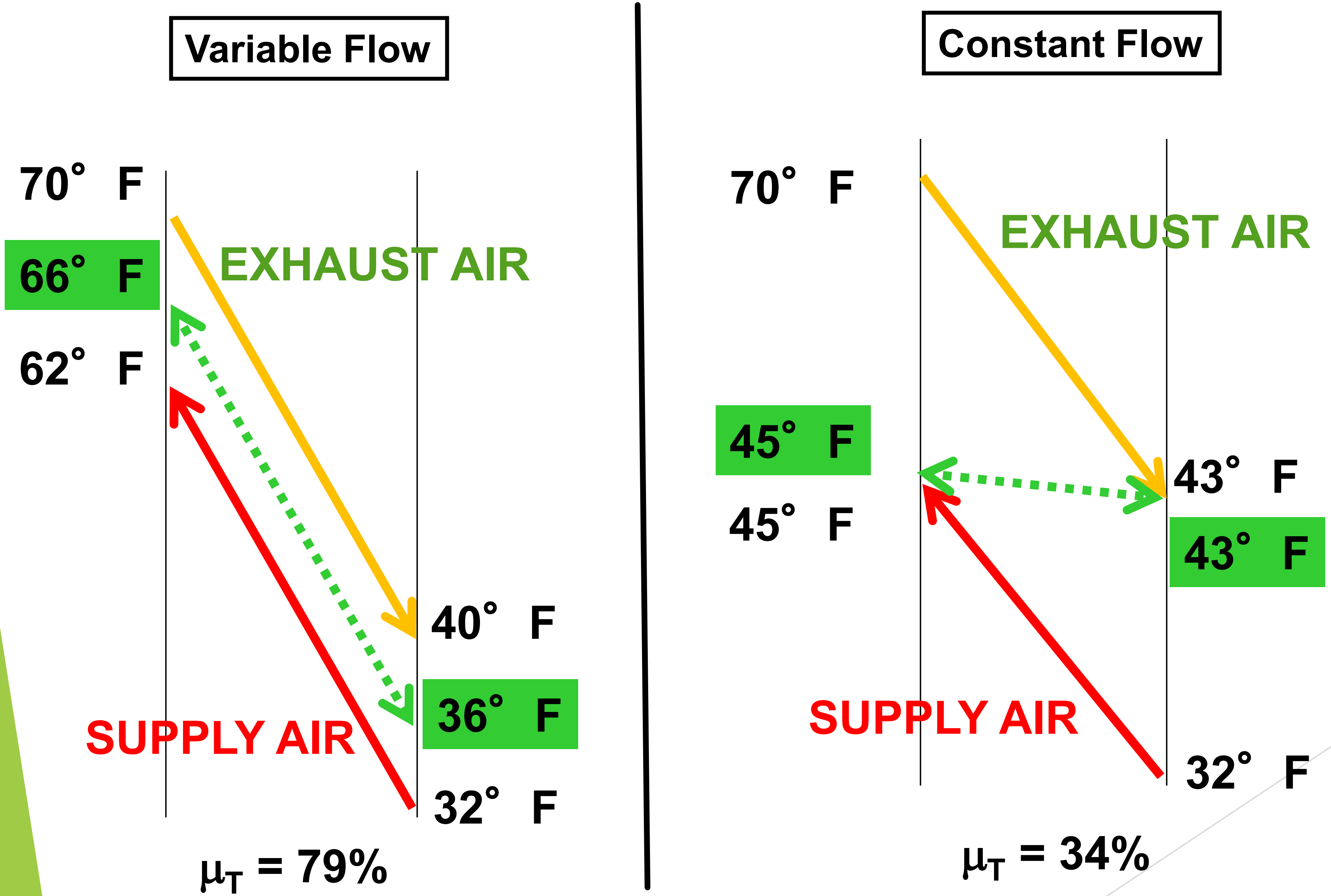
Optimal Recovery of the Energy in the Exhaust Air

Optimum Quantity Circulated at all Operating Conditions

$$Q = A * k * \Theta_m$$

Q = optimal ⬅ Θ_m = maximum

High Performance Coils



Prerequisite to Control High Performance ER-Systems:

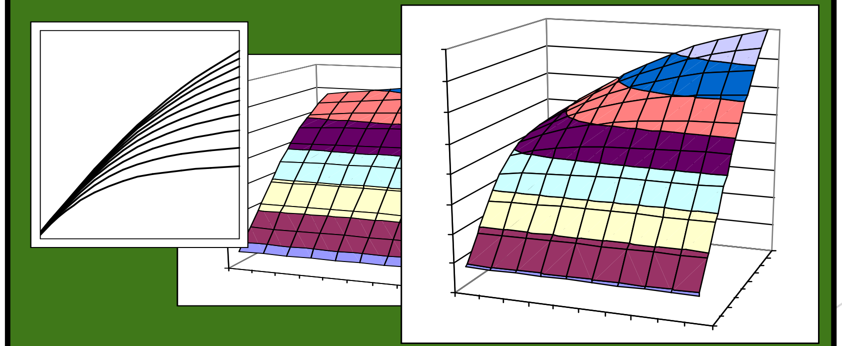
Continuously Vary Fluid Flow Rate According to Air Volumes & Air Temperatures To Maximize Energy Recovery

Numerical Simulation Performance-Mapping

Heat Demand
- Outside Temperature
- Supply Air Volumes
- Set Point Temperatures

Available Heat
- Exhaust Temp / Humidity
- Exhaust Air Volumes
- Heat Inputs from Plate & Frames

Performance Maps
- Heat Exchangers, Pumps, Valves

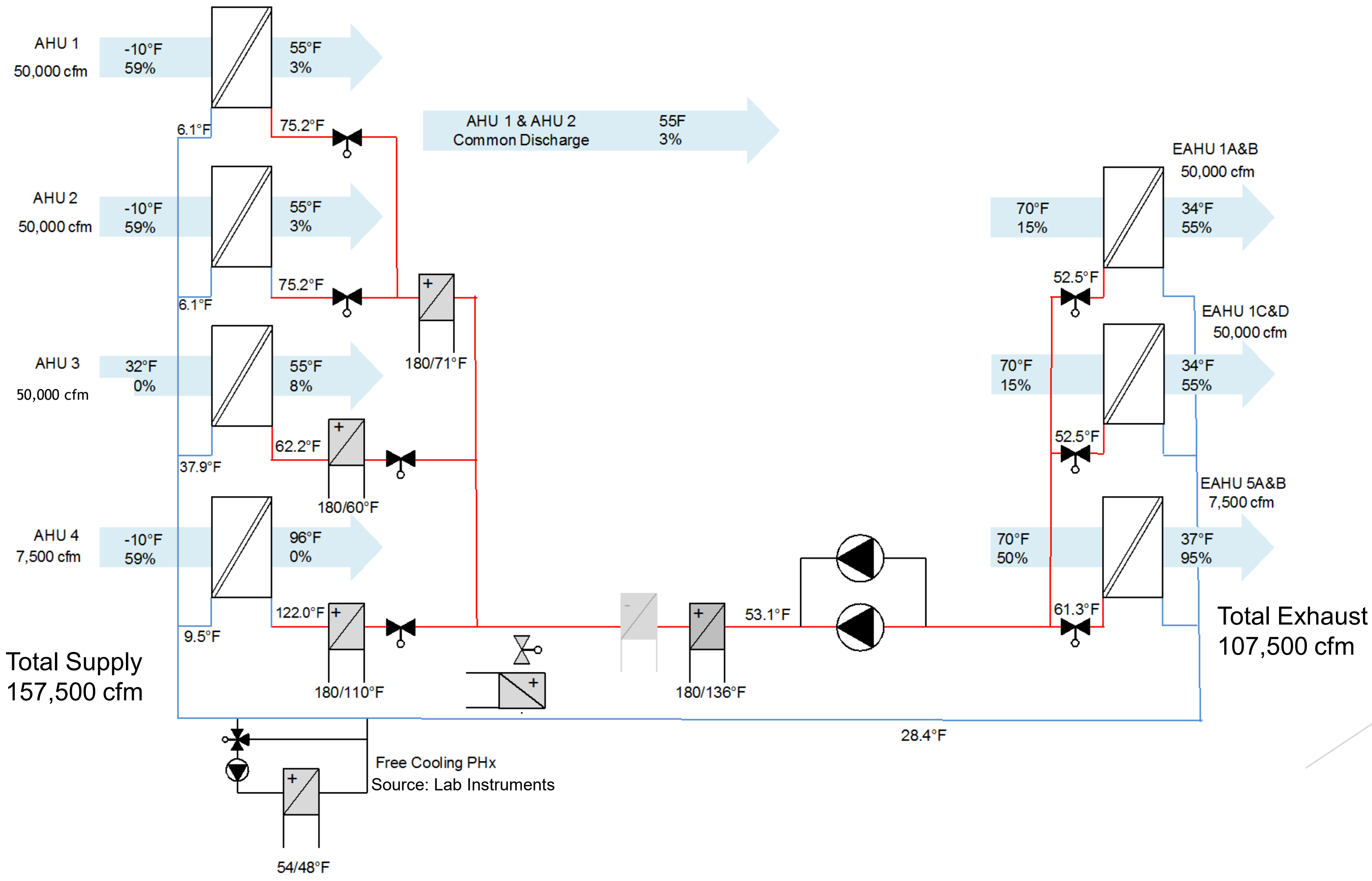


Hydronic Module Containing Controller Hardware & Software

Winter Design Point With Free Cooling:

PHx Heating Eliminates Heating Coil

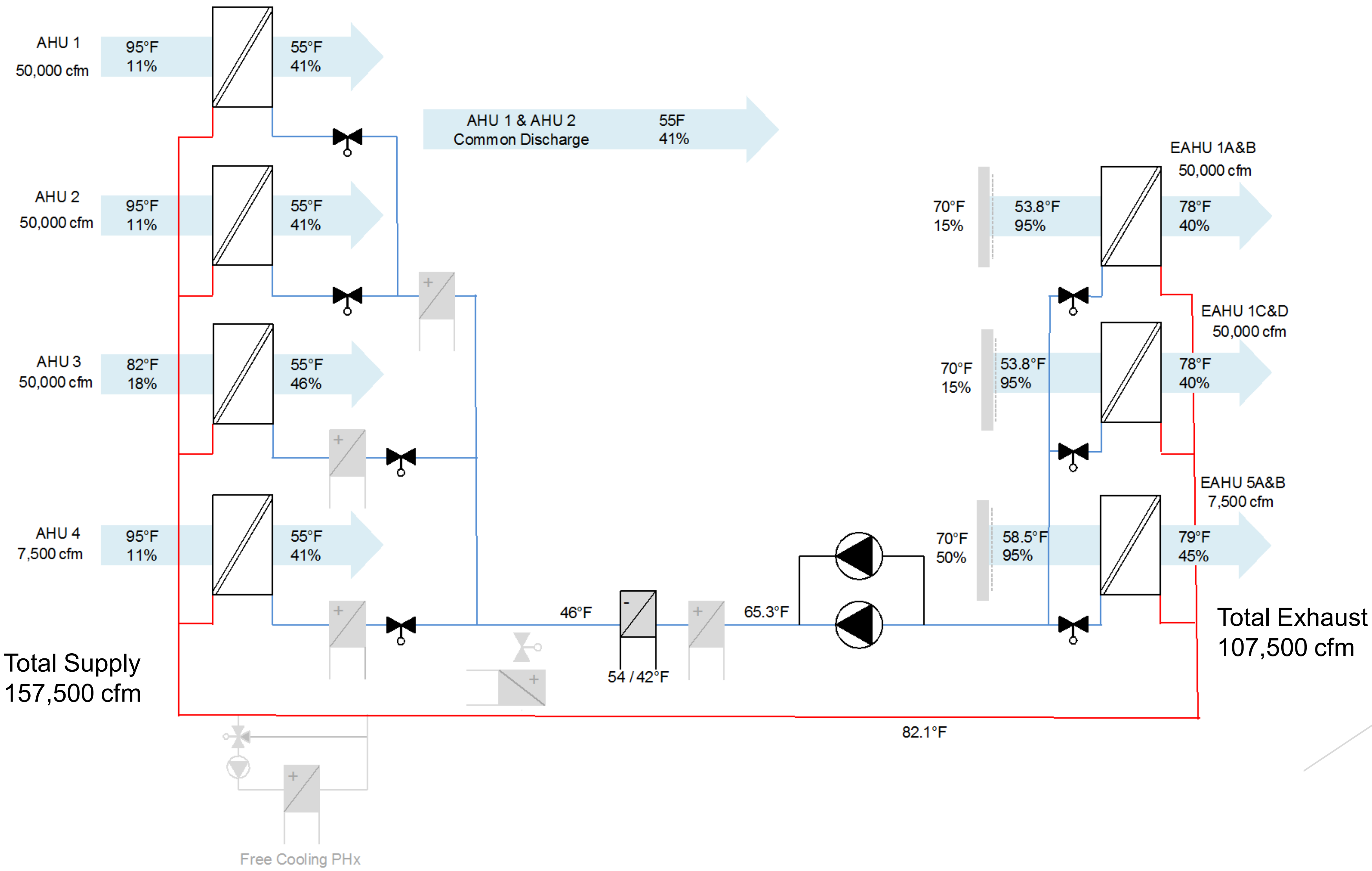
(Heating to 55F)



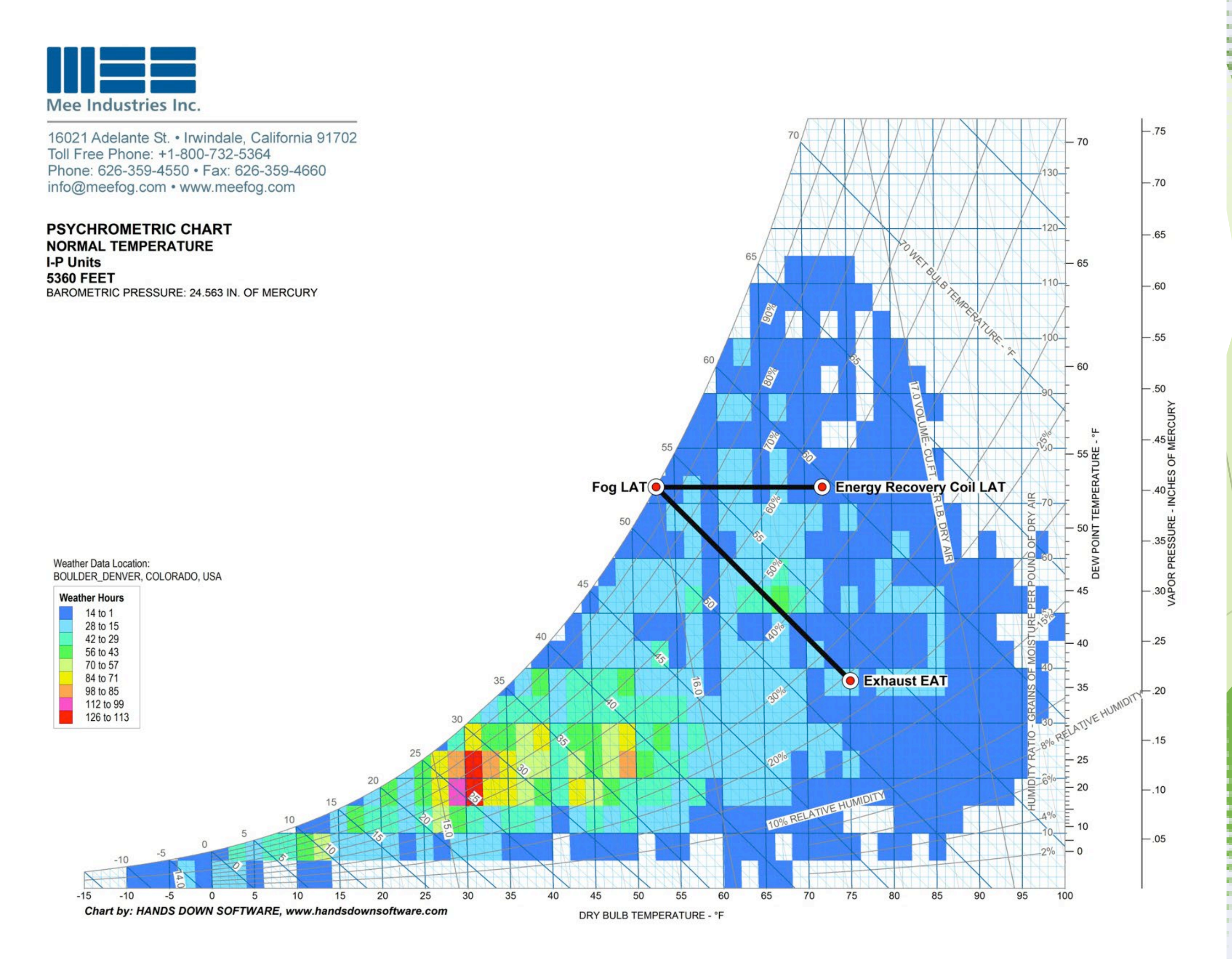
Summer Design Point With Adiabatic Cooling:

PHx Cooling Eliminates Cooling Coil

(Cooling to 55F)



- Exhaust EAT:
  75 db / 53 wb
- Fog LAT:
  53 db / 53 wb
- Evaporative cooling effect = 22 degrees



Energy Model

Denver, CO		Without Energy Recovery	Konvekta REARS	Konvekta REARS with Free Cooling
Winter				
Heating Energy Requirement	kWh/a	3,426,3450	337,416	214,554
Effectiveness Heating (heating to 55F)			90%	94%
		Without Energy Recovery	Konvekta REARS	Konvekta REARS with Free Cooling
Summer (with adiabatic exhaust cooling)				
Cooling Energy Requirement	kWh/a	2,119,433	852,303	852,303
Effectiveness Cooling (cooling to 55F)			60%	60%

Energy Model

Denver, CO		Without Energy Recovery	Konvekta REARS	Konvekta REARS with Free Cooling
Year				
Heating Energy	kWh/a	3,426,345	337,416	214,554
Cooling Energy	kWh/a	2,119,433	852,303	852,303
Electricity (Fans/Pumps)	kWh/a	259,068	321,513	321,513
Total Energy Consumption	**kWh/a**	**5,804,846**	**1,511,232**	**1,388,370**
Effectiveness			**74%**	**76%**

		Without Energy Recovery	Konvekta REARS	Konvekta REARS with Free Cooling
Peak Demand				
Cooling	**tons**	**492**	**271**	**271**
Heating	**MBTUH**	**8,000**	**2,200**	**1,700**

Energy Model

Denver, CO	Without Energy Recovery	Konvekta REARS	Konvekta REARS with Free Cooling
Annual Energy Cost			
Heating Energy	$82,918	$8,165	$5,192
Cooling Energy	$80,115	$32,217	$32,217
Electricity (Fans/Pumps)	$9,793	$12,153	$12,153
Total Energy Cost	**$172,825**	**$52,536**	**$49,562**
Energy Cost Savings		**$120,289**	**$123,262**

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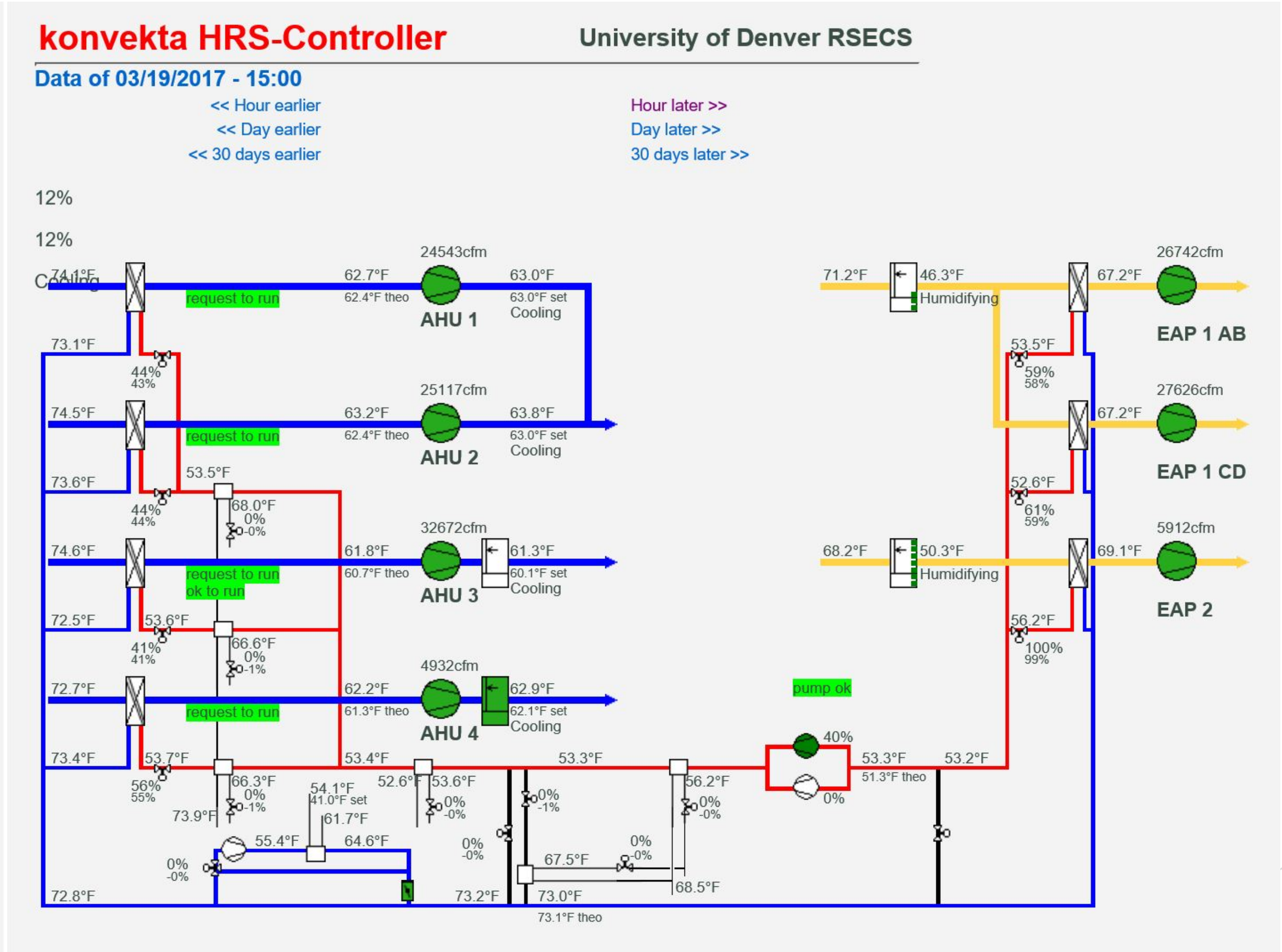
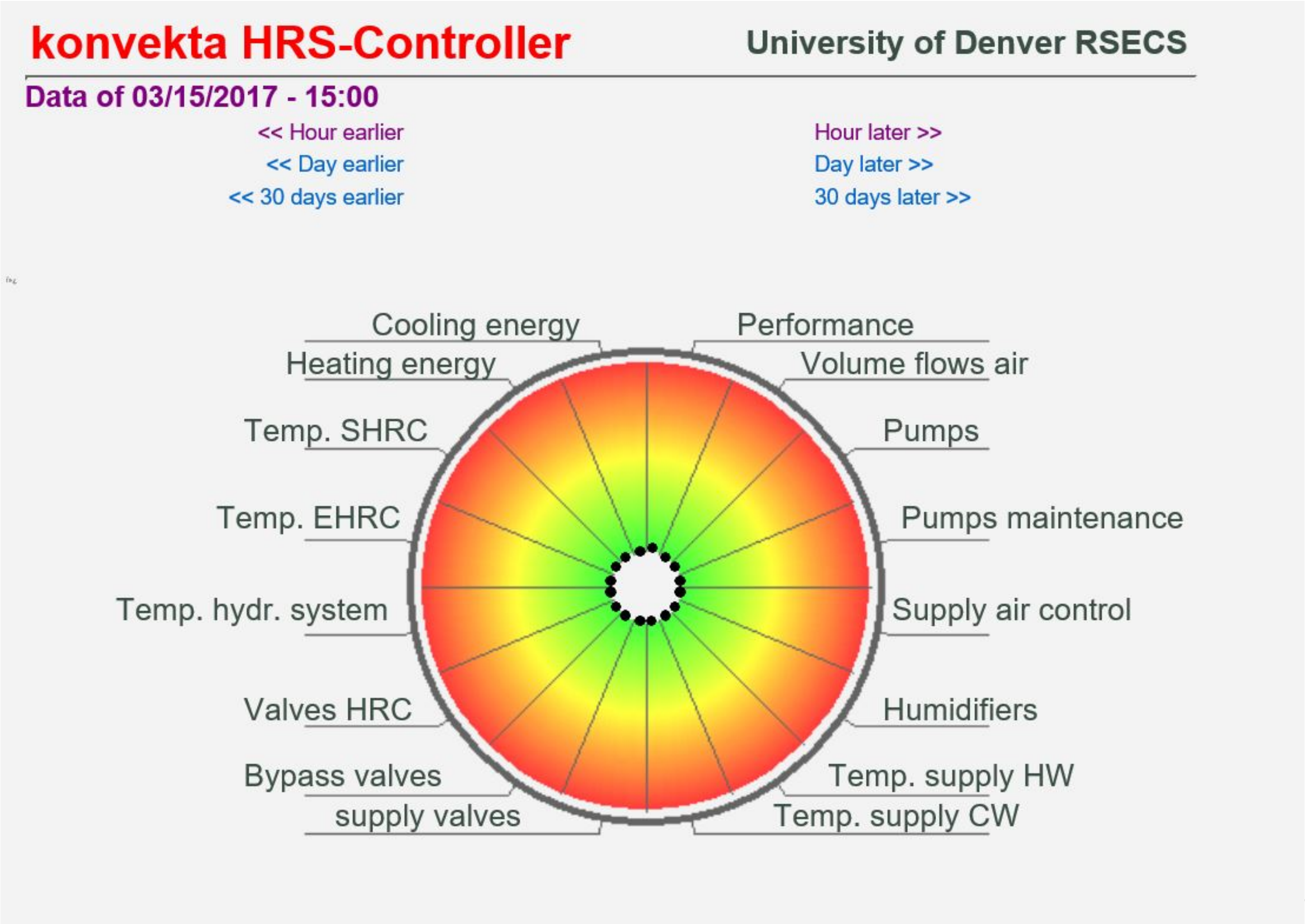
Continuously Monitor All Operating Parameters



Continuous Monitoring To Ensure Maximum Recovery Efficiency



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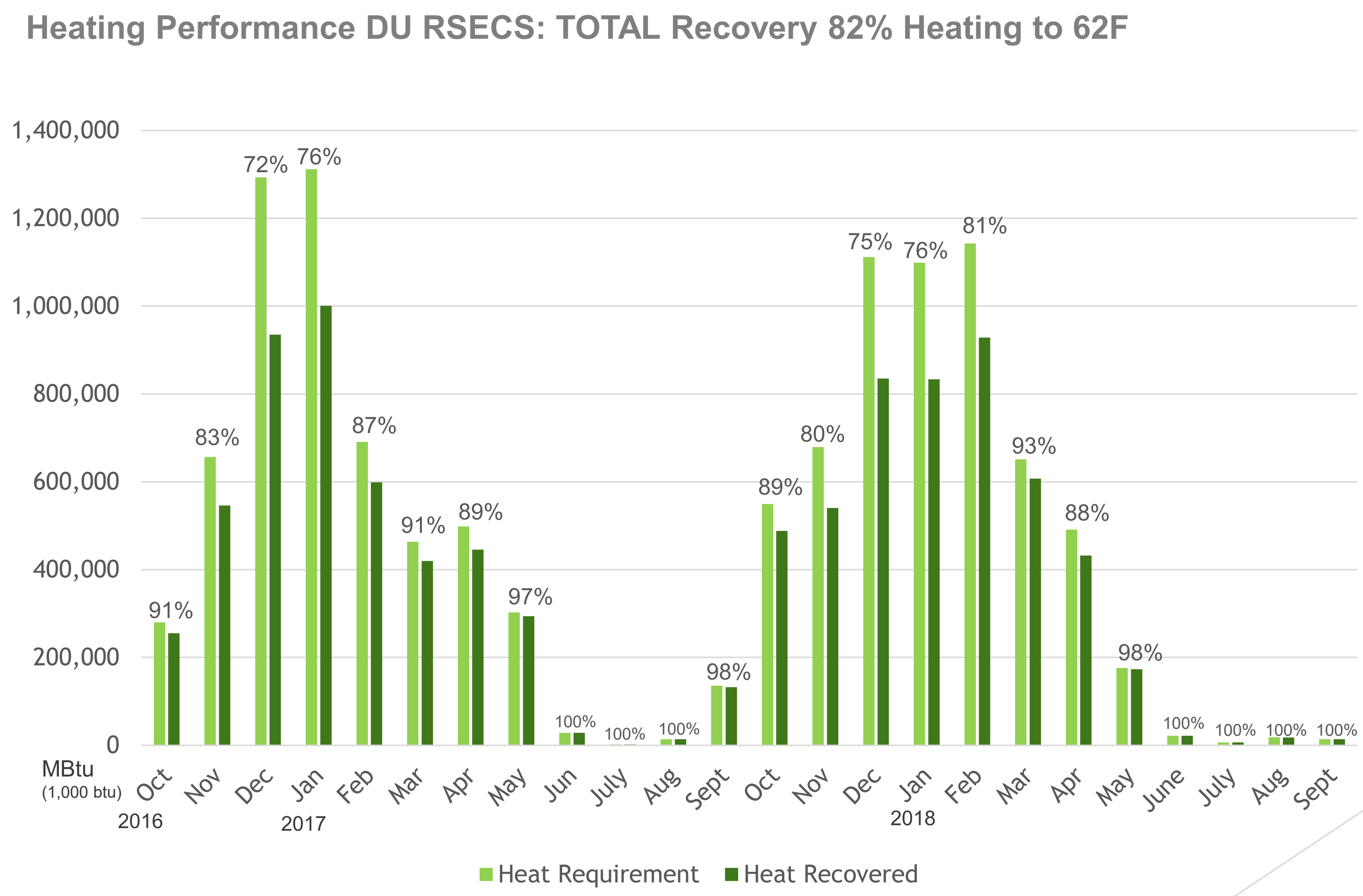

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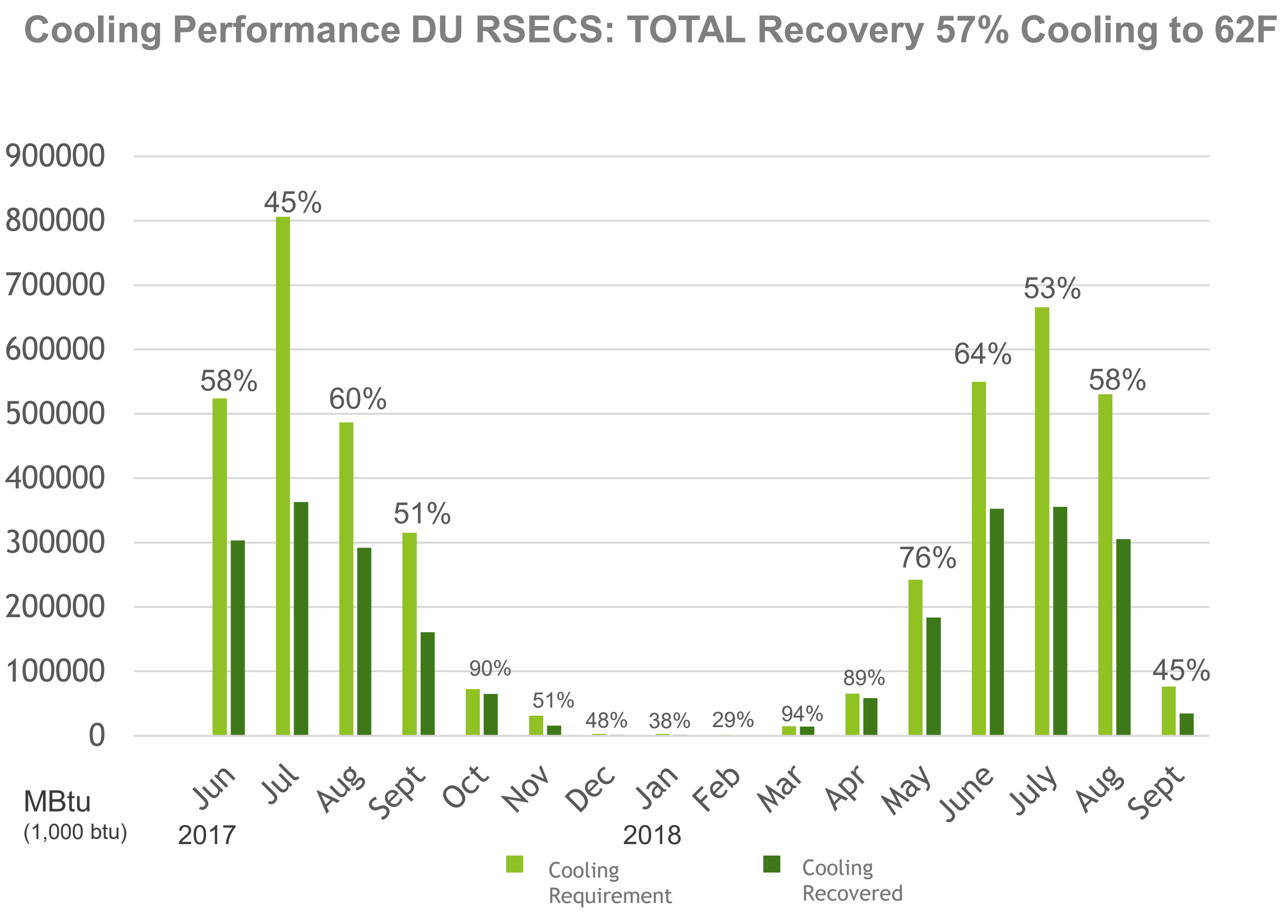

Questions

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