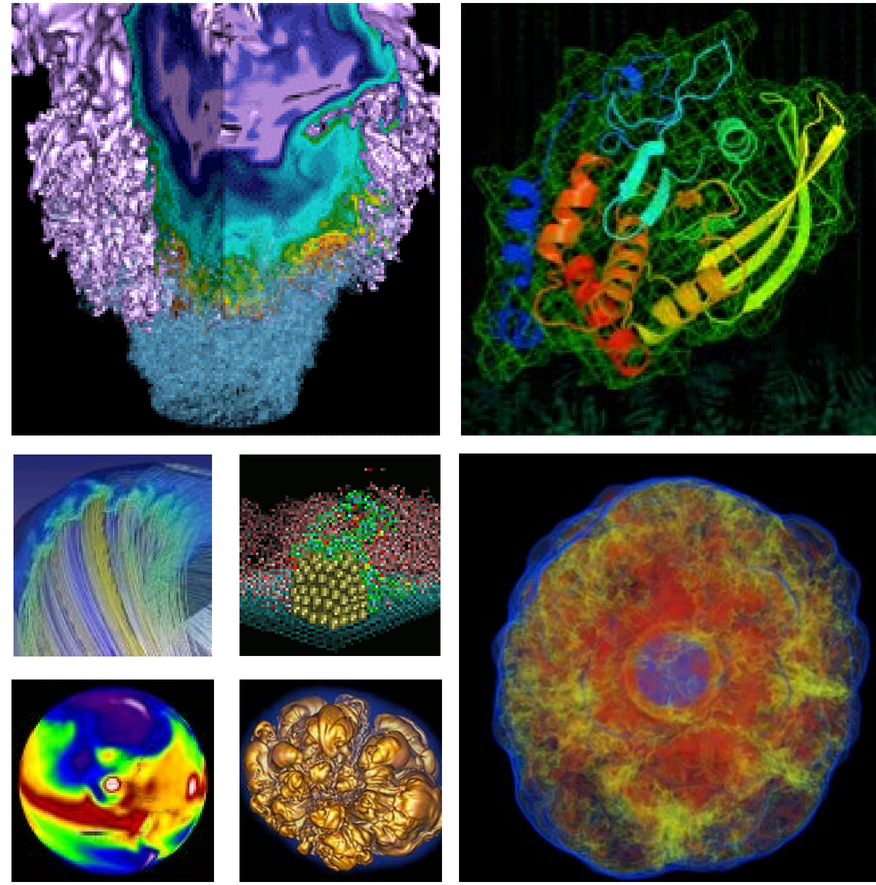
NERSC Computational Theory and Research Building (CRT)



Better Buildings Summit
Washington DC
May 16, 2017
Dale Sartor, PE

NERSC 40 YEARS at the FOREFRONT 1974-2014

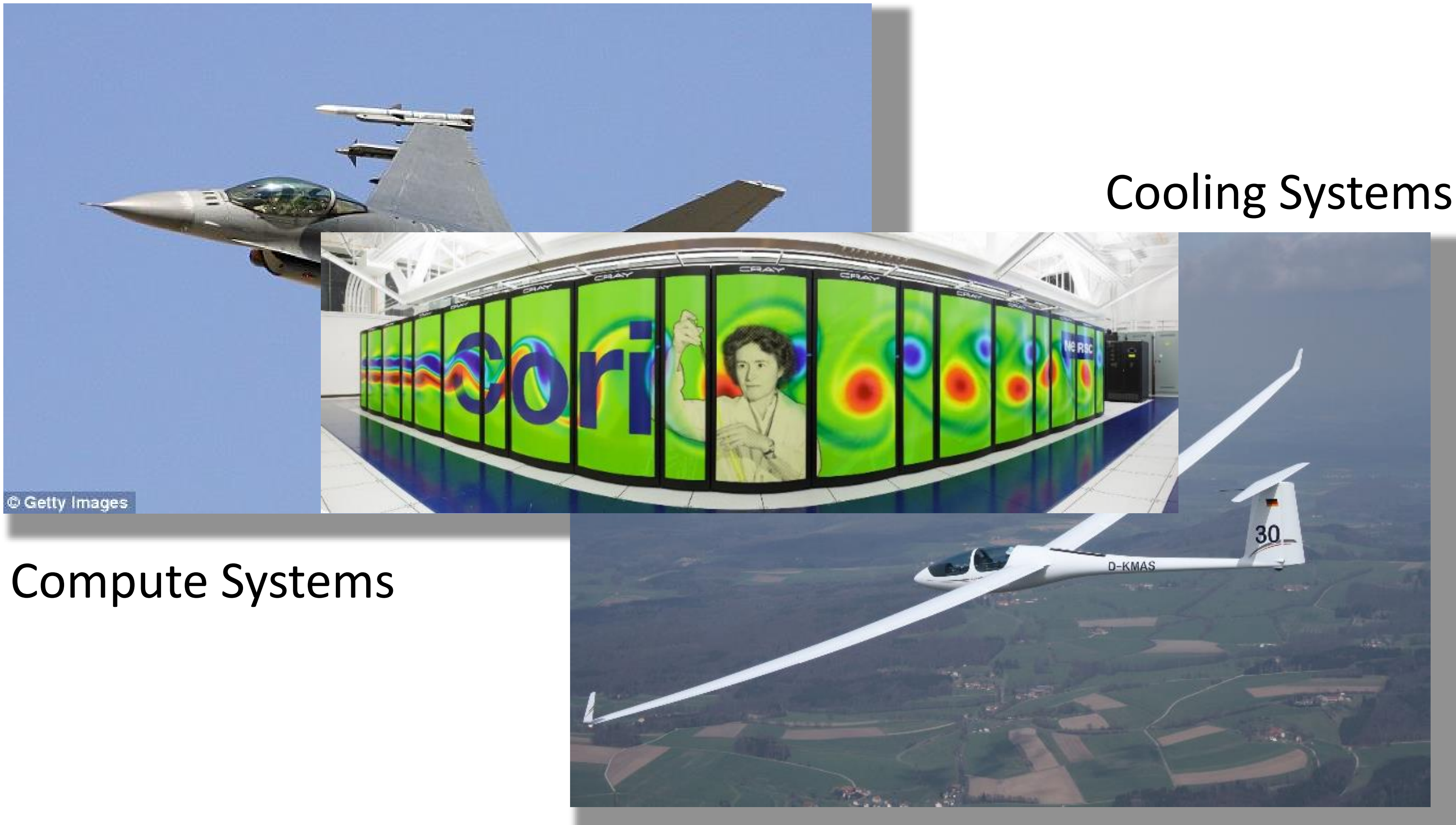
U.S. DEPARTMENT OF ENERGY | Office of Science

Version: 050417

BERKELEY LAB

What does your Energy look like?

Cooling Systems



Compute Systems

The New Home for NERSC

UC's Computational Research and Theory (CRT) Facility

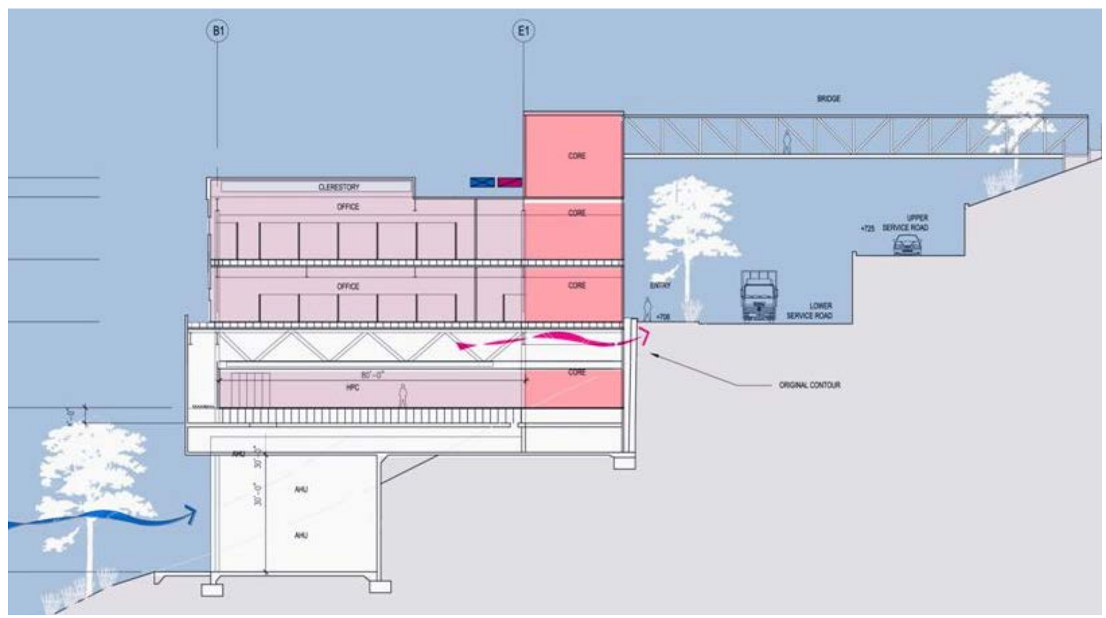
- 142,000 square feet total
- 7 MW IT load to start, then up to 17, then ???
- IT load will dominate building
- 4 large AHUs for air-cooled loads
- 4 cooling towers with a heat exchanger for water-cooled loads
- Water-cooled supercomputers
- Air and water side economizers
- Air-side heat recovery for heating offices
- IT loads cooled without compressors

NERSC hosts Cori (#5 Top 500, Nov 2016)

File Systems and Air Cooled Computers

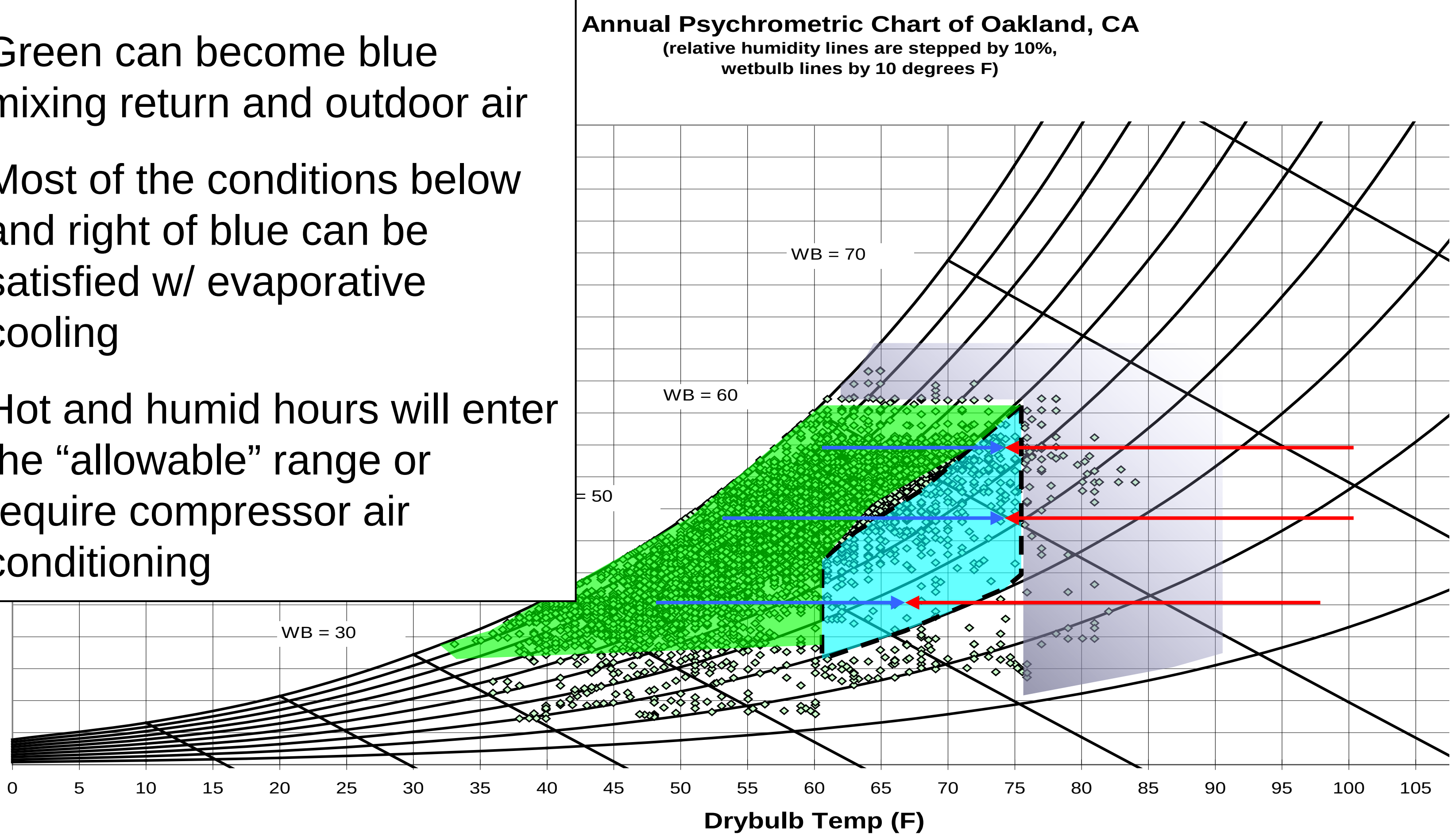
Air System Design Approach:

- Annual PUE less than 1.1
- Air-Side Economizer
- Direct Evaporative Cooling for Humidification/Pre-cooling
- Low Pressure-Drop Design



Free Cooling – Outside Air Based Design

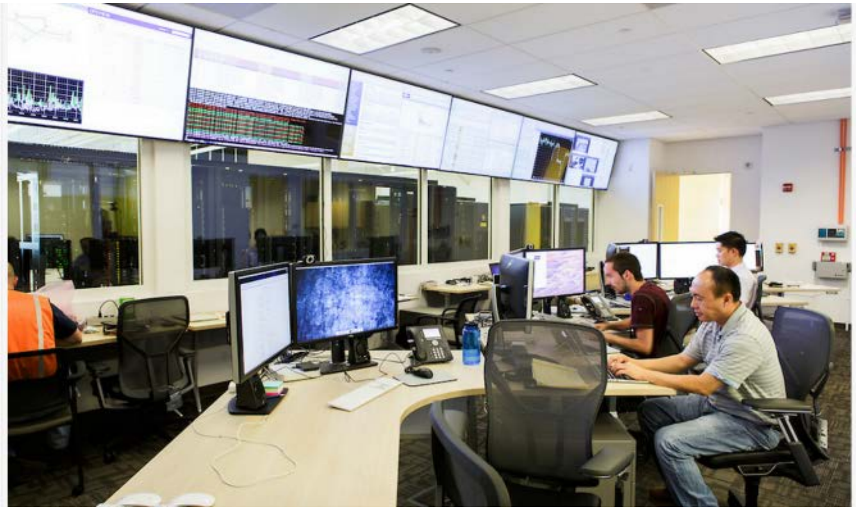
1. Blue = recommended supply
2. Green can become blue mixing return and outdoor air
3. Most of the conditions below and right of blue can be satisfied w/ evaporative cooling
4. Hot and humid hours will enter the "allowable" range or require compressor air conditioning



Free Cooling - Water Based Design

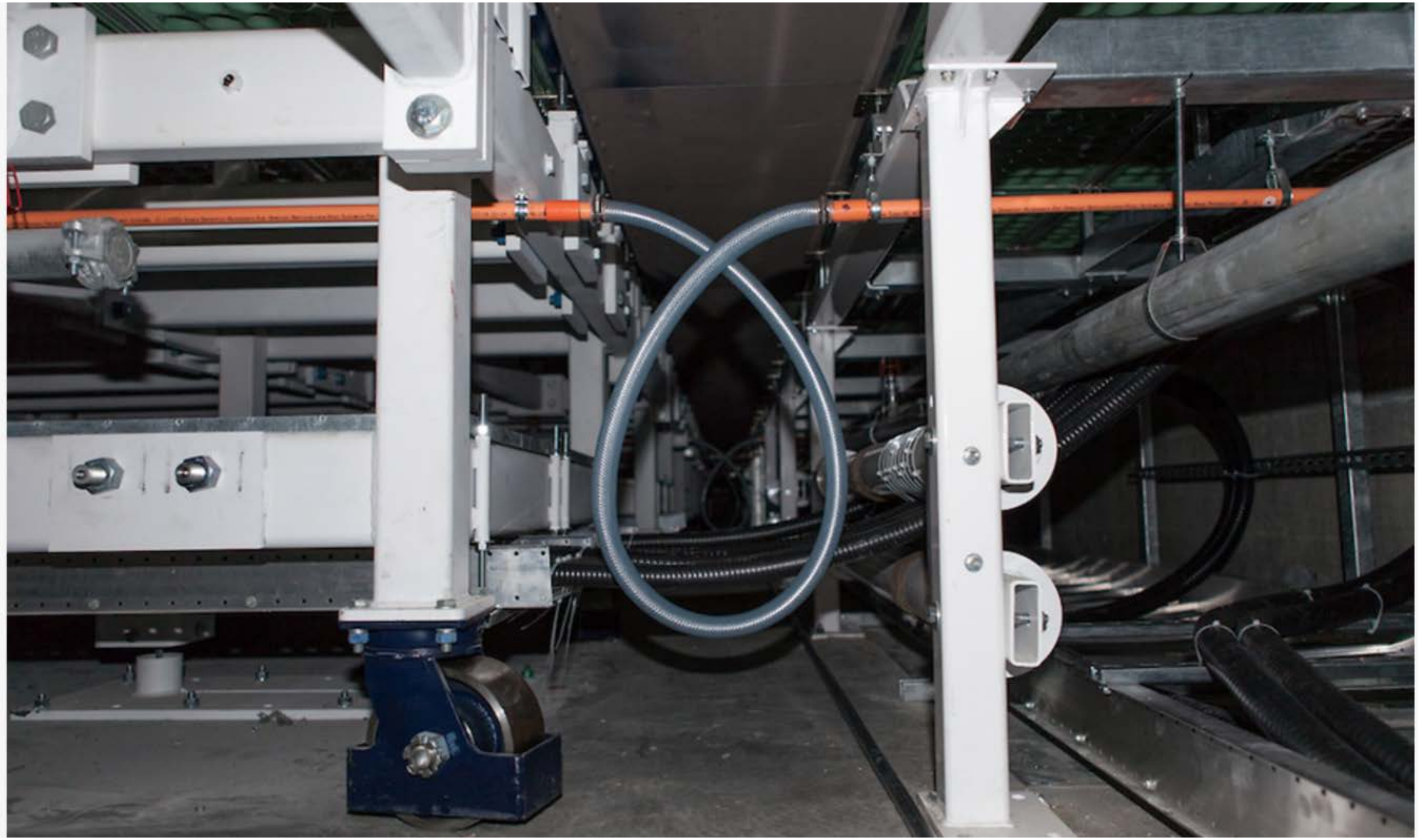
CRT Performance:

- Annual PUE less than 1.1
- Closed-loop treated cooling water from cooling towers
- Headers, valves and caps for modularity and flexibility



1st Phase 20k Sq Ft Computer floor

Seismically isolated from building



12.5 MW power (40 MW max)

10 MW liquid cooling (20 MW max)

6 MW of liquid cooled systems installed

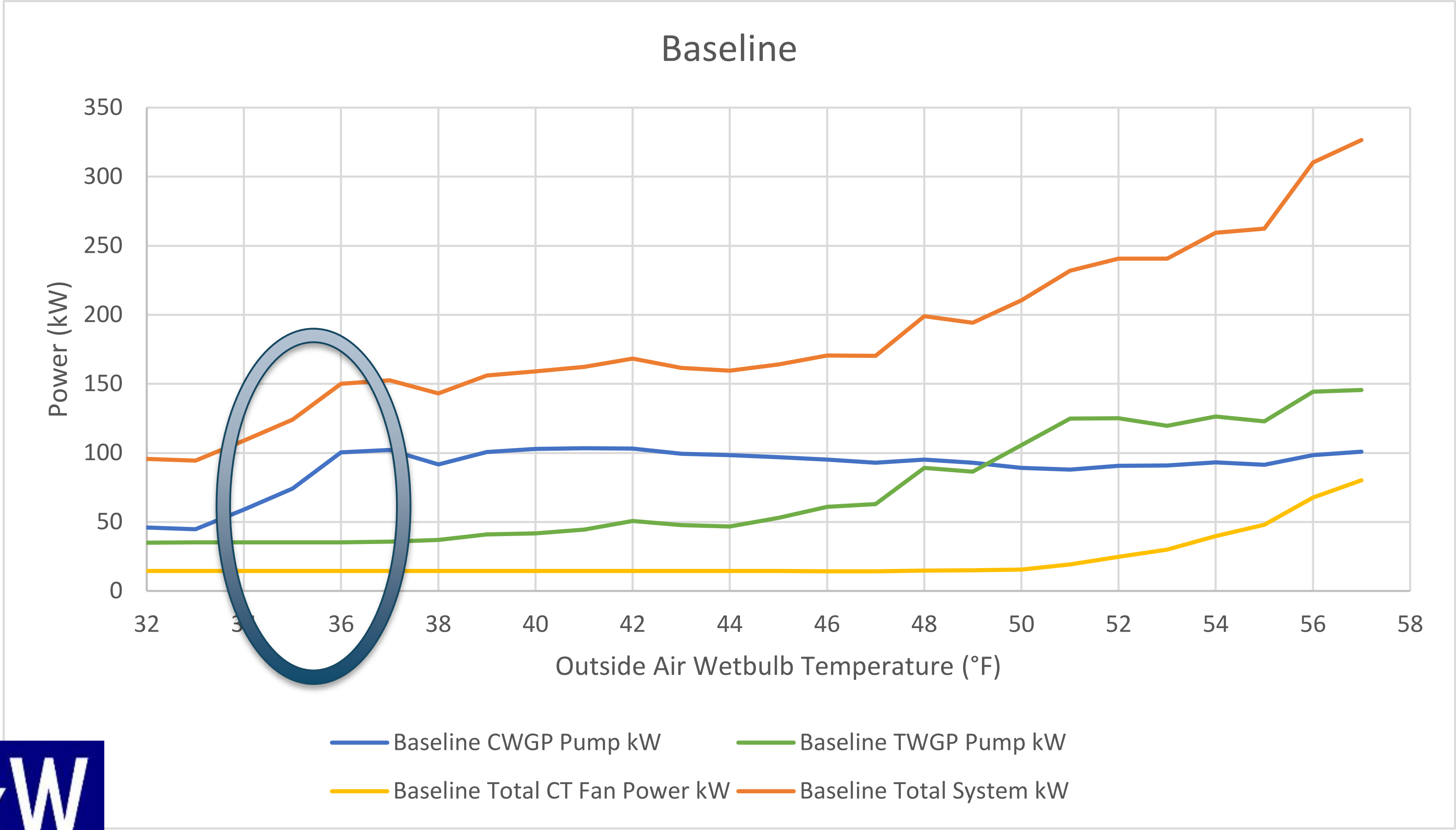
2 MW Air Cooling (17 MW max)

100 % Outside air capable

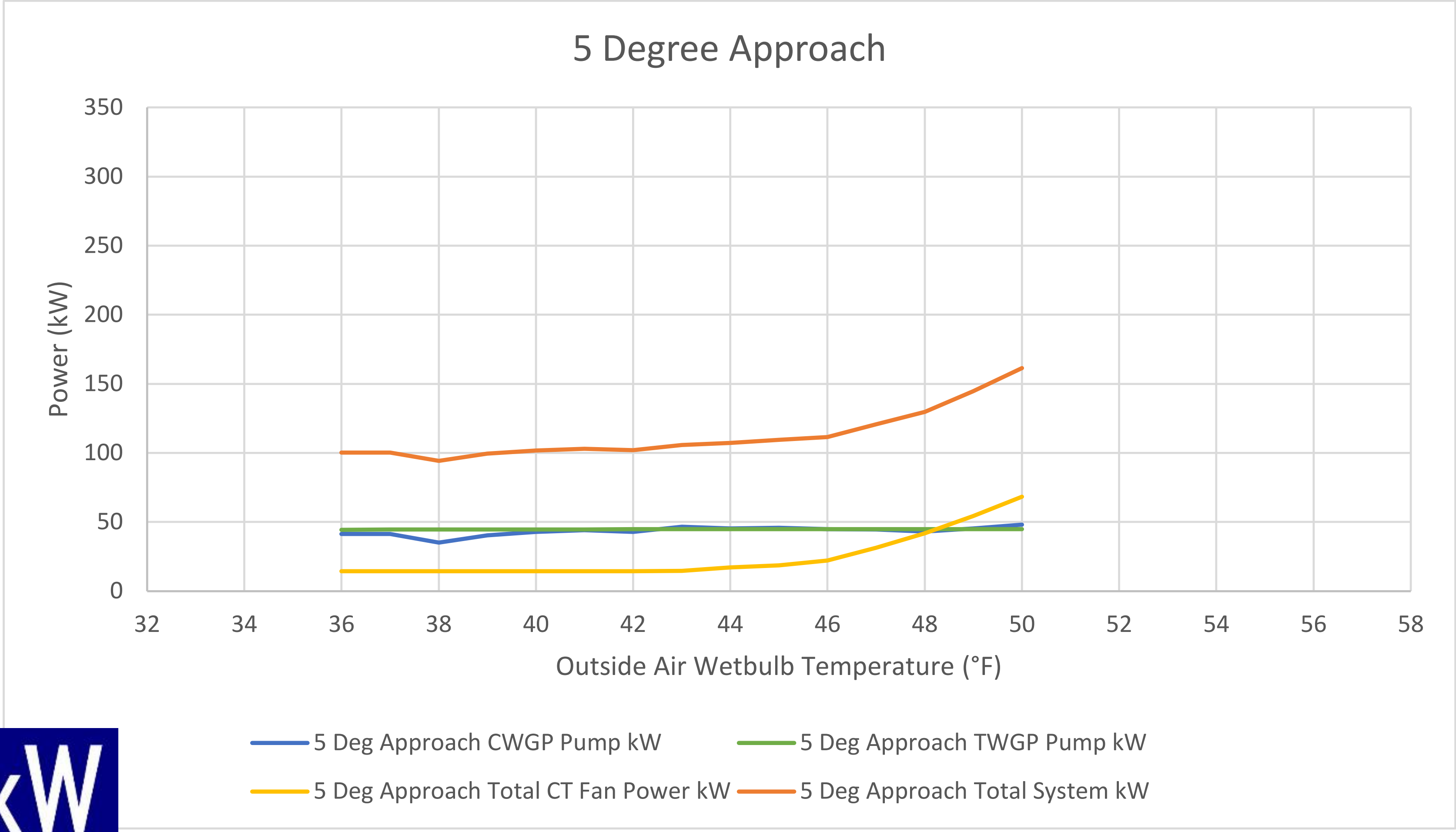
Real Life

- **Performance**
- **Opportunities for improvement/optimization**
- **Lessons learned**

Liquid Cooling Performance Baseline



Liquid Cooling Performance Balanced



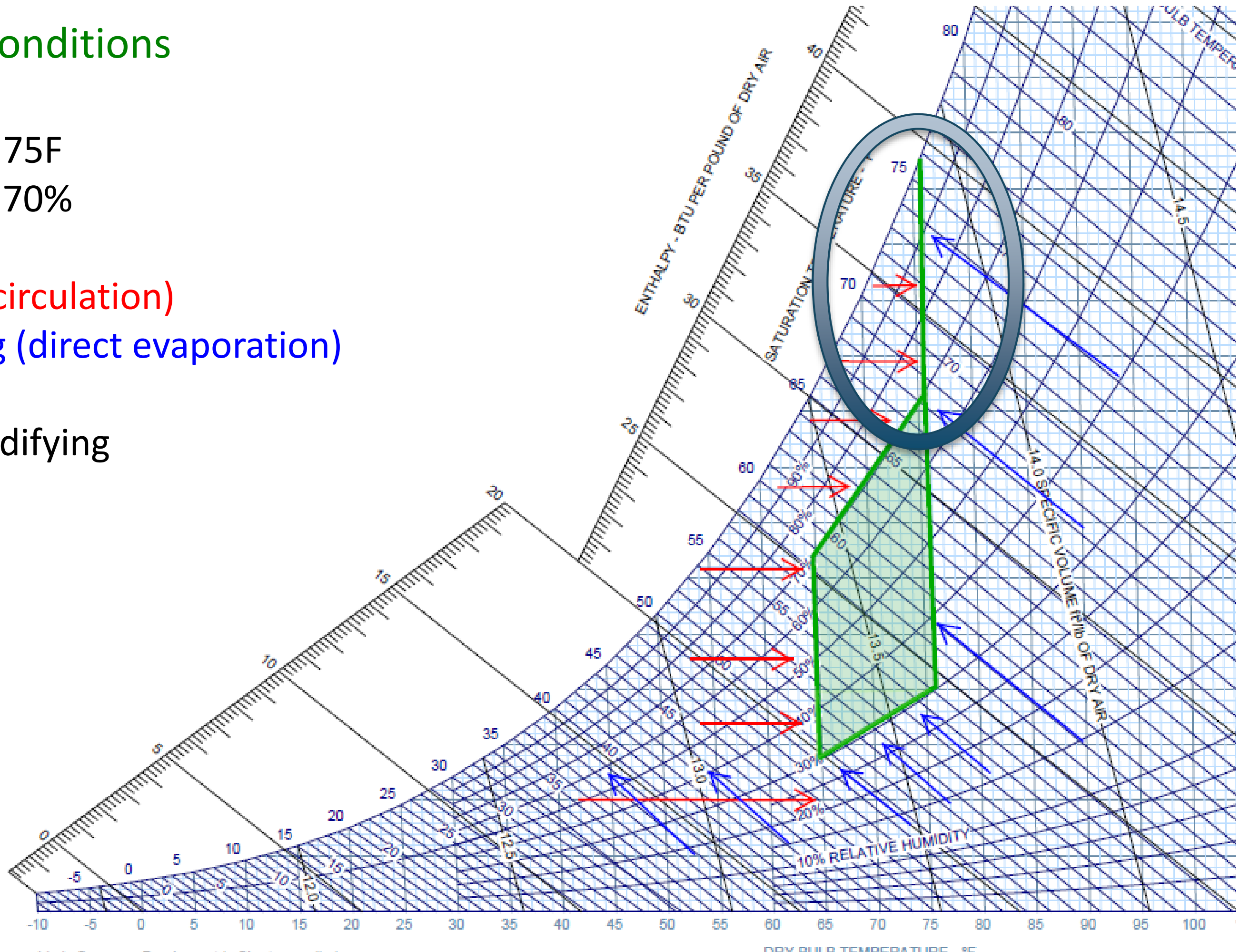
Data Center ASHRAE Design

Baseline Conditions

65F < SAT < 75F
30% < RH < 70%

Heating (recirculation)
Humidifying (direct evaporation)

NO Dehumidifying



Linric Company Psychrometric Chart, www.linric.com

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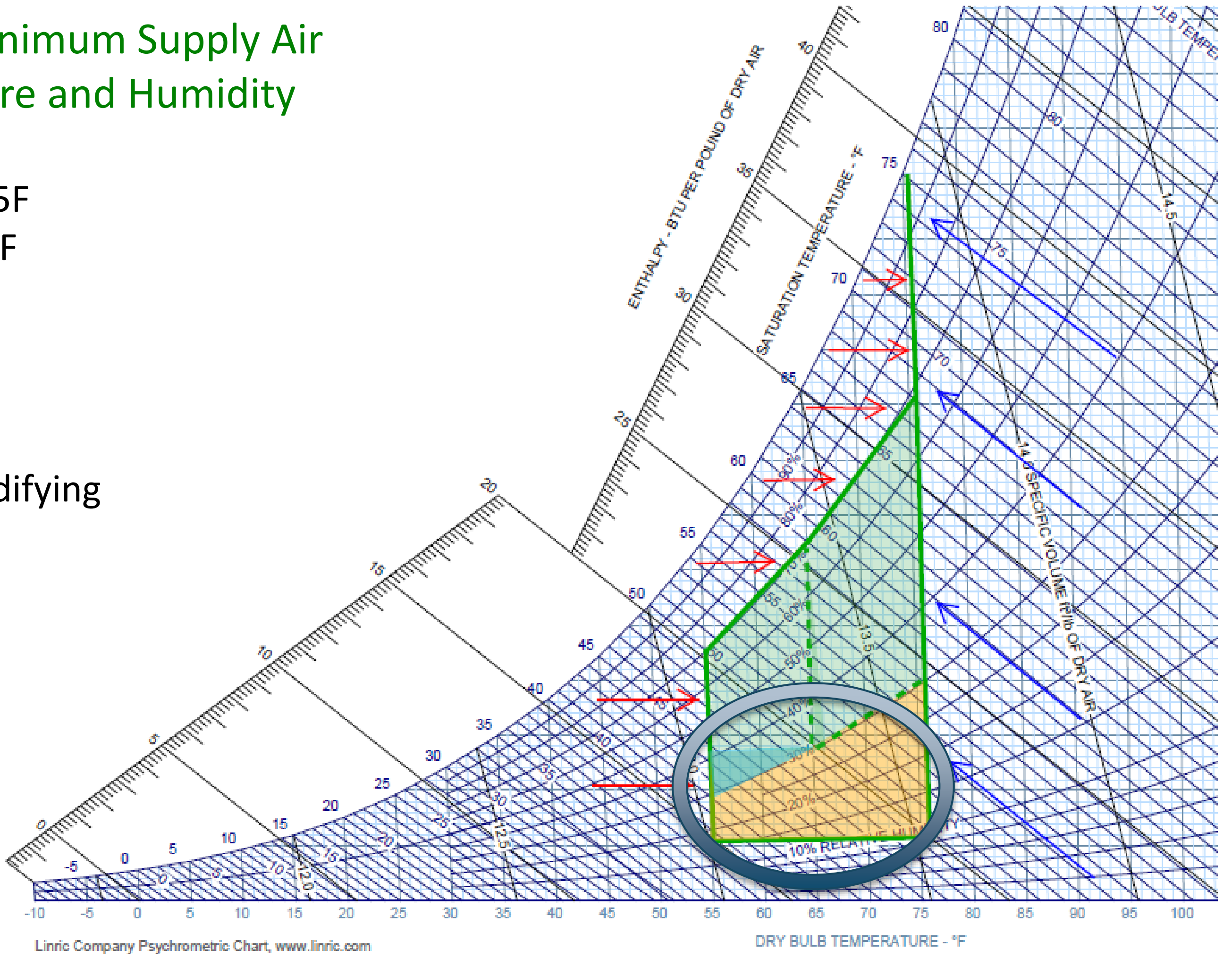
Allowing Lower Relative Humidity

Reduce Minimum Supply Air Temperature and Humidity

Min SAT = 55F
Min DP = 10F

Heating
Humidifying

NO Dehumidifying



Electricity and Water Savings

	Measure Title	Energy Savings (kWh) Estimated	Energy Savings (kWh) Verified	Water Savings Gallons	Cost Savings $	PUE Reduction
Controls						
1	Optimize Cooling Tower Fan and Pump Controls	-	360,000	100,000	$ 20,880	0.007
2	Optimize Closed Loop Pump Control	240,000	-	110,000	$ 13,920	0.005
3	Optimize AHU SAT and Flow Control	300,000	-	-	$ 17,400	0.006
4	Reset Cooling Water Supply Temperature	600,000	-	220,000	$ 34,800	-
5	Install Firmware to Enable ESS Mode for UPSs	190,000	-	65,000	$ 11,020	0.004
Physical Projects					$ -	
6	Cold Aisle Partial Containment	100,000	-	-	$ 5,800	0.002
	Total	**1,400,000**	**400,000**	**500,000**	**$ 100,000**	**0.025**

IT kWh	48,200,000	*Extrapolated based on typical operation*
Total Non-IT kWh	3,200,000	*Does not include CRAY fans*
PUE	1.07	
Estimated Post-Case PUE	1.04	
Savings as a Fraction of Cooling System kWh	56%	

Rough Savings Estimates

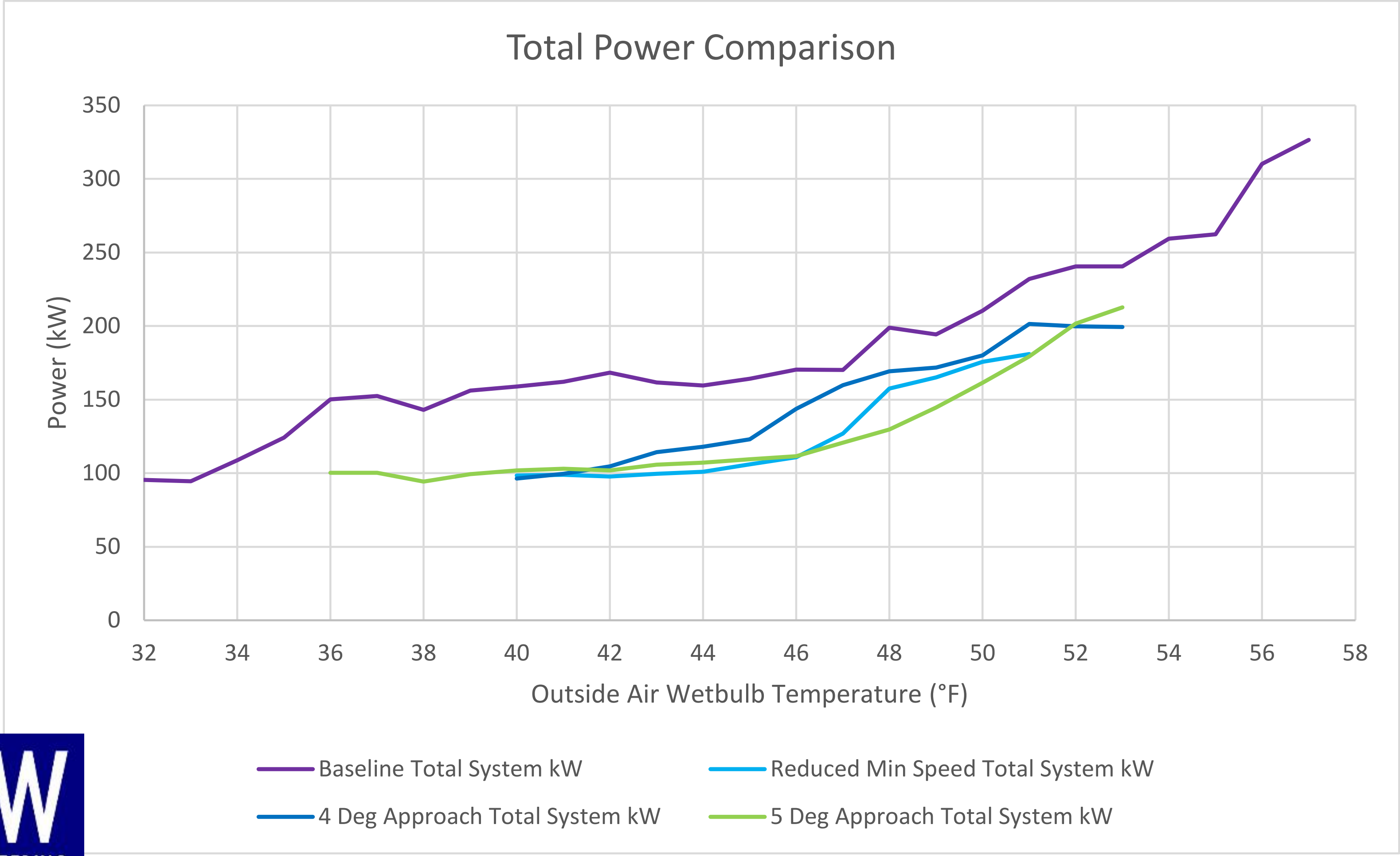
	Measure Title	Energy Savings (kWh) Estimated	Energy Savings (kWh) Verified	Water Savings Gallons	PUE Reduction
Controls					
1	Optimize Cooling Tower Fan and Pump Controls	-	360,000	100,000	0.007
2	Optimize Closed Loop Pump Control	240,000	-	110,000	0.005
3	Optimize AHU SAT and Flow Control	300,000	-	-	0.006
4	Reset Cooling Water Supply Temperature	600,000	-	220,000	(0.001)
5	Install Firmware to Enable ESS Mode for UPSs	190,000	-	65,000	0.004
Physical Projects					
6	Cold Aisle Partial Containment	100,000	-	-	0.002
	Total	1,400,000	400,000	500,000	0.024

Cost of electricity	$ 0.058	/kwh
Non IT load savings	1,190,000	kWh
[illegible]	[illegible]	[illegible]

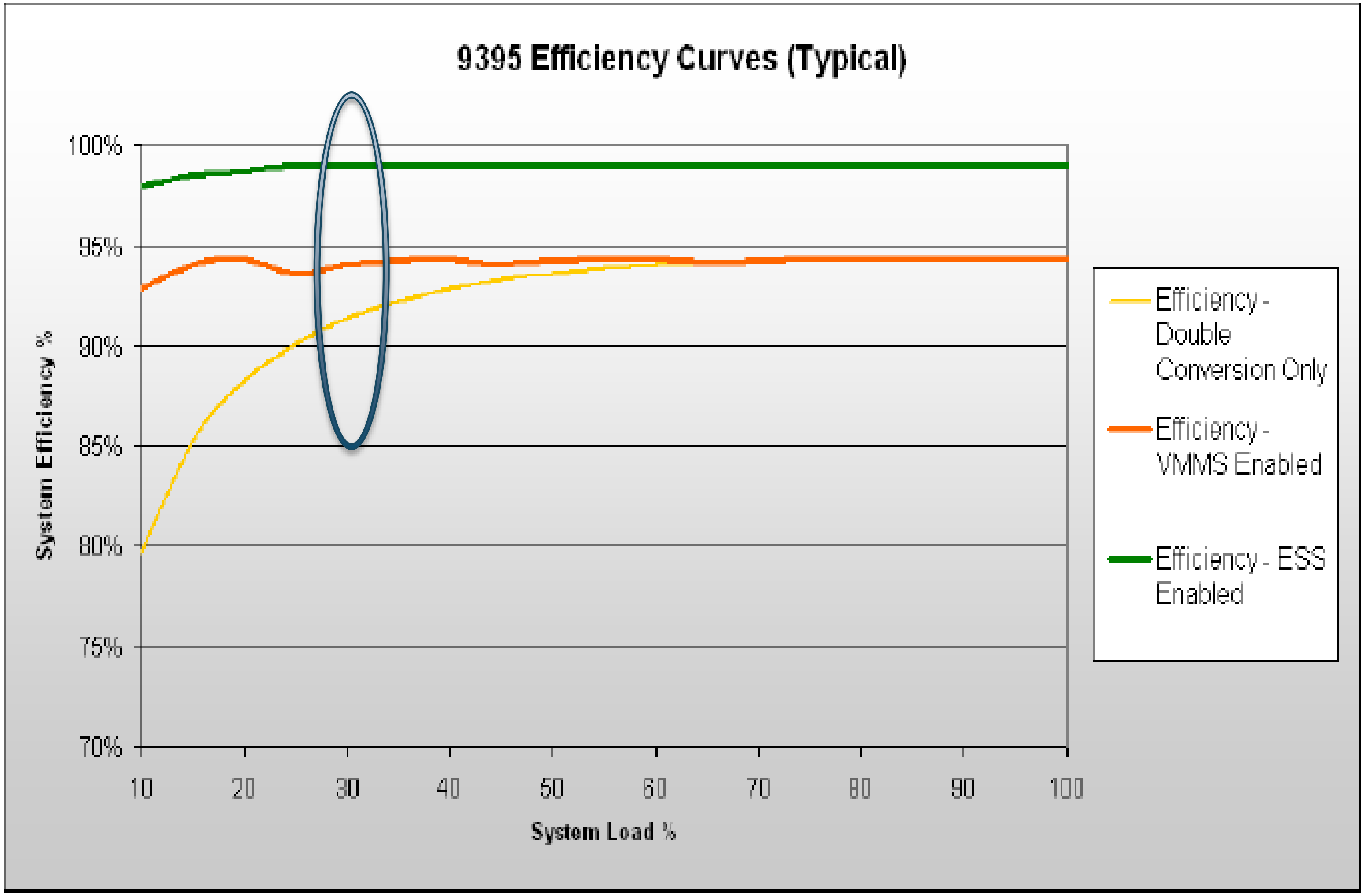
Measure Breakdown

- Cooling tower supply temperature reset based on wetbulb temperature
- Reduce minimum tower water pump speed based on minimum cooling tower flow
- Install booster pump to serve RTUs, lowering differential pressure in main cooling water loop
- Replace closed loop bypass valves with flow limiters
- Adjust closed loop differential pressure reset
- Reduce AHU supply air temperature as outside air temperature drops, and control fan speed based on max cold aisle temperature
- Turn off redundant cooling tower pump to improve pump efficiency
- Enable variable speed fan control on CRAY units and optimize cooling water temperature
- Expand cold aisle temperature/RH envelop based on ASHRAE 2015 guidelines
- Install firmware to enable ESS Mode (eco mode) for UPSs

Cooling System Optimization



Skip the Double Conversion Losses



Our Approach

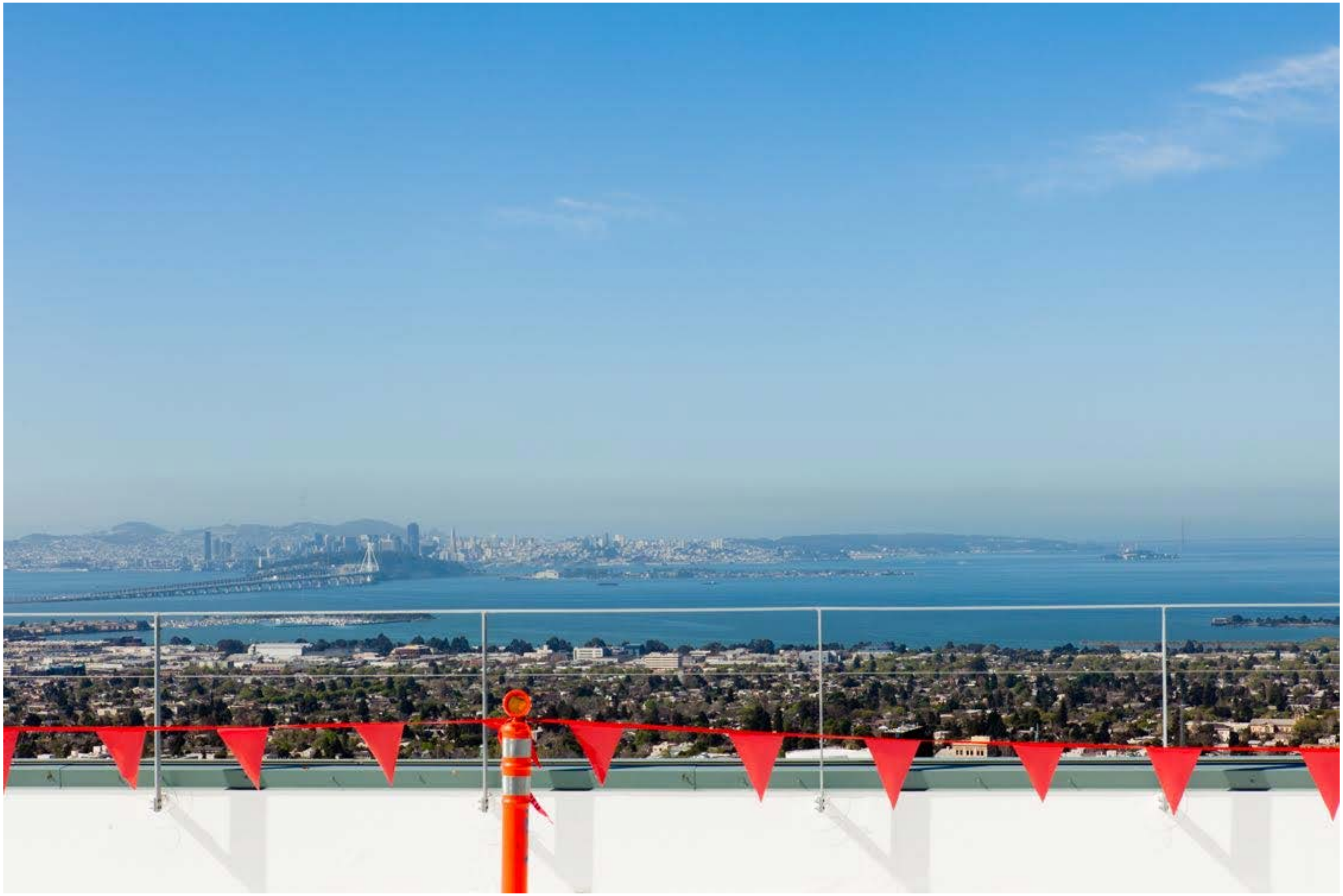
1. Identify opportunities
2. Identify critical control boundaries
3. Try it out!
4. Verify using trend data
5. Repeat until optimized

All parties work closely throughout the project

Takeaways

- Involve full team from measure development through implementation
- Start with client priorities and question everything
- Incremental, iterative progress can be most affective
- Don't underestimate interconnectivity of systems
- A sub 1.1 PUE data center can still be improved!

The source of cool air and cool views …



Questions?

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