



Reaching the Unreachable Loads

for EE and DER using the
High Efficiency Dehumidification
System (HEDS)

DOD ESTCP Competition Winner 2014 & 2018

*DOE FEMP "Call For Innovation" Award
Winner 2016*

*Naval Surface Warfare Center, Carderock
Division "HEDS for Ships" Evaluation Contract
2018*

Prepared for: E Source Forum

Ver 8/6/18

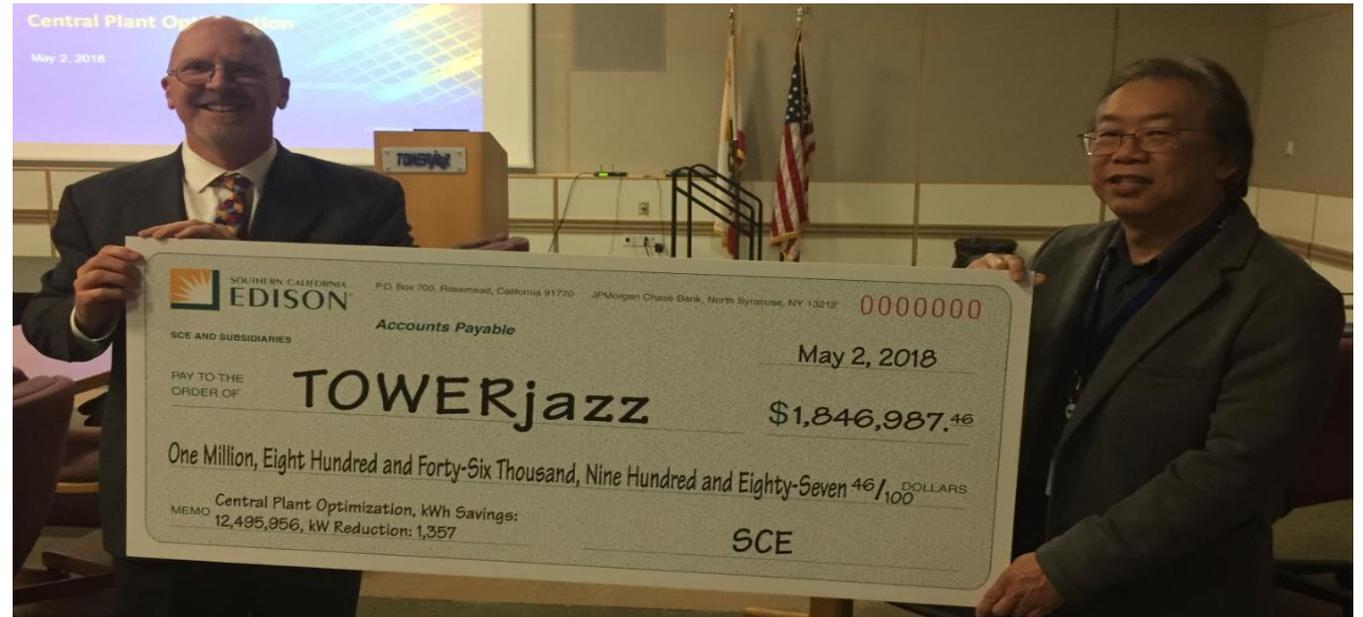


Street Cred – most of you don't know me...

- EE - Two of my projects have been awarded the 1st and 2nd largest Energy Efficiency incentives, ever, in SCE Territory:
 - **\$1,847,000 for TOWERJazz,**
 - **\$1,800,000 for LBA Realty**

DER - We were told by SCE that we delivered more successful Demand Response projects than any other firm, and they all worked as designed!!

Load Shaping - SCE Permanent Load Shift Pilot Program
– 3 MW Load Shift and 30% Efficiency Improvement
Mark Martinez, SCE, as a reference.



Street Cred, continued

- We have won two global DOD competitions for the Environmental Security Technology Certification Program (ESTCP), 2014 and 2018, for HEDS.
- DOD is a huge believer in the HEDS technology, and the DOD is actively helping us work with utilities via the UESC contracting vehicle to install HEDS projects.
- We won the inaugural 2016 DOE FEMP “JUMP” technology competition. HEDS is currently being evaluated by ORNL, and the results are very favorable.
- We won a contract from the Naval Surface Warfare Center to evaluate HEDS for ships, results are very favorable.
- I have been an HVAC SME for the U.S. Army Corps of Engineers for >20 years.
- **PG&E SRVCC:** >75% energy savings for optimized HVAC project per PG&E calculations.
- Inventor of Load Based Optimization System (LOBOS-EE + LOBOS-DR)



Problem Statement 1: Current strategies for humidity control are energy and maintenance intensive, and ineffective.

Problem Statement 2: Utility DSM Programs cannot reach a huge segment of their loads due to the critical temperature and Relative Humidity control needs of their biggest energy demand clients.

- Overcooling and reheating systems
 - inefficient and lead to uncomfortable indoor temps and/or moisture control issues
- Non-Standard equipment cannot be properly maintained in the real world.
- Desiccants/energy recovery wheels/run-around coils/air to air heat exchangers
 - Other RH control methods have some or all of the following drawbacks compared to HEDS:
 - added complexity and equipment required,
 - higher required maintenance skill-sets and costs,
 - Many more potential points of failure,
 - inability to modulate capacity to meet needs,
 - need for near perfect mixed air and exhaust air filtration systems,
 - higher fan energy requirements,
 - higher overall energy requirements,
 - inability to fit into existing mechanical equipment rooms for retrofit projects,
 - significant added weight,
 - reduced chilled water system temperature differential, leading to “Low Delta T Syndrome”,
 - condensate can still get blown off of the cooling coils into the system,
 - wet-filter syndrome for after-filters,
 - potential for condensation and biological growth in the HX systems.
- **Any EE or DSM system or technology that has the potential to cause a deviation in the air temperatures or RH of the critical nature facilities is a non-starter.**

What is HEDS?

- The High Efficiency Dehumidification System is a simple, energy efficient, easy to maintain method of controlling RH and biological growth.
- HEDS uses low quality heat reclaimed from the chilled water return line to provide the reheat energy for the process.
- HEDS was developed at the request of the US Army Corps of Engineers to address rampant energy waste and mold growth problems on Military installations.
- Many US and Foreign Patents and more on the way.

Why HEDS is Important to Utilities and Your Clients

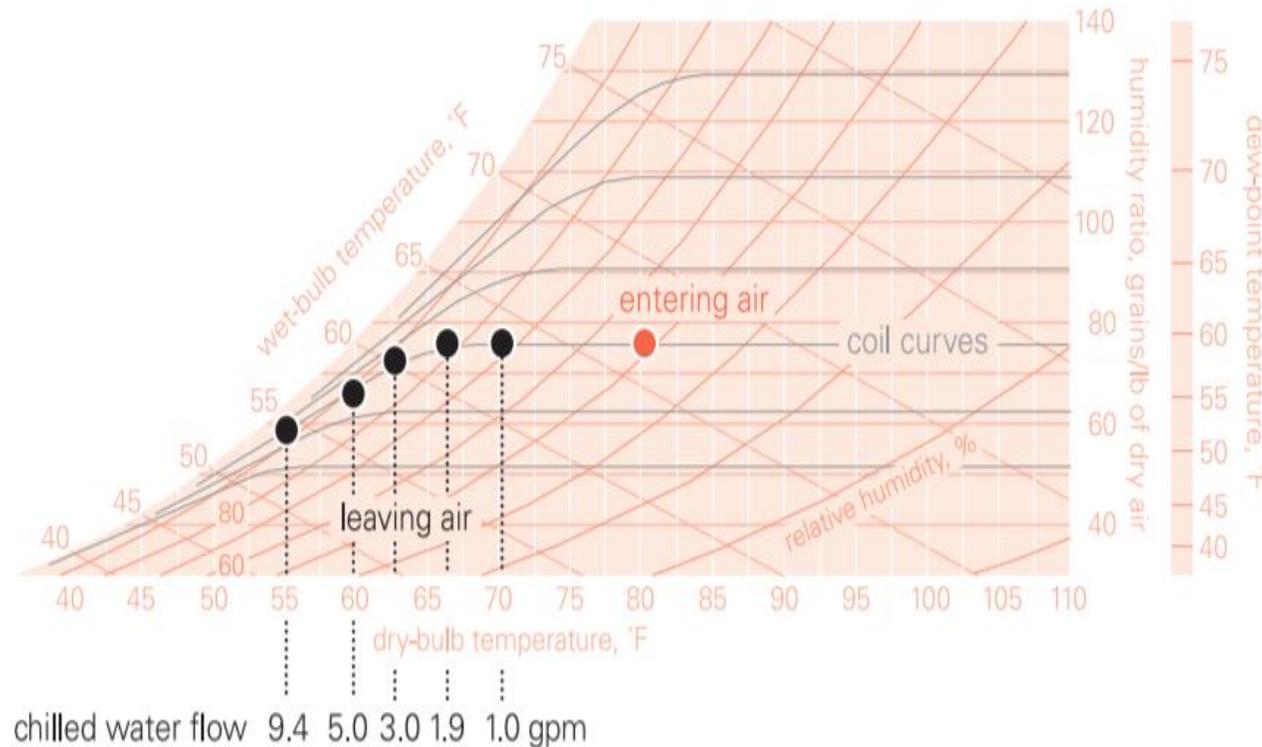
- Calculations from a “Big 3” HVAC manufacturer show connected load can be cut by >50% and energy consumption and demand by >50% for “Indoor Agriculture” (AKA “grow houses”), a looming grid issue for many.
- HEDS works in critical facilities that typical EE and DER cannot touch.
 - You can help clients that you were not able to fully help before.
- DOD field testing at two bases shows >50% reduction in energy use for the cooling/dehumidification/reheat process.
- HEDS can provide a 20% to >30% reduction in the peak electrical demand generated by the typical cooling/dehumidification/reheat process.

Utility Energy Service Contracts (UESCs)

- If your utility is involved in UESC projects, HEDS can increase the project size by 10's of \$millions per site, solving many client problems and generating significant revenue for the utility.
- A recently submitted (but not yet reviewed) Investment Grade Audit (IGA) for an East Coast Army base indicates that **it is possible to increase the UESC Phase 1 contract size by approximately \$40,000,000** while solving a significant number of temperature, RH and equipment failure problems.

Chilled Water Based Systems Show Poor RH Control (and DX can be much worse!)

Figure 2. Part-load dehumidification with modulated chilled water flow



Excerpted from Trane Engineers Newsletter volume 33-2
CAV AHU

In order to properly control RH, the air must be continually subcooled, typically to between 48F and 55F, to condense moisture out of the air, then it must be reheated back up in the AHU to lower the RH to avoid causing condensation in the AHU, the ductwork and the space and to avoid freezing people out of the space.

This is extremely wasteful and **not even possible on many military installations** that are equipped with pre-heat, rather than reheat coils, or two-pipe distribution systems, or zero heating or reheating capability at all (tropics and sub tropics).

HEDS Helps Clients Avoid Encounters with Mold



Mold in AHU enclosures



Mold in ductwork and under insulation systems from high supply air RH and condensate blow off from the cooling coils

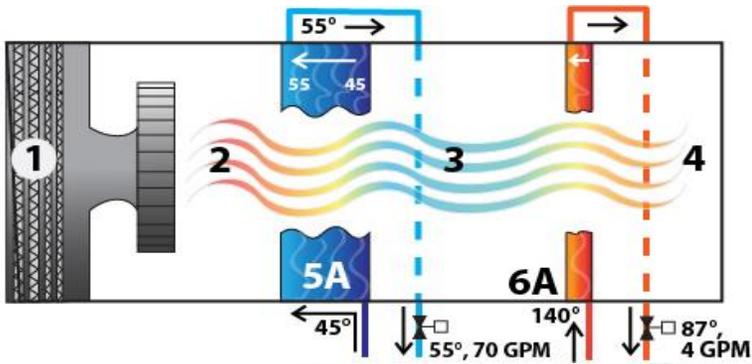


Mold In occupied spaces from high RH and condensation

HEDS is the simplest, most energy efficient RH control technology that can be integrated into DSM programs for critical nature facilities.

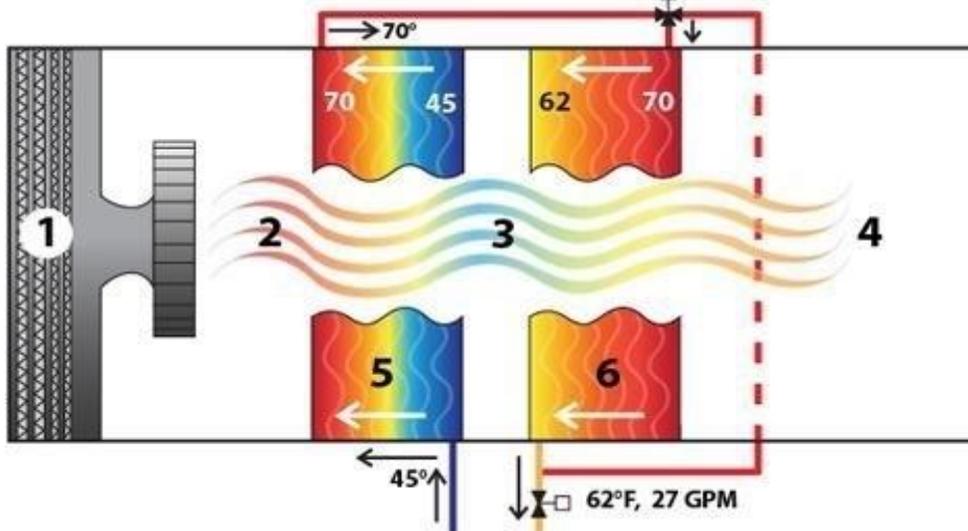
- HEDS uses energy recovery to perform dehumidification and reheat in a very simple way.
- HEDS takes 18% to >40% of the heat removed from the air during the cooling/dehumidification process and uses that reclaimed heat for reheat, locally, at the AHU.
 - This significantly reduces the load on the chiller plant and eliminates reheat energy waste.
- No added rotating parts to fail, no added refrigerant compressors, no need for perfect exhaust and mixed air filtration, no need for bigger fans and energy draw, simplest, most reliable, RH control technology to maintain.
- You can help your clients solve more than just energy and RH issues.

Solution: High Efficiency Dehumidification System (HEDS)



Conventional AHU Design

- Small cooling & reheat coils
- High CHW flow rates
- Low CHW temperature differential
- High AHU air pressure drops
- Propensity to suffer “Low Delta T Syndrome”



HEDS AHU Design

- >50% energy savings for the cooling/dehumidification/reheat process
- Simplest RH control system, ever.
- Heat recovery to replace reheat energy
- Reduces peak cooling electrical loads by 20% to >30%
- High CHW temperature differential/Series Chiller Potential, eliminates “Low Delta T Syndrome”
- Increases effective chiller capacity by >20%
- Low AHU air pressure drops
- Reduces infrastructure, O&M costs

1-Filter bank and supply fan, 2-mixed air, 78F/65F, 3-48F to 55F air, 4-53F to 68F air, 5-Cooling Coil, 6-Cooling Recovery Coil

HEDS DOD Field Performance Results

Fort Bragg NC, Tinker AFB, OK
The “worst” savings is still over 50%!

Application	Tested Supply Dewpoint Temperature Range (lower equals drier)	AHU Cooling Load % Reduction	AHU Dehumidification Heating Load % Reduction	Estimated Total Dehumidification-Related Cooling + Heating Plant Energy Savings
Operating Rooms, Industrial Clean Rooms – Hot / Humid Climates	Less than 50°F	20%	100%	57-81%
Dining, barracks, Dedicated Outdoor Air Systems, hospital, labs, industrial clean rooms, equip coating facilities, and Corrosion Control Facilities	Between 50°F and 52°F	31%	100%	63-85%
Less Humid Environments	Between 52°F and 56°F	37%	100%	67-87%
Office and Administrative	Between 50°F and 56°F	27% to 29%	100%	79-91%

Simple Payback Period

- The simple payback period is very load, rate, and climate dependent.
- Ignoring the non-energy and load shaping benefits, and excluding incentives, we see simple payback ranges from:
 - <4 years for “grow-houses”
 - 4 years for hospitals and manufacturing facilities in So Cal Edison territory,
 - to >10 years at Fort Bragg, NC whose average rates are \$0.055/kWh and \$0.58/therm.
- If you serve an area that is dry with low utility rates, there is most likely not a problem that we can help you solve.
- On the other hand, we did not think that Southern California, which is a desert, would be viable, but for loads that need dry air, such as hospitals and manufacturing, HEDS turns out to be a viable solution.
- If RH-problem related costs are considered, simple payback can be <2 years.

The Ask

- Consider developing a pilot program around the HEDS technology.
- Consider inclusion in an “Emerging Technology” demonstration project.
- Consider inclusion in a limited, customized incentive program for facility types that existing DSM programs cannot really reach. **“the unreachable loads”**
 - Could include kWh reduction, therm reduction, peak kW demand reduction, demand response and grid load shaping aspects.
- **We will help you help your clients solve their energy and RH problems, while helping you shape your grid load profile.**
- **Our team will help to identify clients and sites, educate and help to persuade your clients as a part of your team, provide M&V protocols, provide training and help to publicize the program.**

Contact Page

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Appendices follow

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Much of the Low Hanging Fruit for EE and DER Have Been Implemented – but not in Critical Load Facilities

- Utility and 3rd Party Energy Efficiency Incentive programs have done a pretty decent job of reaching the low hanging fruit.
- Many facilities have critical thermal loads that have not been able to be reached by, or included in, typical EE and DR/DER programs.
- Until now, the cooling/dehumidification/reheat/Relative Humidity (RH) control loads at industrial, clean room, laboratory, hospital, manufacturing, Pharma and other facilities could not be reached effectively by any EE/DER technology on the market.
- These loads total hundreds of MWh annually, and into the 1,000's of peak kW demand.
- HEDS allows you to reach these unreachable loads.

Saving Lives While Reaching Unreachable Loads

- HEDS for Hospitals

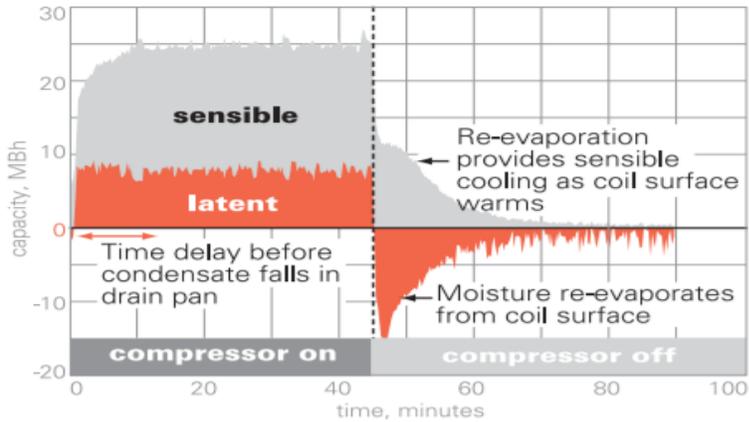
- The CDC reports that around 99,000 people per year in the USA die from “Healthcare Acquired Infections” or HAIs. Another 1,600,000 people are affected by HAI’s at an estimated cost of \$20B/year.
- Poor IAQ is a contributor to these deaths and poor patient outcomes.
- HEDS projects can improve IAQ and reduce HAIs via a combination of design strategies specific to hospitals and healthcare facilities, while cutting energy consumption and allowing load shaping to occur.

HEDS Reaches “Unreachable Loads” Allowing: EE, DER, Reg Up, Reg Down, Duck Curve Mitigation

- HEDS is the ONLY HVAC-RH control technology that can dramatically improve Energy Efficiency and assist in DER grid load shaping at facilities with extremely critical temperature and RH control needs:
 - Hospitals
 - Laboratories
 - Clean Rooms
 - Manufacturing
 - Industrial
 - Big Pharma
 - Museums
 - Chip Fabs

DX Based Systems Show Even Worse RH Control

Figure 3. Part-load dehumidification (cycling compressor, constant-volume fan)



Shirey, D., H. Henderson, and R. Raustad. 2003. DOE/NETL Project DE-FC26-01NT41253

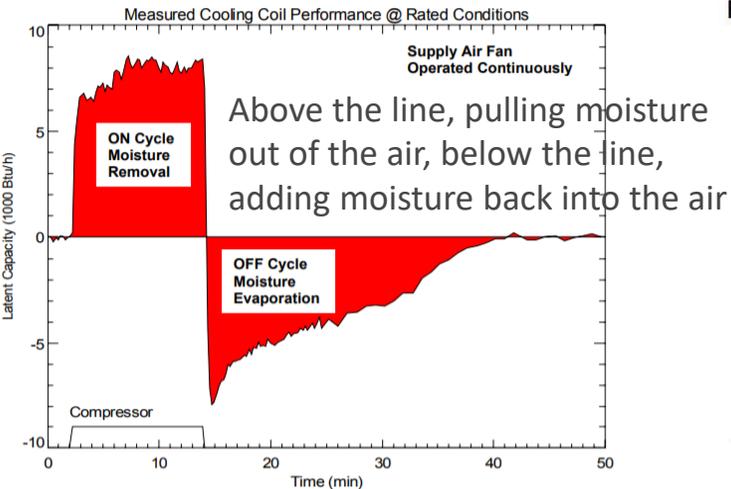


Figure 1-1. On-Cycle Condensation and Off-Cycle Evaporation of Moisture from a Cooling Coil (Henderson 1990)

Figure 4. Effect of compressor cycling on air leaving the cooling coil

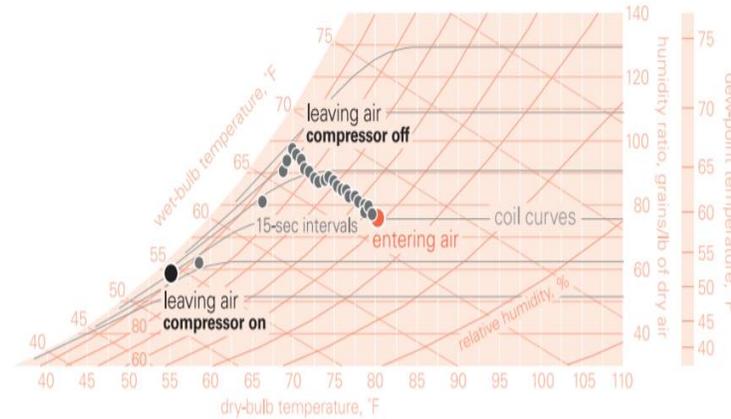
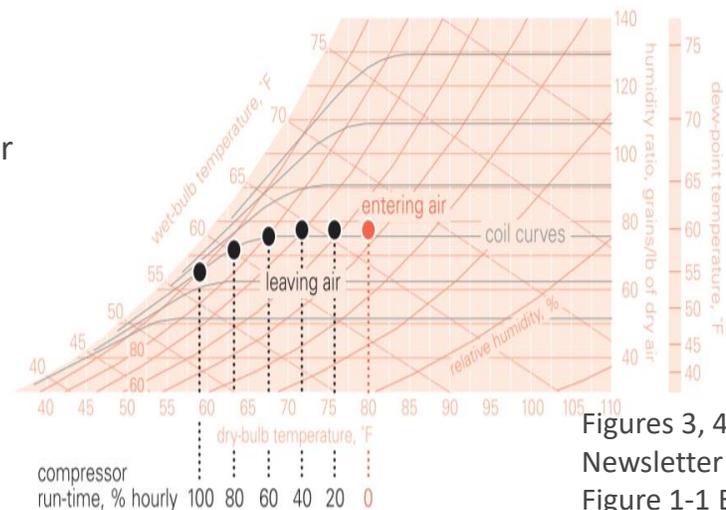


Figure 5. Net dehumidification as a function of compressor run-time



Condensate is actually re-evaporated into the airstream, re-humidifying the spaces and ductwork that were just dehumidified

DoE and Trane testing confirm that significant condensate re-evaporation occurs when DX compressors cycle off for capacity and temperature control.

This is an inherent problem of typically installed DX designs and cannot be avoided without significant equipment and controls modifications.

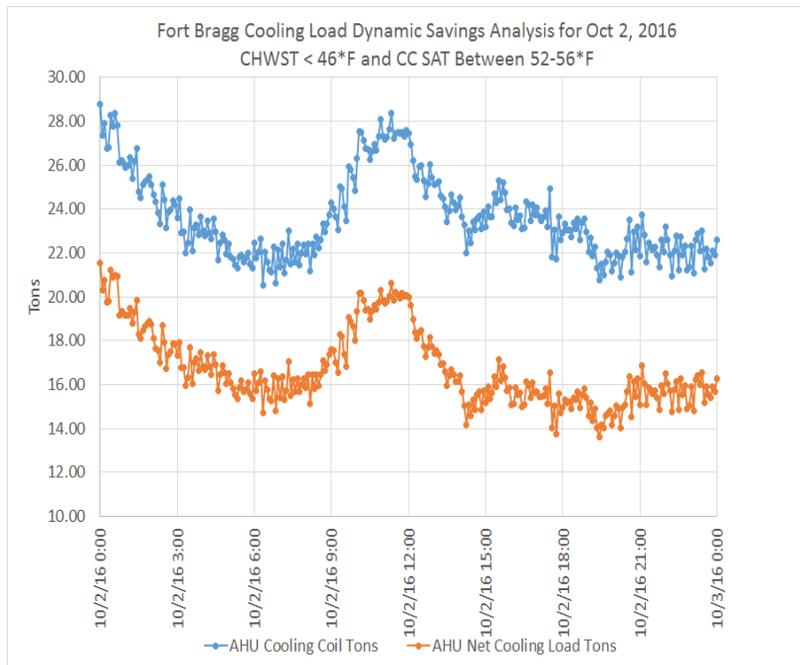
This essentially precludes RH control from occurring unless the system is continually providing low dewpoint air (typically 48F to 55F) plus reheat, and the DX compressor does not cycle off, ever, during operational hours when dehumidification is occurring.

Figures 3, 4, 5 Excerpted from Trane Engineers Newsletter volume 33-2
Figure 1-1 Excerpted from DOE/NETL Project No. DE-FC26-01NT41253. CAV AHU



HEDS Field Performance Results – DOD Testing Shows that the Recovered Energy is Saved Twice

The recovered energy is saved twice – once from the chiller plant and once from the boiler plant.



Fort Bragg Cooling Load W/O HEDS (blue line)

Cooling Load Sent to Plant with HEDS energy recovery from CHWR line (orange line)

I know that this sounds like perpetual motion, but it is just the Laws of Thermodynamics being on your side for a change...

Every BTU that comes out of the CHW line reduces the load sent to the chiller plant and it is also used to heat the air, so the same # of BTU's is saved on the reheat side as well.

That is how the savings can be so high – the energy is saved twice.

The area between these two curves is the amount of cooling BTU's that were taken out of the CHW return line and used as reheat energy, so the CHW load is reduced by that many BTU's.

The area between these two curves is also the amount of heating BTU's that were added to the supply airstream as the reheat energy source, so the reheat load is reduced by exactly that many BTU's as well.



HEDS Psychrometric Chart, Fort Bragg

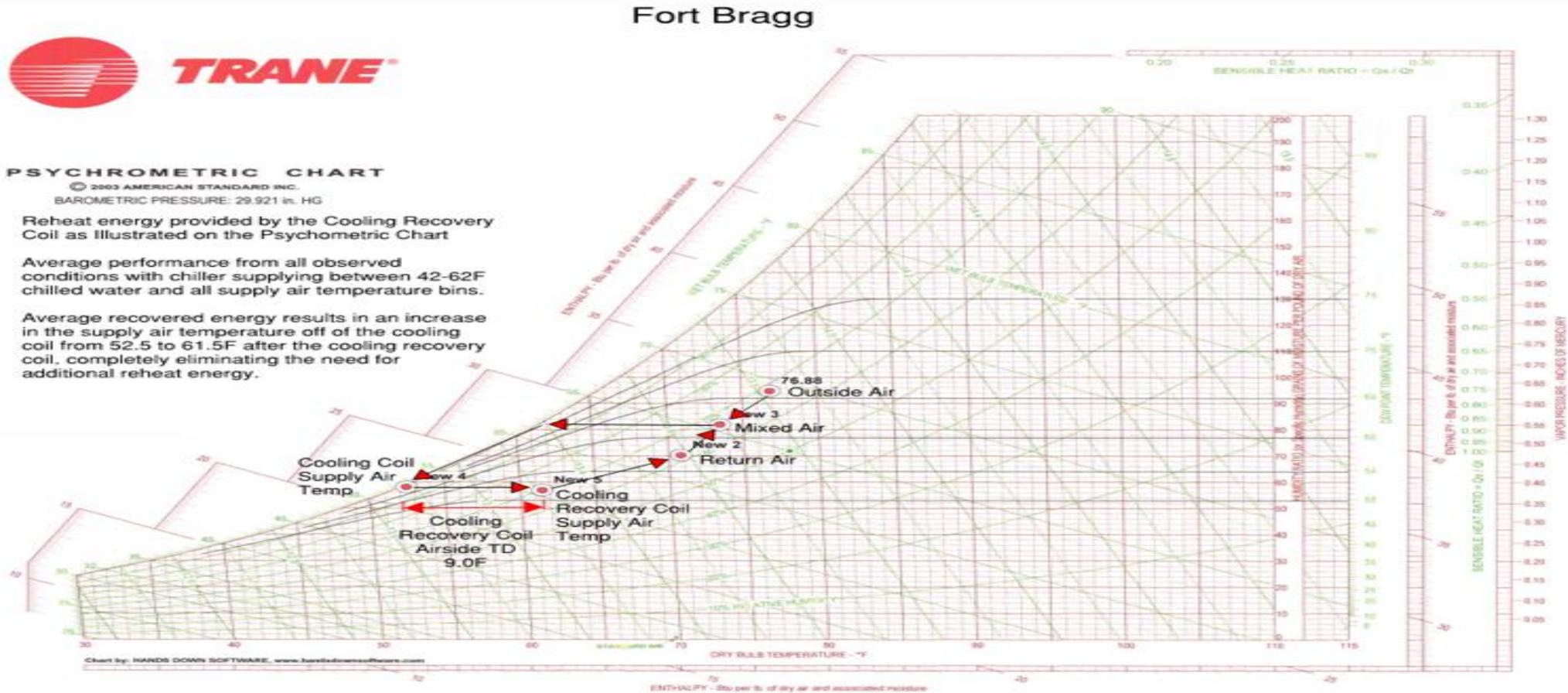


Figure 19. Psychrometric chart highlighting the impact of the cooling recovery coil on HEDS system performance at Fort Bragg.

There is a HEDS Energy Efficient Option for Every RH Control Situation

- Here are some of the design variations that we have in the works:
 - 100% Energy Recovery HEDS (ERHEDS or “airheads”) for mothballed facilities to help reduce mold growth
 - HEDS DOAS Dedicated Outdoor Air System for undersized HVAC systems
 - HEDS MicroGrid Integrated Design
 - HEDS Retrofit/Repair Kits for AHU’s and DOAS
 - HEDS to Fix DX, VRF™ and VRV™ System Problems
 - HEDS for Homes/Small Buildings
 - HEDS for Ground-Sourced Heat Pumps.
 - HEDS “Vapor Battery™” Resiliency and Grid Load Shaping Software
 - HEDS for Salt Air Environments
 - HEDS for Hospitals
 - HEDS Fan Coil Units for Small Loads
 - Fail-Safe HEDS
 - HEDS Grid Failure/Demand Response Software