Welcome to the 2015 DoD Virtual Energy Summit

FIRSTFUEL

HARNESSING ANALYTICS TO ACHIEVE ENERGY TARGETS IN FEDERAL BUILDINGS

Domenic Armano, VP Customer Solutions

October 28, 2015

ENERGY INTELLIGENCE PLATFORM FOR GOVERNMENT

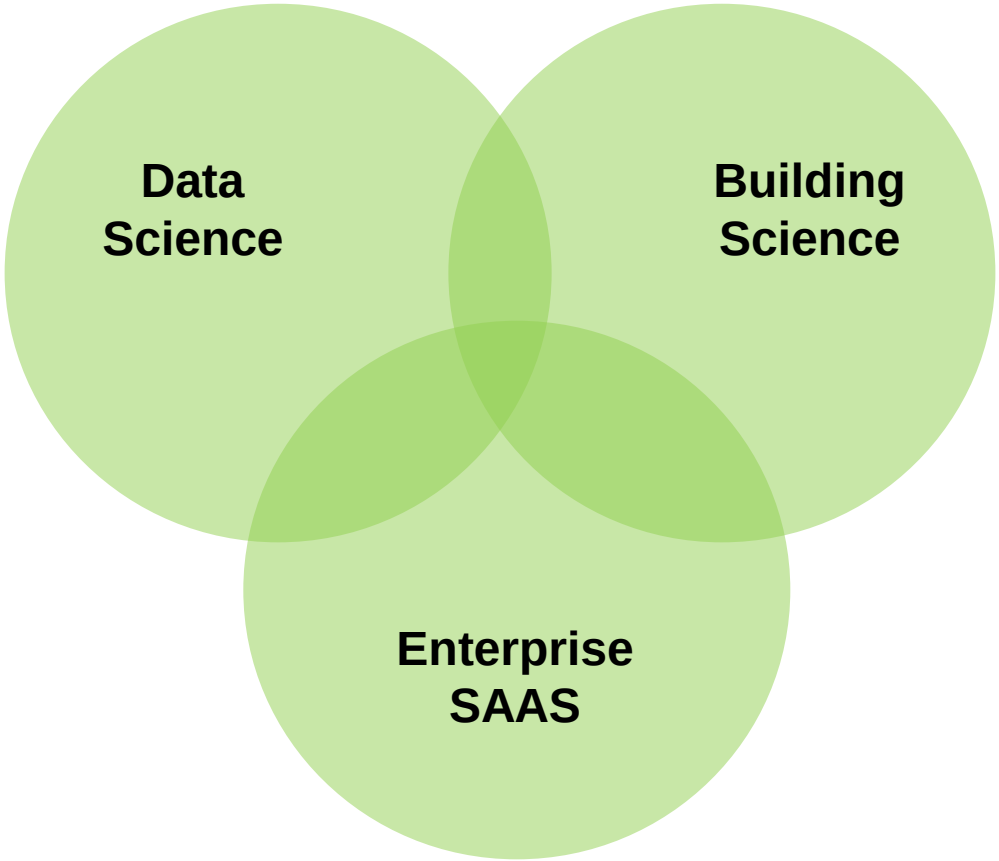
We harvest the insights within your energy meter data

Delivering customer intelligence via 'zero-touch' analytics

Enabling you to achieve energy savings and meet EISA 432 and other regulatory targets at scale

UNIQUE APPROACH AND CUSTOMER VALUE

ENGAGEMENT & EE/DSM PROCESS INTEGRATION



Sample Customers

PG&E

SOUTHERN CALIFORNIA EDISON

efficiency MAINE

GSA

SMUD™ Sacramento Municipal Utility District

Los Angeles LADWP Department of Water & Power

DEPARTMENT OF DEFENSE

DGS THE DEPARTMENT OF GENERAL SERVICES

e·on

TURNING DATA INTO ACTIONABLE INSIGHTS

1 CONVERT EXISTING DATA

2 INTO ENERGY INTELLIGENCE

3 TO MAKE INFORMED DECISIONS

FROM UTILITY

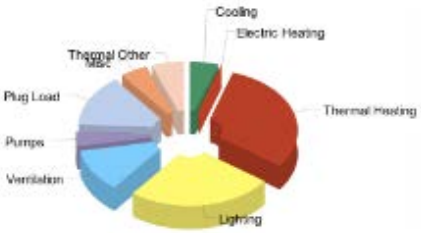
BUILDING ADDRESS

1 YEAR ELECTRIC METER DATA + GAS DATA

FROM FIRSTFUEL

LOCAL WEATHER DATA

GIS MAPPING/ SEMANTIC SEARCH



EX: END-USE DISAGGREGATION

Fraunhofer USA

PG&E

eebHUB Energy Efficient Buildings Hub

EPRI ELECTRIC POWER RESEARCH INSTITUTE

TECHNICALLY VALIDATED FOR ACCURACY

EISA 432 & Compliance

- Target Covered Buildings
- Meet Audit Requirements
- GSA 100% Compliant

Energy Strategies

- Operational
- Retrofit
- ROI Estimate

KEY GOVT ENERGY CHALLENGES : ANALYTICS-BASED SOLUTIONS

SUPPORT ALL BUILDINGS	*$15,000 - $50,000 budget may be largely consumed by onsite audits….nothing left for EE implementation*	***Analytics can deliver audit, monitoring and compliance platform for 10-20% the cost of onsite audits***
TIME-CONSUMING PROCESSES	*Many months to contract, schedule & conduct just one onsite audit…*	***FirstFuel audits completed in 2-4 hours***
ORGANIZE & MANAGE EFFORTS	*100s of non-standard paper audits, difficult to track across portfolio*	***Analytics approach captures results from all buildings, including offline results, in a standardized fashion***
TRACK & REPORT PROGRESS	*Cities must manually track overall progress including audits, implementation and actual savings*	***FirstFuel platform automatically aggregates results of all efficiency activity in one centralized repository***
PRIORITIZE RESOURCES	*Difficult to determine where to spend limited resources*	***FirstFuel's screening capability targets biggest opportunities prior to conducting audits***
IDENTIFY LOW-COST SAVINGS	*Onsite audits miss low/no-cost operational savings – 50% of all potential savings*	***Analytics technology finds operational savings missed by on-site audits***

Example Deployment

DEPARTMENT OF DEFENSE

DOD: USING ENERGY ANALYTICS TO MEET DIVERSE GOALS

DEMONSTRATION PROJECT SCOPE

100 DoD Buildings Analyzed

11 Different DoD Installation Bases

5 Different Building Types

DoD Objectives

- Diversity of building stock and geography
- Cost of multiple metrics
- Scalability on a timed time frame
- Accuracy of recommendations

DoD Assessed Building Types

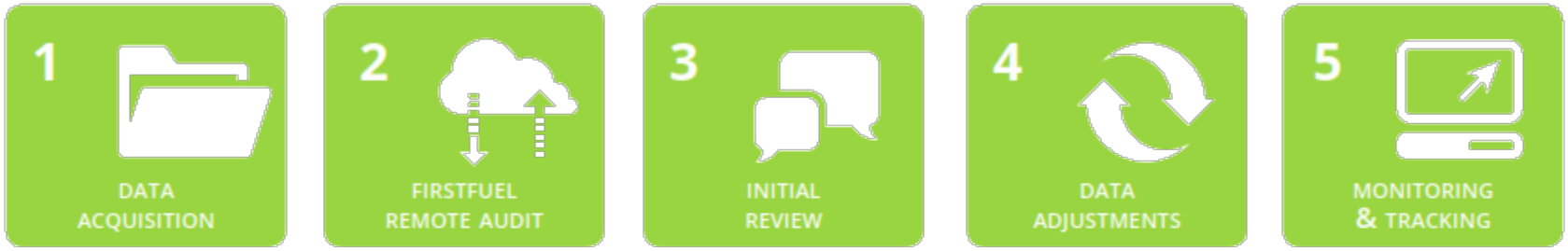
- Headquarters, Classrooms
- Barracks, Dining Facilities
- Warehouses, Commissaries
- Rec centers, auditoriums
- Facilities with lighter process loads

"FirstFuel demonstrated a tremendous capability for the Department of Defense to use data analytics to meet it's challenging energy auditing requirements that traditionally require much more time, money and manpower,"

–Dr. James Galvin, Former Program Manager-Energy and Water, ESTCP

DOD: TOUCHLESS AUDITS FOR SPEED, EASE, AND ACCURACY

FIRSTFUEL REMOTE ENERGY AUDIT DELIVERY



FirstFuel requires:

- 1 year of interval consumption data
- Building address
- Short building survey (optional)

FirstFuel adds weather, GIS, and other inputs to perform the analysis. Results are placed on branded web portal

FirstFuel engineer reviews results with building stakeholders via Efficiency Planning webinar

Analysis may be updated based on webinar discussion

Building owners/ operators track ongoing savings from efficiency actions

Elapsed time of ~2 weeks compared to ~2-4 months with onsite audits

Building manager time commitment of <2 hours compared to >8 hours for onsite audits

"The company's unique approach to data analysis enabled us to save significant time and money, while yielding the same – if not better – results than traditional onsite audits.

- *Dr. James Galvin, Former Program Manager- Energy and Water, ESTCP*

DOD: PROGRAM MET OR EXCEEDED ALL SET TARGETS

DoD ESTCP 2014 Project of the Year: Energy and Water

The Project of the Year recognizes scientific advances and technological solutions to some of DoD's most significant environmental challenges

1 Accuracy + Depth	2 Analysis 'Coverage'	3 Cost + Speed	4 Deployment Ease
Identifies **more energy conservation measures** than traditional methods through meter data analysis	Performs remote audits on **wide variety of DoD building** types	**Six times faster** than traditional on-site methods **Three times less expensive** than on-site methods	**Portfolio views** to inform base-level EE

DOD: FORT BLISS- A CASE STUDY

Primary Activity: Vehicle Maintenance Shop

Size: 115,742 square feet

Consumption: 1,044,840 kWh

- **Total potential electrical savings opportunity:** 29% of annual consumption
- 60/40 split between low-cost and capital measures
- Top low-cost recommendations:
  - HVAC Scheduling Control
  - HVAC Operations & Maintenance Measures
  - Eliminate unnecessary Simultaneous Heating and Cooling

	ENERGY	CARBON	INCENTIVES	SAVINGS	COST	ROI
ELECTRICITY	300,280 kWh (29%)	163 tonnes	N/A	$21,020	$91.5K to $152.5K	4.4 Years to 7.3 Years
TOTAL	1,024,555 kBTU	163 tonnes	N/A	$21,020		

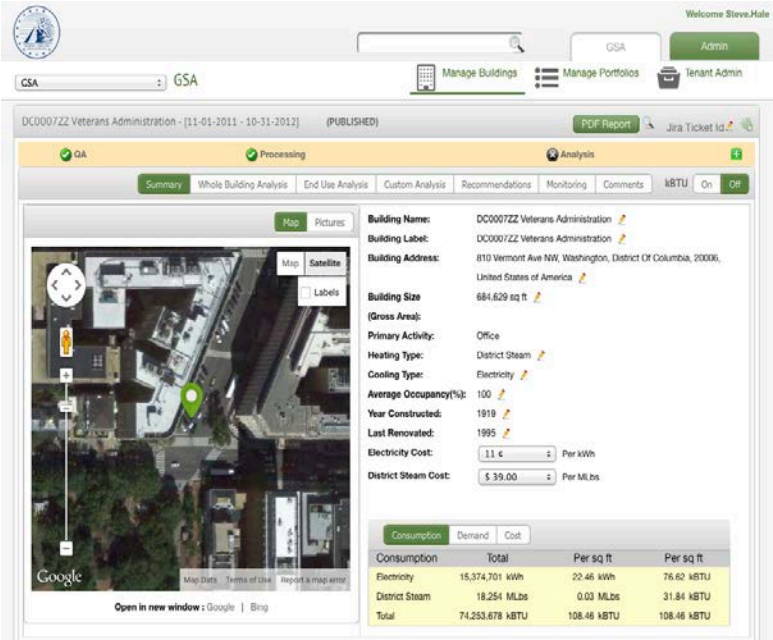
RECOMMENDATIONS | MY PLAN | ACTIONS & NOTES | Options

TYPE	SUMMARY	INCENTIVES	SAVINGS	COST	ROI
	HVAC Scheduling Control Created by FirstFuel	N/A	$10,364	$2,500 to $5,000	3 Months to 6 Months
	Lighting Retrofit Created by FirstFuel	N/A	$7,651	$71,500 to $115,000	9.3 Years to 15 Years
	HVAC Operating and Maintenance Measures Created by FirstFuel	N/A	$1,825	$5,000 to $7,500	2.7 Years to 4.1 Years
	Upgrade to EE Motors Created by FirstFuel	N/A	$616	$10,000 to $15,000	16.2 Years to 24.4 Years
	Eliminate Unnecessary Simultaneous Heating and Cooling Created by FirstFuel	N/A	$564	$2,500 to $10,000	4.4 Years to 17.7 Years

Example Deployment

GENERAL SERVICES ADMINISTRATION

GSA: ENERGY ANALYTICS FOR COMPLIANCE AND SAVINGS



GSA Objectives

- Utilize Investment in Smart Meters
- Use Meter Data for Rapid Building Energy Audits
- Tack Action on both Operational and Retrofit ECM's
- Report Using Energy Usage and Analysis System
- Results put into EISA 432 Compliant Tracking System

GSA Overview

Year 1
25 Buildings

Year 2
75 Buildings

Year 3
183 Buildings

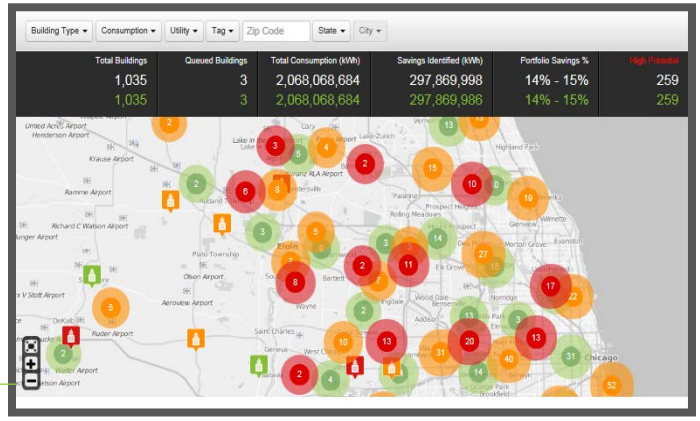
Total 2012-2015
258 Buildings

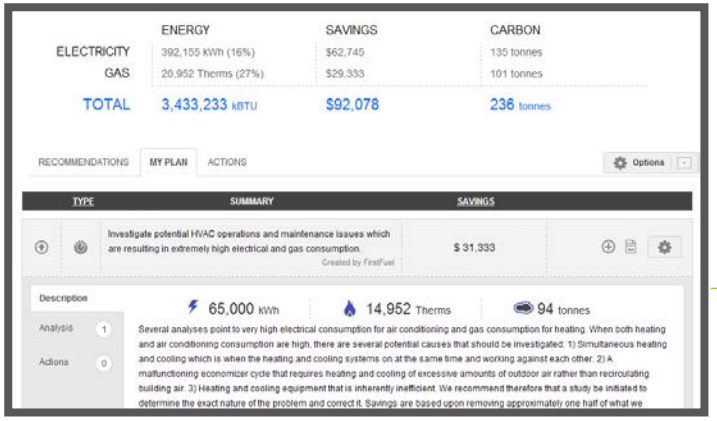
"These three related initiatives – advanced metering, Rapid Building Energy Assessments and Energy Usage and Analysis System – resulted in energy intensity reductions of 9.3% and a savings of $27.3 million in FY 2013 as compared to FY 2011"

– GSA as part of the FEWM Awards 2014

GSA: FOUR TYPES OF VALUE FROM ANALYTICS

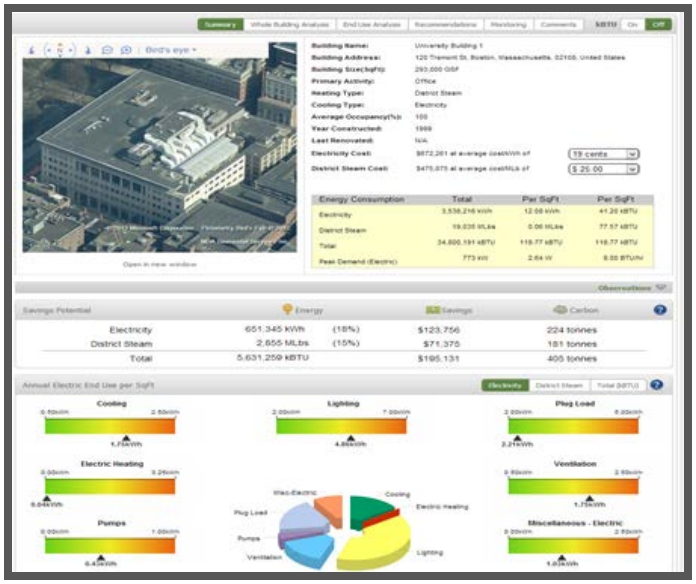
Provides screening in the beginning so you can allocate resources.

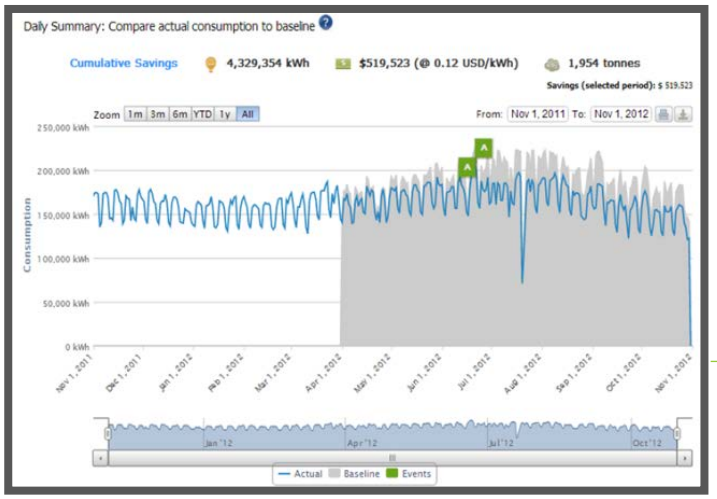




Provides usage based building specific recommend-ations.

Overview of building's energy use.





Ongoing monitoring so you can track and verify progress.

GSA: SIGNIFICANT TIME AND MONEY SAVINGS

Federal Energy & Water Management Award Winner 2014

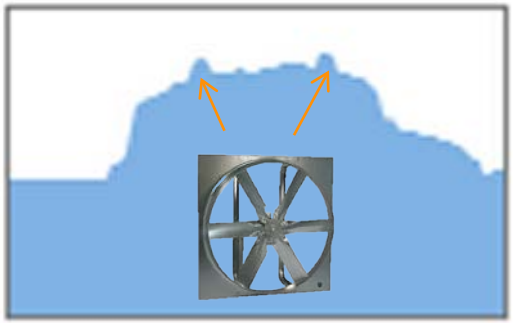
The Federal Energy and Water Management Awards recognize individuals, groups, and agencies for their outstanding contributions in the areas of energy efficiency, water conservation, and the use of advanced and renewable energy technologies at federal facilities.

1 Savings in Dollars	2 Savings in Time	3% Operational Savings	4 EISA 432 Compliance
Identified **$21 Million in energy savings** potential	Complete the energy analysis in **24 weeks vs. 3 years** at a rate of **85% faster.**	**60% of energy savings are operational.** FirstFuel drives operational savings through support and monitoring.	EISA 432 covered Federal Buildings need to be **audited every 4 years.**

GSA: THE RONALD REAGAN BUILDING- A CASE STUDY

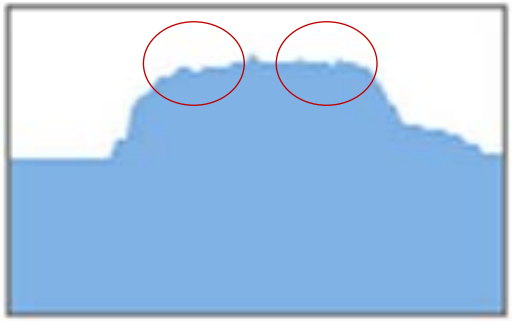
AUDIT → **PLAN AND ACT** → **TRACK SAVINGS**

Wed 11 May, 2011



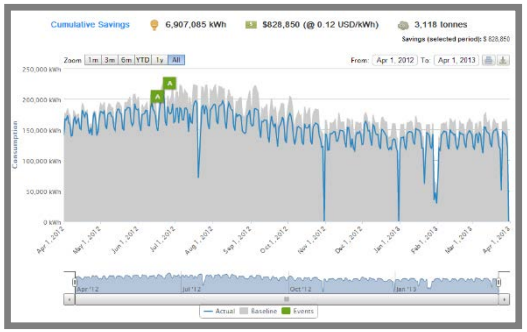
"Consumption spikes"… are actually rogue garage fans

Fri 04 May, 2012



FirstFuel "coaches" building manager to modify controls

*FirstFuel portal**



Consumption decrease : 6.9 GWh
Energy savings: $825,000

*** Energy reduction/savings reflect total across multiple measures**

THANK YOU

For additional information, please visit
www.firstfuel.com

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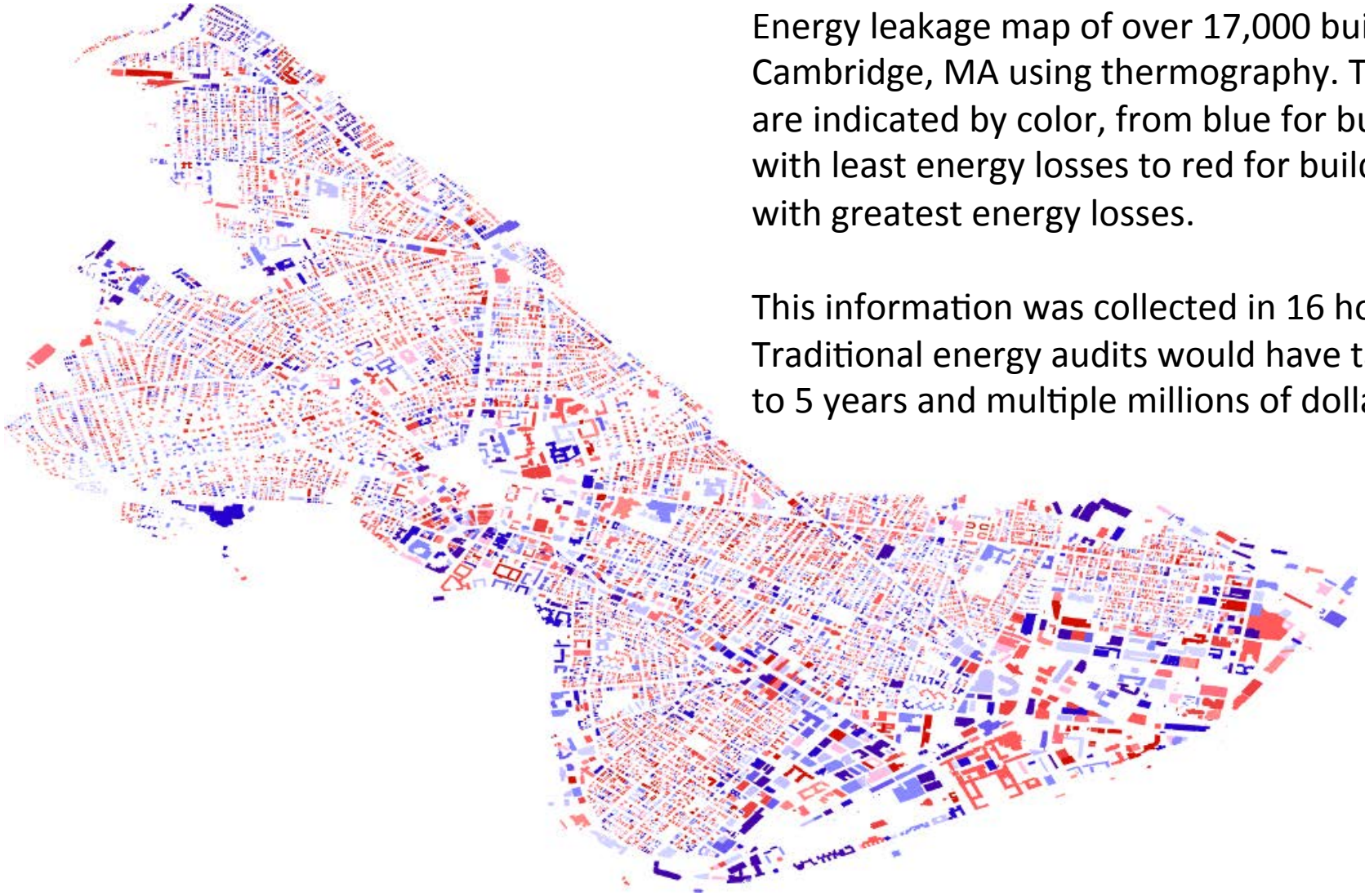
Essess Mobile Thermal Imaging

Tom Scaramellino
President & CEO, Essess
October 27, 2015

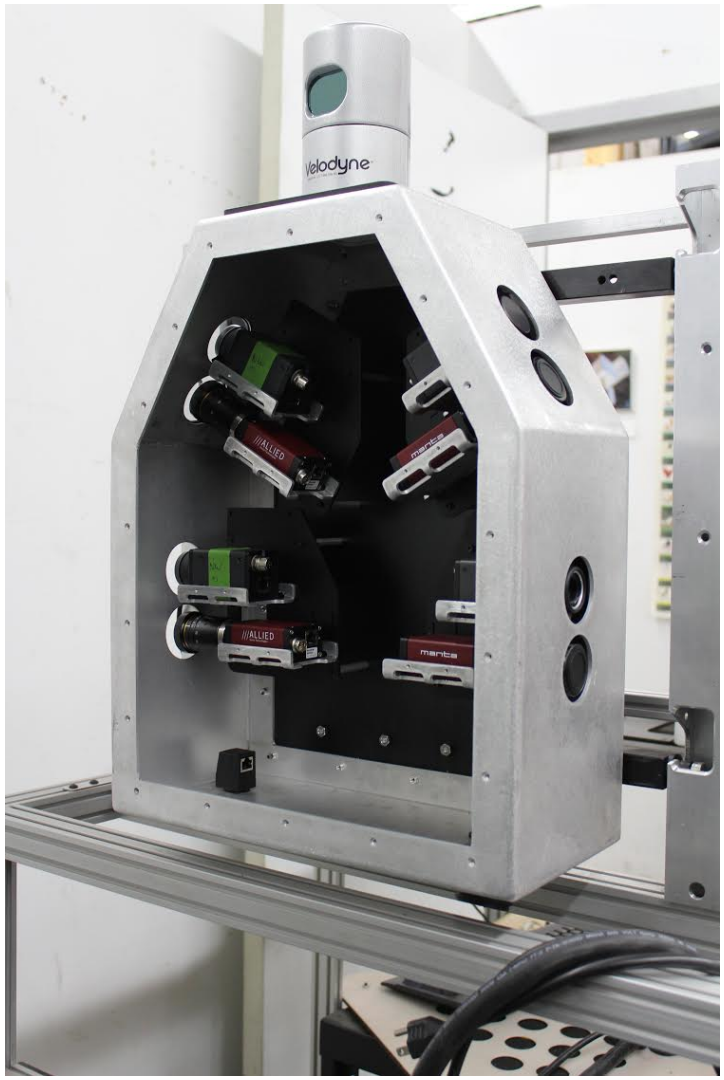
Mapping Energy Loss



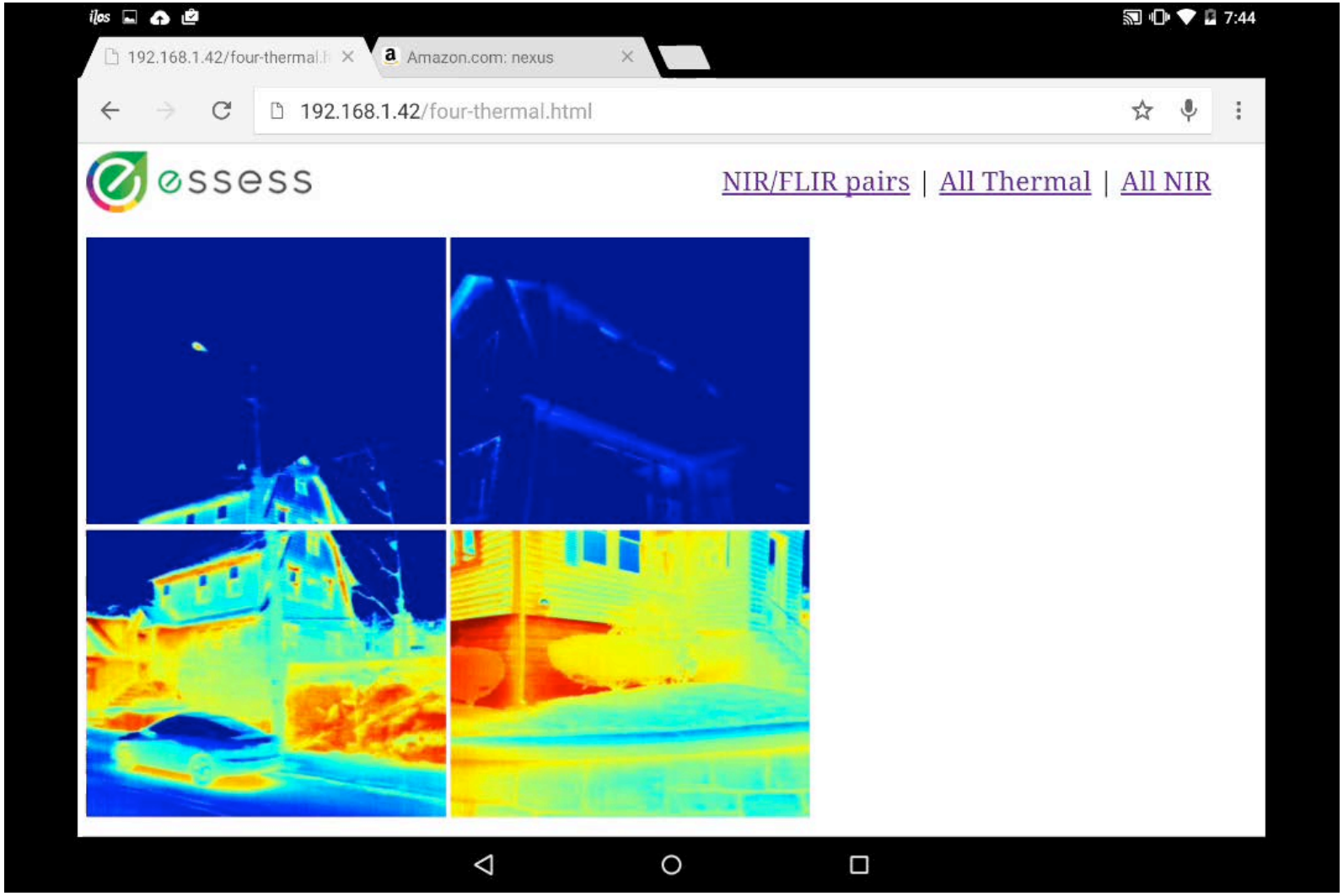
Energy leakage map of over 17,000 buildings in Cambridge, MA using thermography. The scores are indicated by color, from blue for buildings with least energy losses to red for buildings with greatest energy losses.

This information was collected in 16 hours. Traditional energy audits would have taken up to 5 years and multiple millions of dollars.

Imaging System – “The Rig”



Driver UI & Data Quality Monitoring



Driver UI & Data Quality Monitoring

Building Detection Pipeline

Essess Scan Data

GIS Data

Scan Data Segmentation

Raw scan data is linked with building properties using GPS, GIS, and LIDAR data

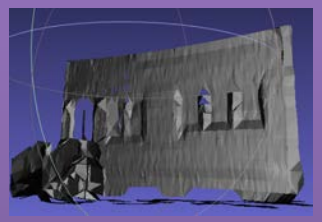
2D Image Registration & Stitching

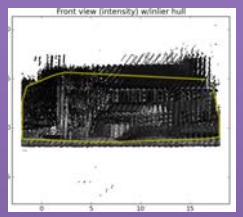
Top & Bottom NIR + LWIR camera images are stitched together and registered into single multi-channel images

2D Image Home Detection

Homes are detected using 2D classifiers and thermal data in the registered NIR + LWIR images

3D Facade Detection





Homes detected in 2D images are projected into 3D space to generate target areas for RANSAC-based plane segmentation and mesh-based facade detection

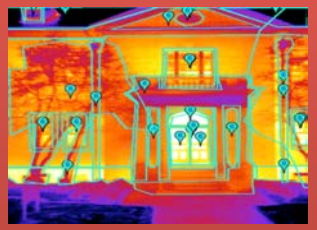
2D Facade Polygon Fitting

Facade outlines detected in 3D are projected back onto the 2D image to generate a preliminary polygon

2D thermal data and classifiers help to "tighten" the polygon

Obstructions (trees, bushes, …) are identified based on temperature values and/or 3D position values of the pixels contained within the polygon

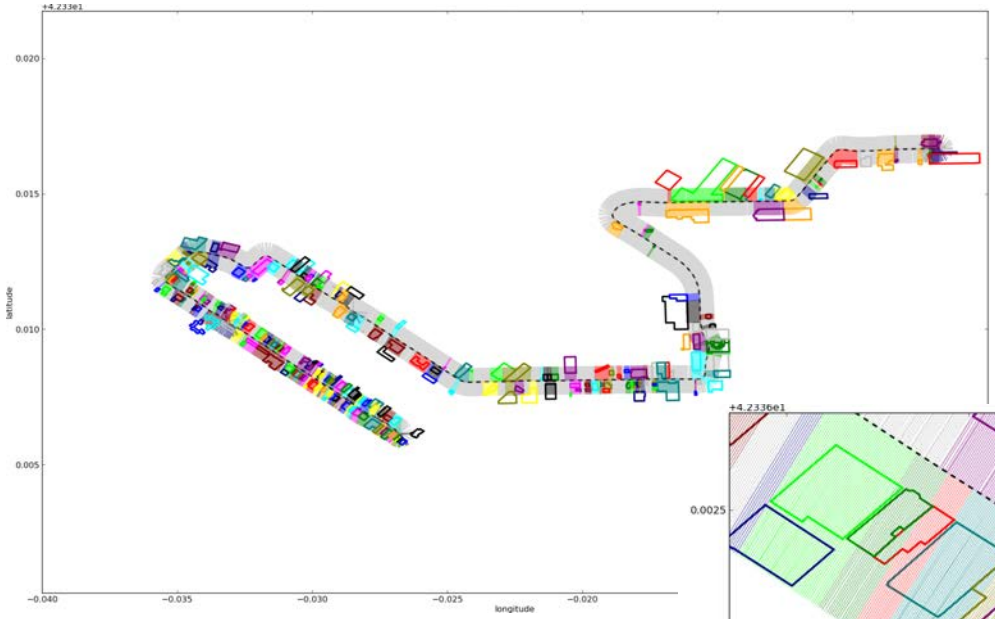
Building Component Detection

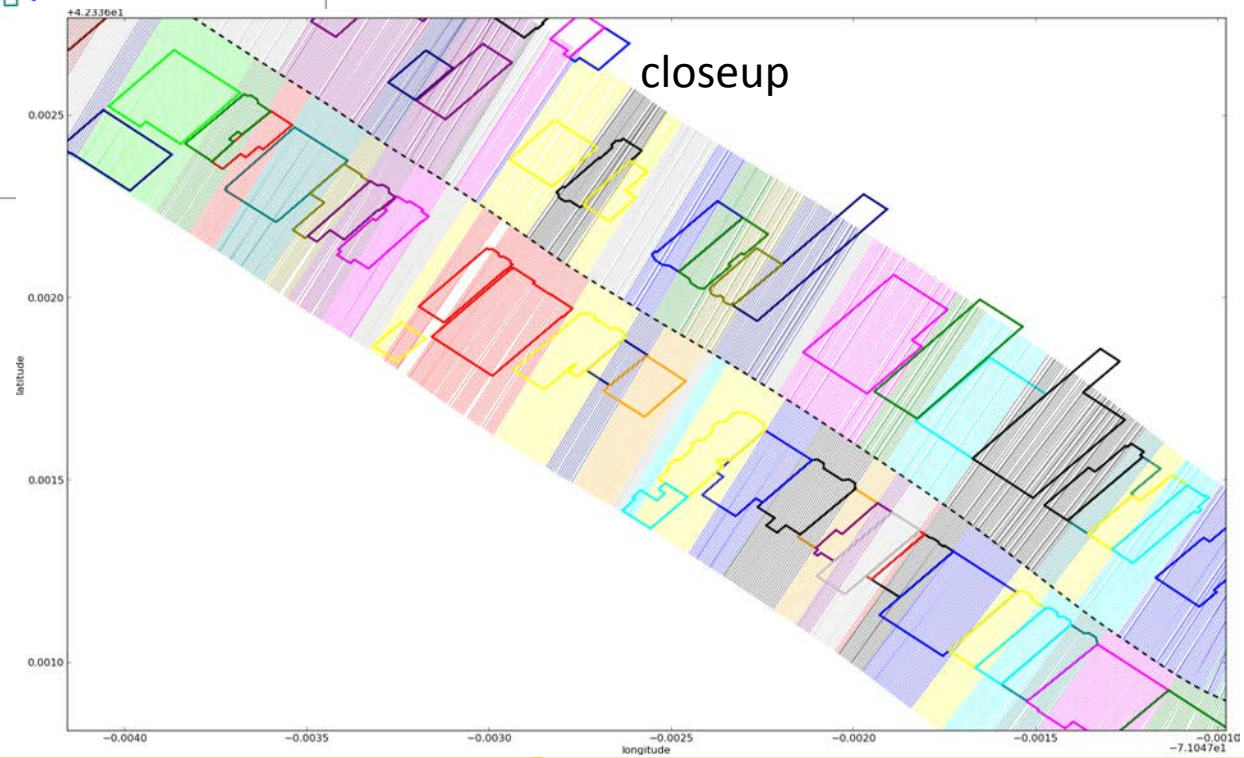


Components are detected within the segmented building facade using 2D classifiers , thermal, and 3D data

2D Image Registration & Stitching

Matching Along The Driving Route





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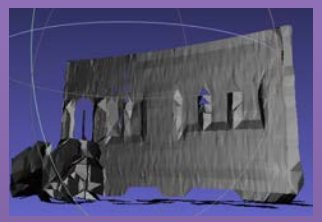

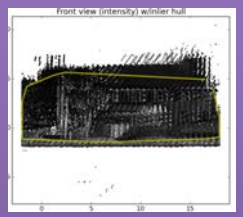

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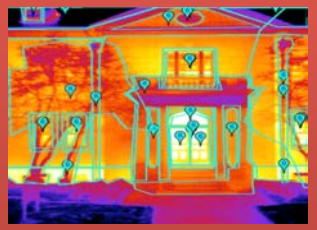

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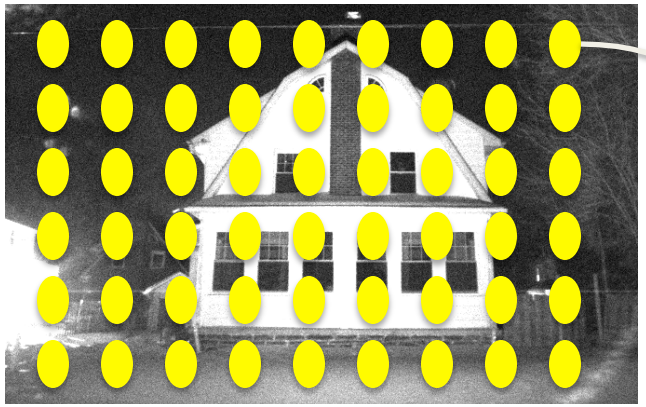
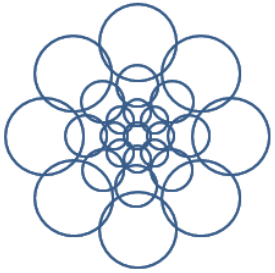
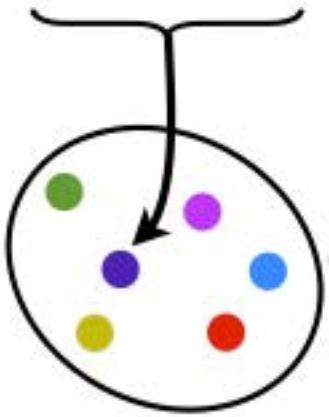
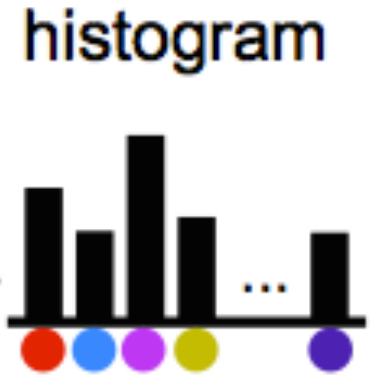
Algorithm Example – Bag of Words

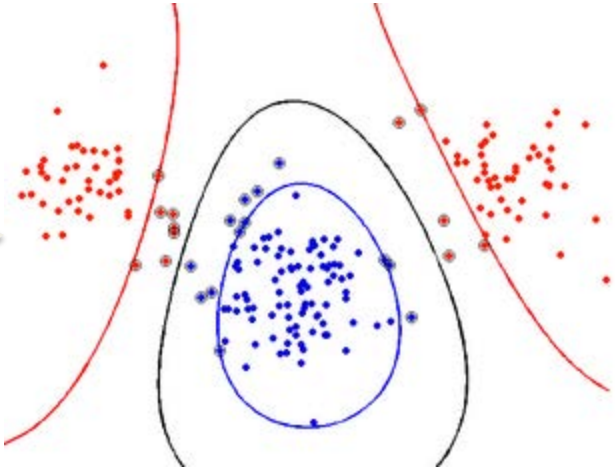




"Dense Daisy Descriptors"

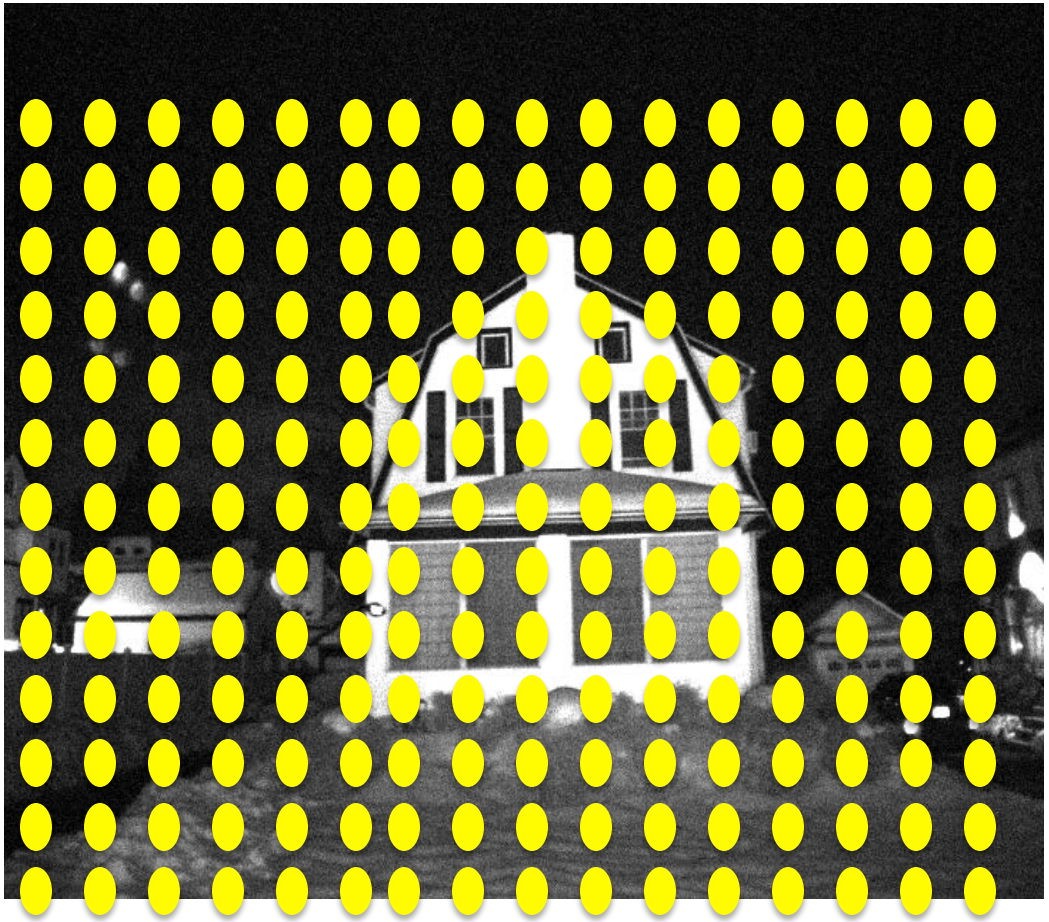




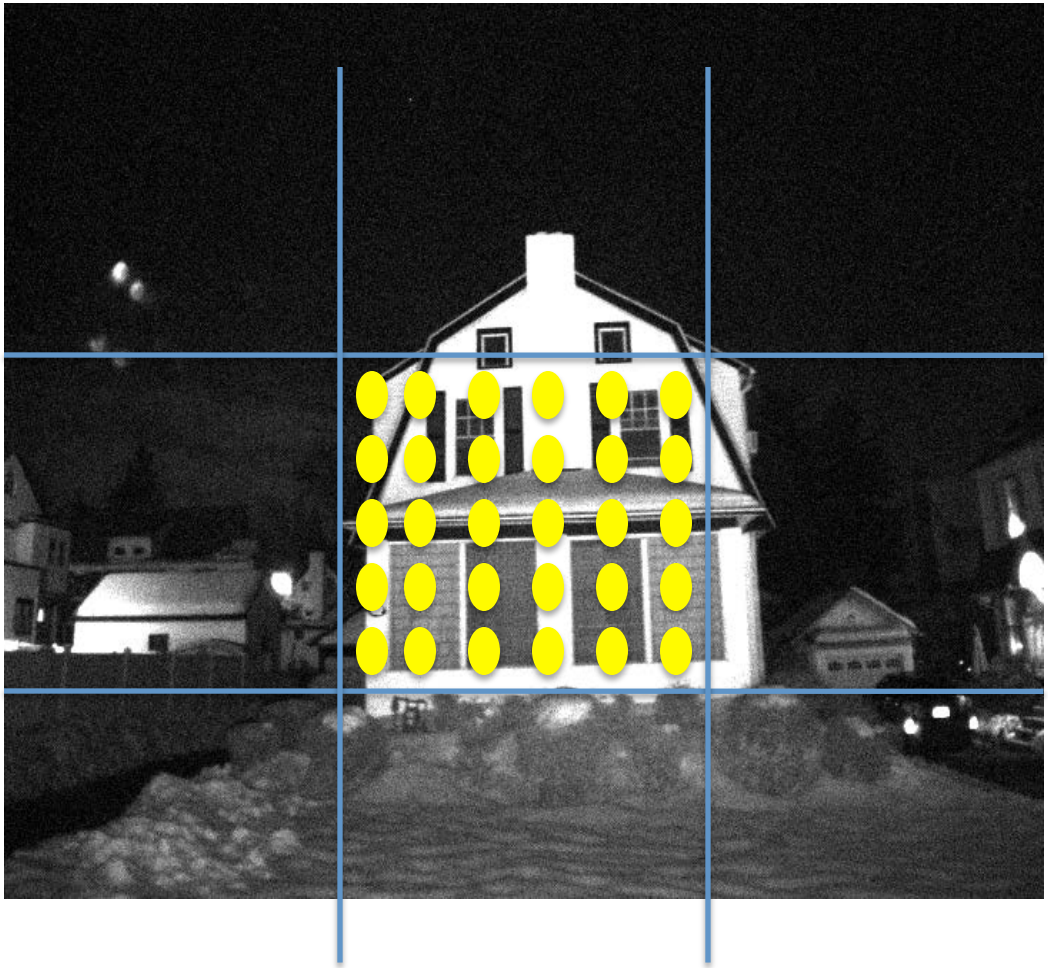


Support Vector Machine

Histogram of Gradients

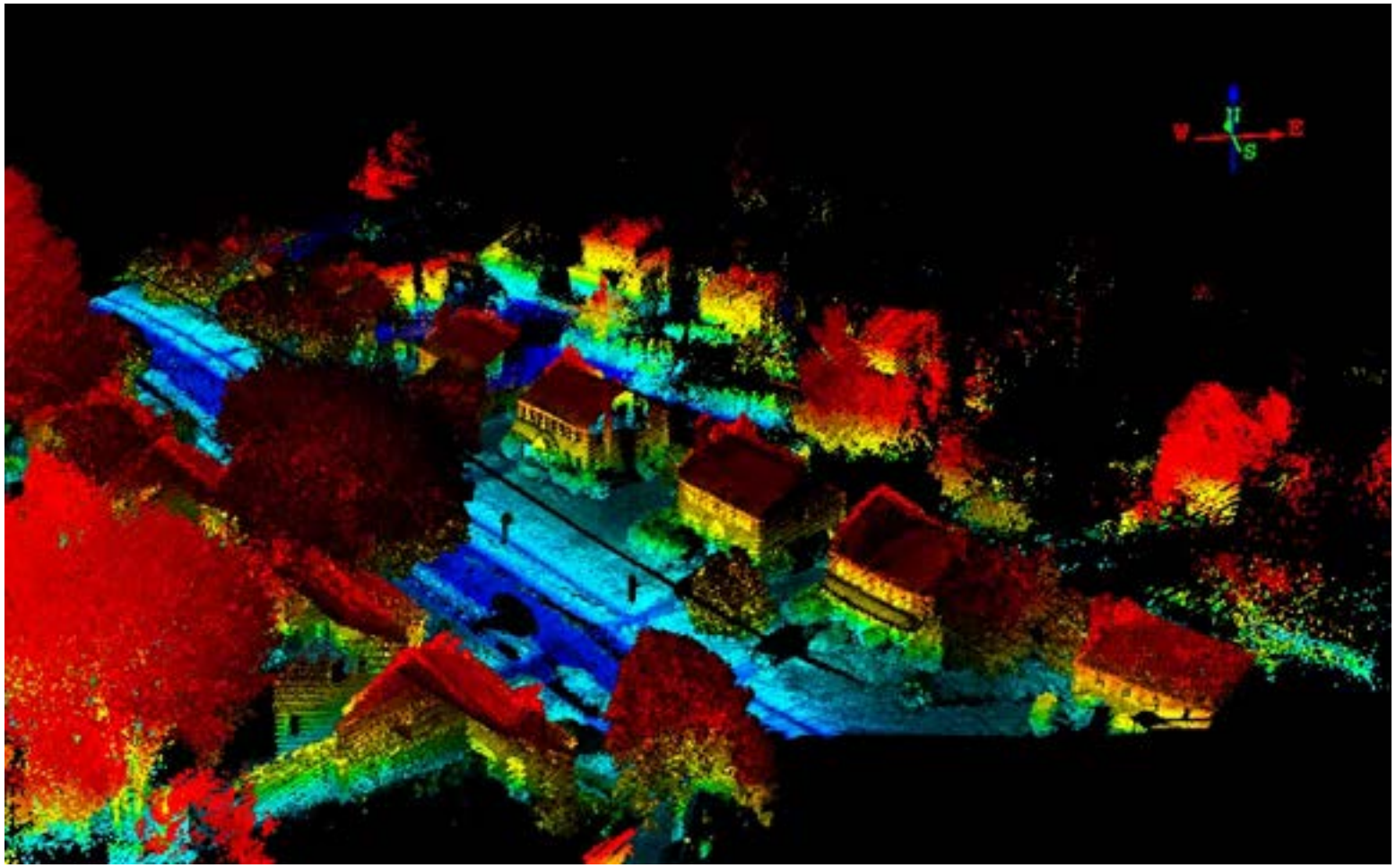


Multi-Level HOG



Our Machines See Homes Better than Humans!

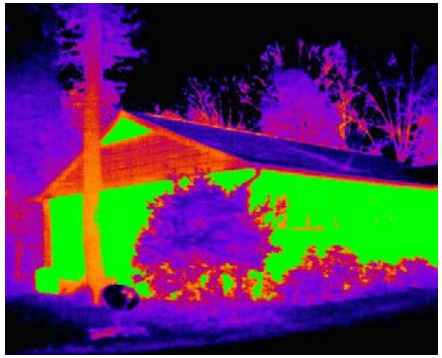
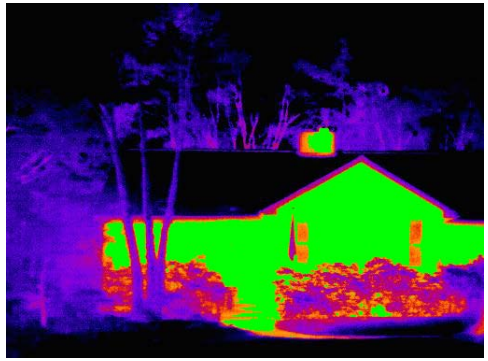
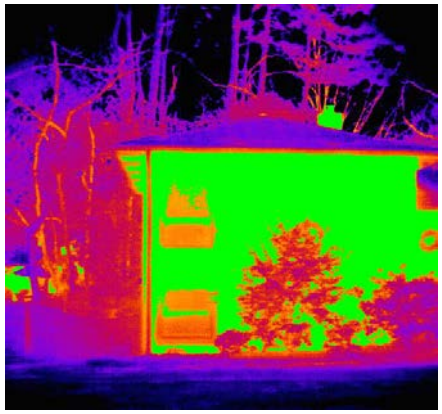
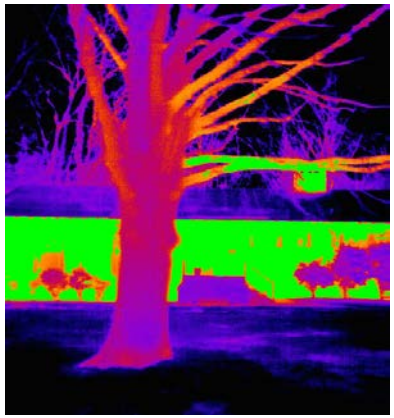
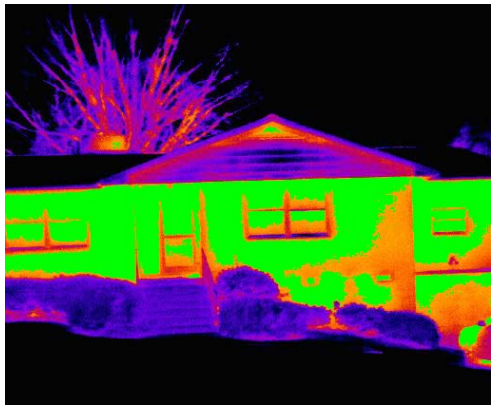
3D Representation of Large Territories



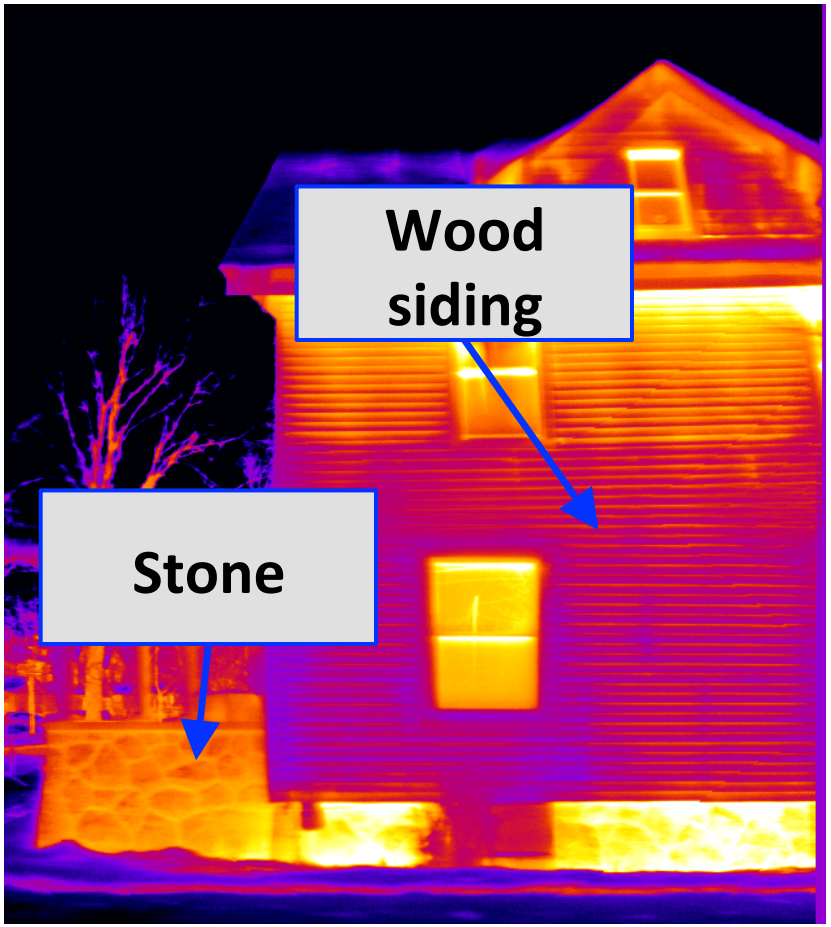
2D Facade Detection & Obstruction Removal

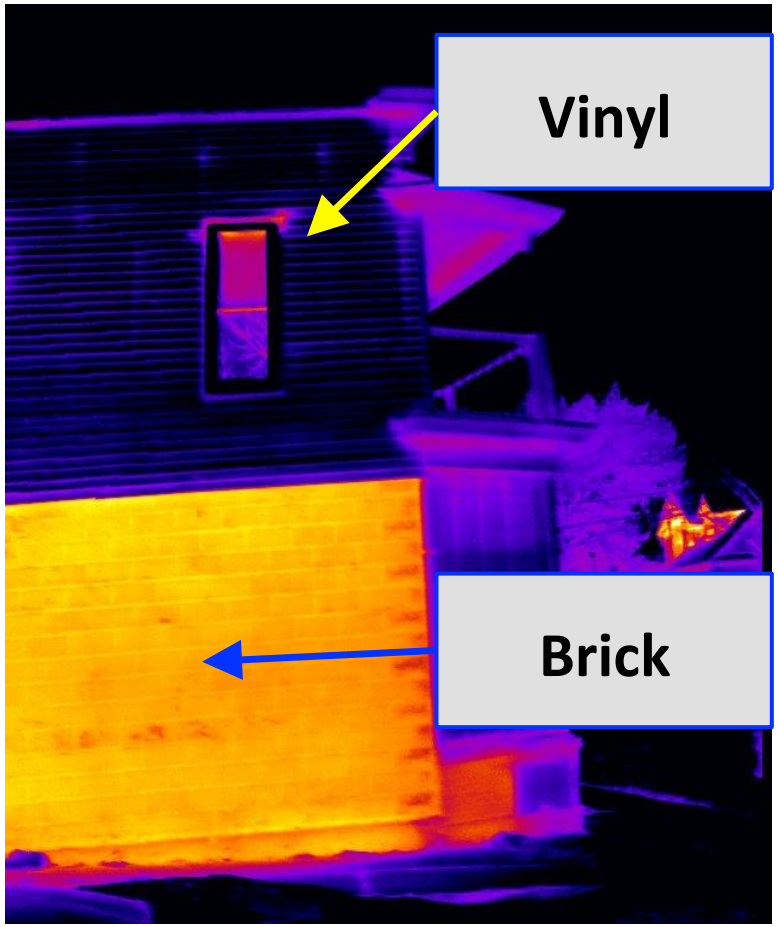
Polygon results from 3D facade detection may require tightening

- We can use the registered LWIR data to extract high-likelihood building pixels
- The images below demonstrate likely building pixels in high-contrast green
  - Note how obstructions (trees, bushes) are easily identified and so can be easily segmented

Materials Affect Instantaneous Surface





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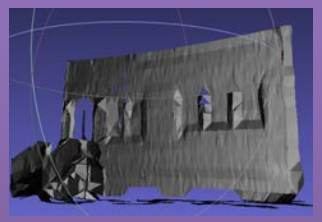
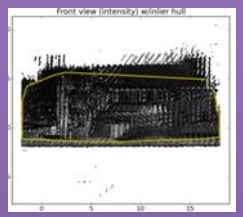
Homes are detected using 2D classifiers and thermal data in the registered NIR + LWIR images

3D Facade Detection





Homes detected in 2D images are projected into 3D space to generate target areas for RANSAC-based plane segmentation and mesh-based facade detection

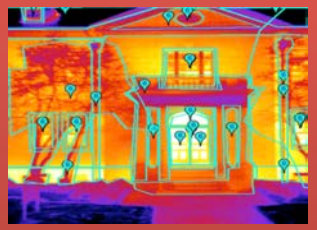
2D Facade Polygon Fitting

Facade outlines detected in 3D are projected back onto the 2D image to generate a preliminary polygon

2D thermal data and classifiers help to "tighten" the polygon

Obstructions (trees, bushes, …) are identified based on temperature values and/or 3D position values of the pixels contained within the polygon

Building Component Detection



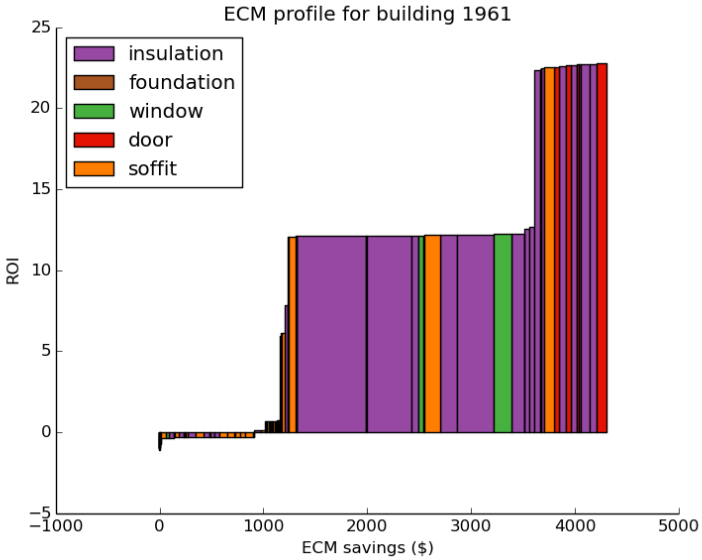
Components are detected within the segmented building facade using 2D classifiers , thermal, and 3D data

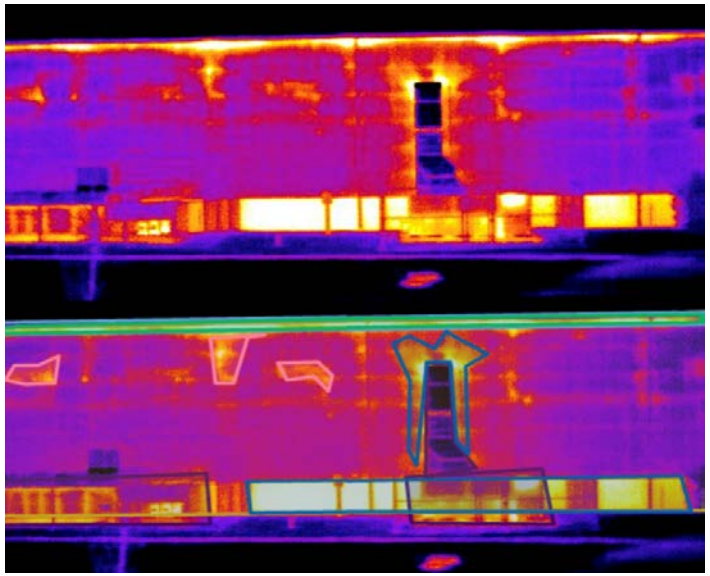
Comprehensive Remediation Analysis

Raw output identifies all potential surface remediations.

Final output prioritizes and displays only attractive surface remediations based on client criteria.

Building Remediation Measures





Building 1961 Envelope ECMs						
ECM Name	kWh Saved	Therms Saved	Dollars Saved	Upfront Cost	Payback Period	ROI
Fix Wall Insulation Holes	4488	9193	5675	16184	2.9	4.3
Fix Soffit Insulation Holes	1391	2783	1720	2743	1.6	8.4
Fix Doorsill Leaks	242	513	316	394	1.2	11.0
Fix Foundation Leaks	98	204	126	664	5.3	1.8

Building 1961 Non-Envelope ECMs						
ECM Name	kWh Saved	Therms Saved	Dollars Saved	Upfront Cost	Payback Period	ROI
Efficienct Fluorescent Lights	344279	-4478	18418	120072	6.5	1.3
Boiler Tuneup	0	289	145	983	6.8	1.2
LED Exit Signs	16250	-171	890	1950	2.2	5.8
Occupancy Sensors	224564	-2921	12013	12038	1.0	14.0

Case Study: Example Military Base

ESTCP

essess

RESULTS

In one night, Essess' technology identified 3,263 distinct feature components on 146 different buildings on Scott Air Force Base. These features were categorized by type (e.g., brick wall, roof, window glass, window frame) and surface temperature. Heat losses were calculated based on the temperatures of the features, the times of observation, the orientations of the features, and the outdoor air temperature.

SAVINGS

Potential Savings Per Annum:	**$304,393**
Potential Savings (Total):	**$4,385,376**
Investment Needed for *ECMs (Total):	**$2,211,500**
Payback Period:	**7.3 years**

*ECMs = Energy Conservation Measures

Case Study: Example Military Base

SPATIAL ANALYSIS

The maps in Figure 7, 8, and 9 show spatial results of the analysis of conductive leaks (heat being lost through walls, thermal bridges, or the roof), convective leaks (heat being lost through air leaks), and the payback period for all remediation measures.

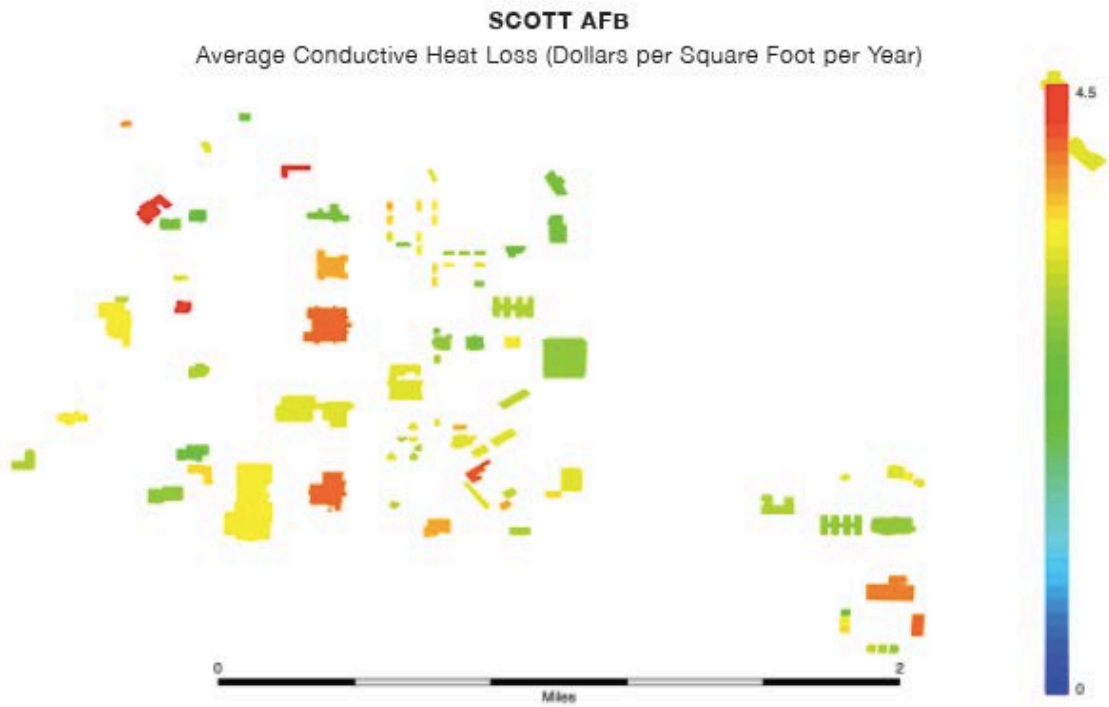


Figure 7. Average conductive heat loss for Scott AFB represents the average dollar loss per square foot of floor area from conductive leaks, e.g., leaks of energy through walls, roods, and other surfaces due to poor insulation.

Case Study: Example Military Base

TOP ACTIONABLE RESULTS FROM SCOTT AFB

Table 5 lists the high-impact cost-effective remediation measures that the Scott AFB Energy Manager should target first when making energy efficiency related upgrades to Scott AFB. These are primarily wall insulation-related measures for the buildings identified as the most emissive. The table lists the initial (estimated) R-value, a post-remediation R-value, and the savings associated with each fix. The cost of the remediation measure and the payback period are also included.

Table 5 Immediately actionable remediations for Scott Air Force Base

Label No.	Bldg No.	Action	Material	Init R Value	New R Value	Savings ($)	Cost ($)	Payback (yrs)
1	1600	Improve Wall Insulation	Brick	8.1	13.7	2509	11427	4.6
2	533	Improve Wall Insulation	Brick	8.1	13.6	1835	8337	4.5
3	1600	Improve Wall Insulation	Brick	8.4	13.6	1733	8706	5.0
4	1575	Improve Wall Insulation	Brick	8.4	13.6	1511	7694	5.1
5	1575	Improve Wall Insulation	Brick	8.0	13.7	1436	6327	4.4
6	1575	Improve Wall Insulation	Brick	8.3	13.7	1382	6721	4.9
7	40	Improve Wall Insulation	Brick	8.9	13.6	1362	8041	5.9
8	533	Improve Wall Insulation	Brick	8.2	13.6	1338	6306	4.7
9	1989	Improve Wall Insulation	Brick	8.6	13.6	1043	5628	5.4
10	1456	Improve Wall Insulation	Siding	6.9	10.0	1022	5340	5.2

Scott Air Force Base

https://driveby.essess.com/clients/scott_air_force_base

Logged in as Scott Air Force Base | Log Out

essess

30 buildings chosen for analysis

NOSC #1575	Visual Info Service Center #700
Medical Center #1530	HQ AMC #1521
868 Comm Squadron #61	Fitness Center #6
932 Squad Ops #470	Airman Family Rediness Center #1650
Commissary #1980	Base Supply #4001
USTRANSCOMM #1900	Fire Department 1 #460
TRAFFIC MGT FCLTY #4010	AMC #40
USTRANSCOMM Annex #1961	Pax Terminal #8
Flight Med #1529	Hangar 1 #433
TWR, CON #3689	Vehicle Operations #548
Vertical Shop #549	COMM #5
HQ AMC #1600	DITCO #3600
Lab, PME #352	DECCO #3189
Electrical Shop #516	HQ AMC/CSS #861
MPF #10	Billeting #1512

Export CSV

Structure	375 AW HQ
Building ID	3

101 HERITAGE, SCOTT AFB, IL 62225-5011

☐ Analyze this building

Additional Benefits of Thermal Imaging at Scale

- Transformer analysis
  - Map overheating transformers throughout the city and determine load on high voltage power lines
- District steam or chiller leak detection
  - Improve district cooling system or any steam systems by detecting leaks across the city
- Road surface management
  - Pot hole detection, detect drainage issues
- Structural integrity and inventory street features
  - Telephone poles, street lights and trees
- Mapping Hard to Access Geographies
- Chemical Spectroscopy

AdvanTek
EXPERT POWERED :: CLIENT DRIVEN

Michael West, PhD, PE
Advantek Consulting Engineering, Inc.
Mike.West@advantekinc.com

Package DX Units:
Performance Optimization & Field Tests

Background

Unitary equipment is ubiquitous.

- 60% of US commercial space is cooled with RTUs (DOE)
- 54% of commercial building cooling primary energy consumption (EIA)
- Total annual installations over 300,000 units
- Estimated 1.6 million legacy units operating at low efficiency levels

  100,000 units at DoD facilities / 20,000 buildings
  100,000 units at USPS facilities / 30,000 buildings
  500,000 units at 65,000 “big box” retail stores

RTU – Rooftop packaged air-conditioner Unit
DOE – U.S. Department of Energy
EIA – Energy Information Administration
USPS – United States Postal Service

ROOFTOP

PORTABLE

PAD MOUNT

SPLIT SYSTEM

Performance Ratings

" How much cooling you get for the electricity it uses"

Btuh per Watt (MBH per kW)

- **EER** – Energy Efficiency Ratio

  Full Load @95F Ambient

- **IEER** – Integrated Energy Efficiency Ratio

  Weighted Full Load & Part Load @**95**, **81.5**, **68**, and **65F**

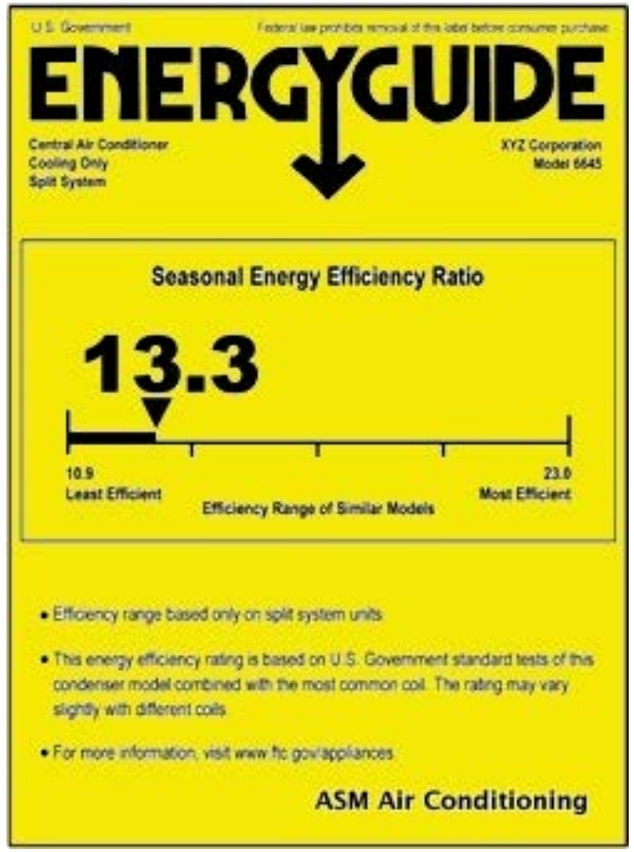
- **SEER** – Seasonal EER

  Part Load @82F Ambient x 0.875

  Cyclic Performance Load Factor

- **IPLV** – Integrated Part-load Value

  Legacy rating (no longer standard)



ANSI/AHRI Standard 340/360-2007

Drivers

1. Energy saving goals continue to rise

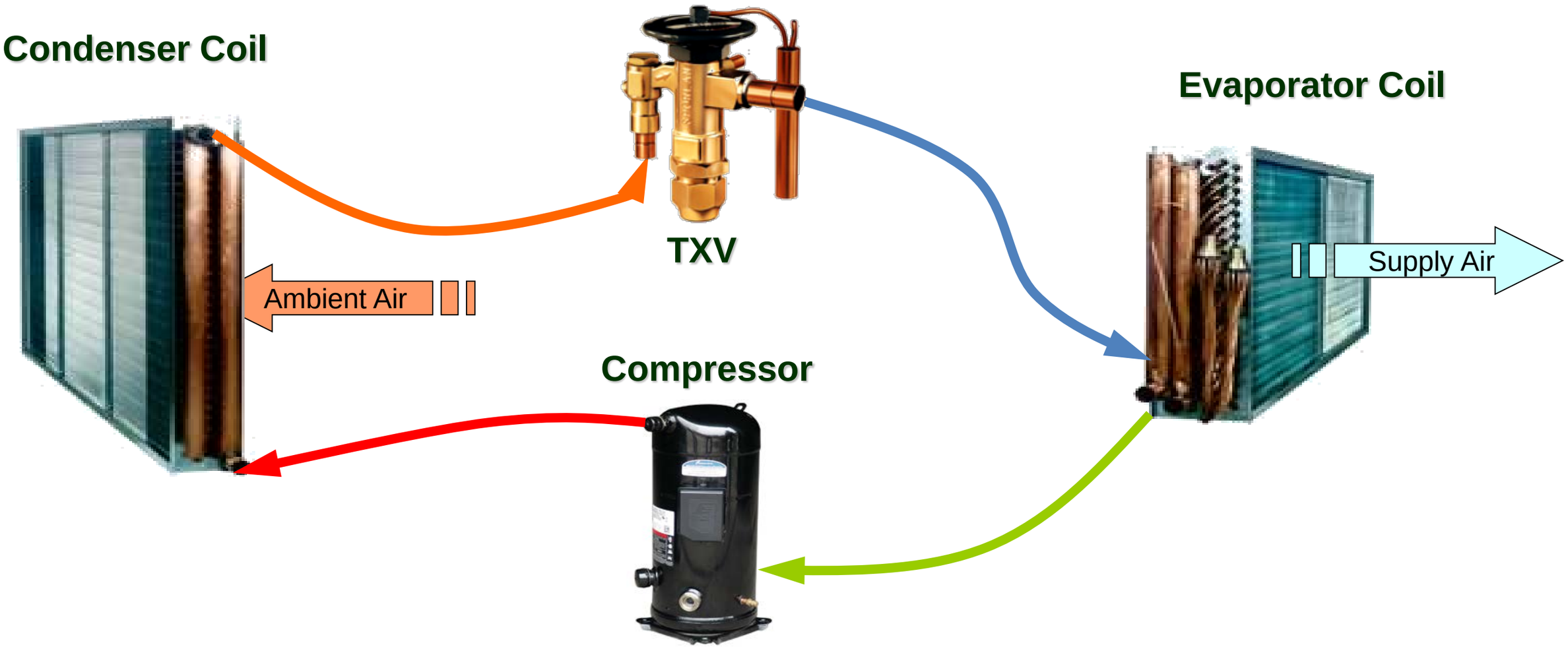
- **IEER -** Integrated Energy Efficiency Ratio 10.0 to 13.0, **EER** – Energy Efficiency Ratio 9.7 to 11.7
- Upcoming DOE 10% and 30% increases in efficiency minimums
- Single-zone VAV and DDC requirements of Energy Standard 90.1-2013 and Green Standard 189.1-2014

2. Dehumidification needs are increasing

- Reduced sensible loads means lower SHR
  - Lower lighting Watts / sqft
  - Higher insulation R-values
  - Heat reflective / low-e glass
  - *often addressed with energy intensive reheat*
- Part-load requirements of IAQ Standard 62.1-2013 s.5.9 (< 65%rh)

often "solved" with energy intensive reheat

Basic DX Cycle



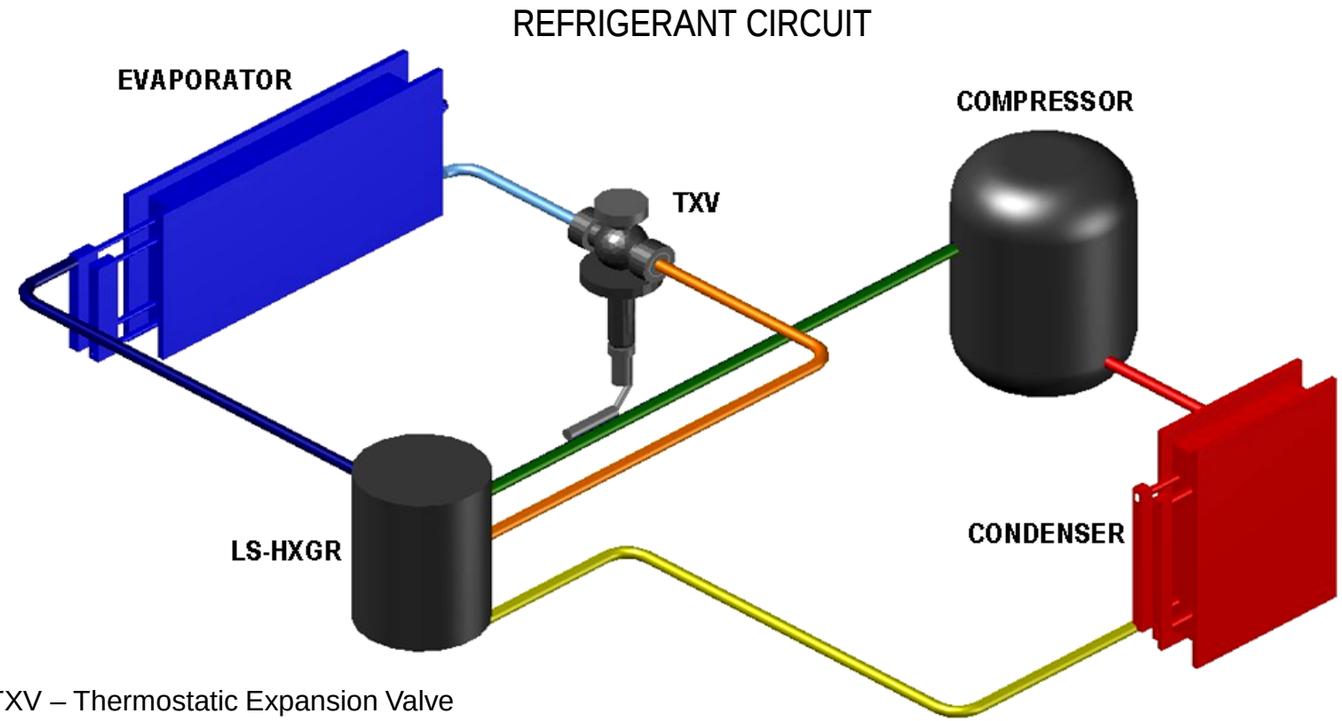
Modified DX Cycle

Revises the traditional refrigeration cycle at a fundamental level.

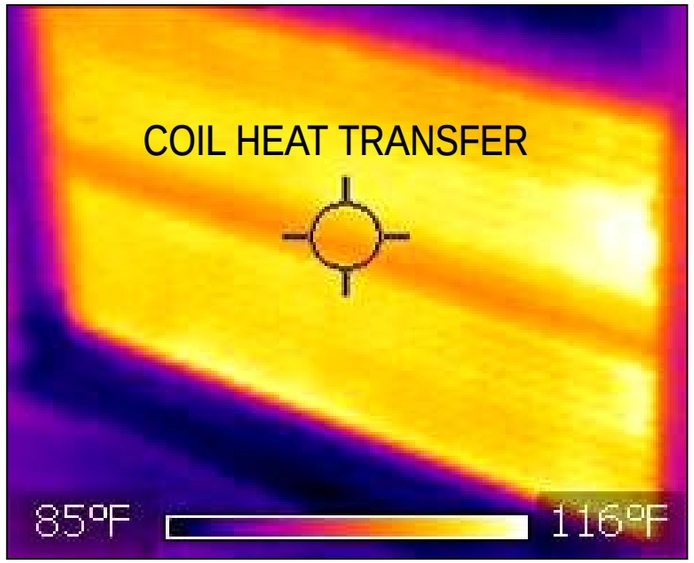
Improvement of evaporator refrigerant / two-phase heat transfer.

Increased suction density improves compressor volumetric efficiency.

Variable sensible heat ratio optimizes airside performance.



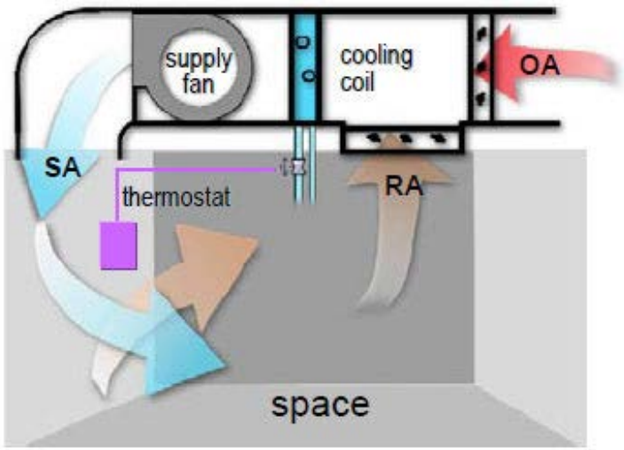
TXV – Thermostatic Expansion Valve

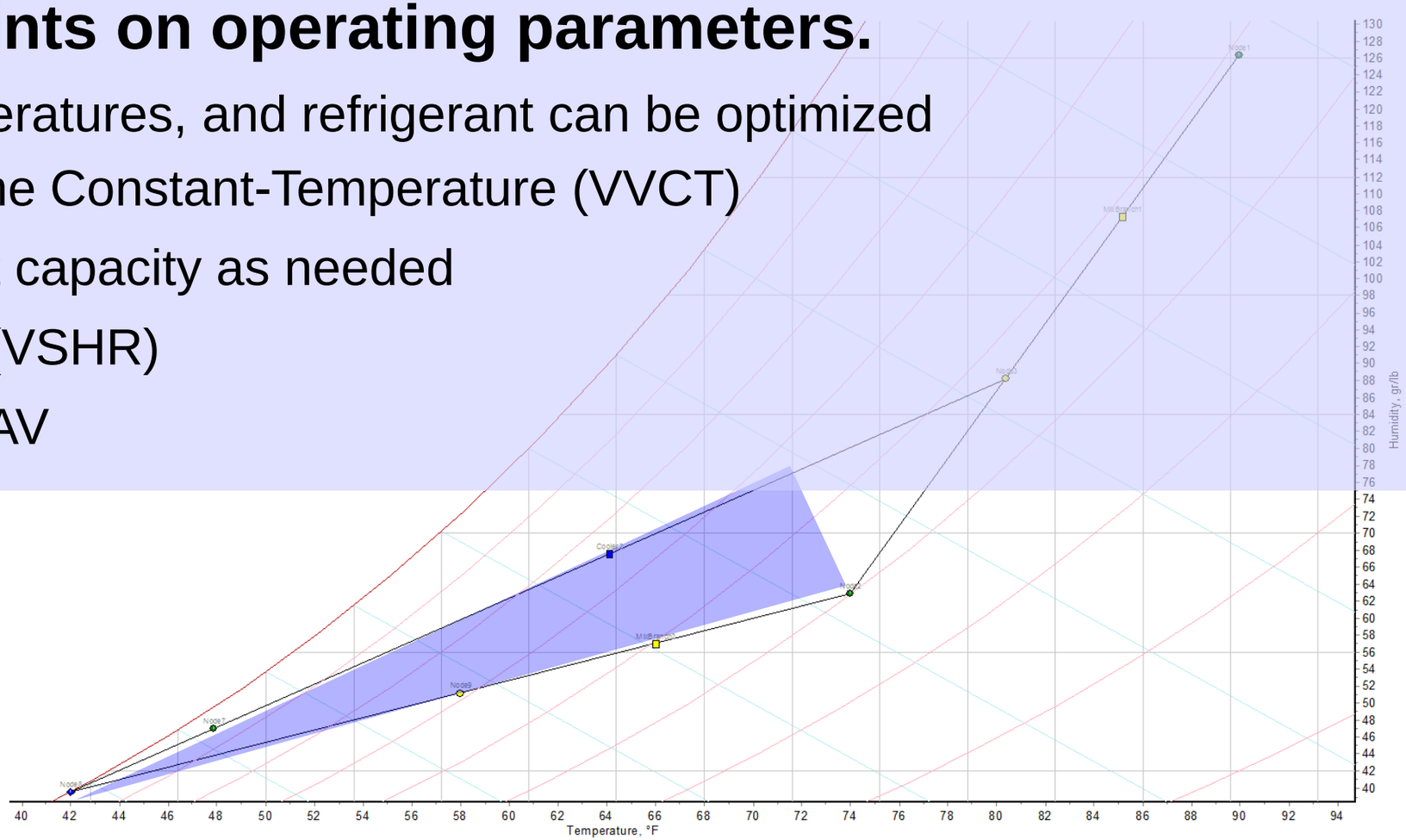


Significance of DX Modification

Releases constraints on operating parameters.

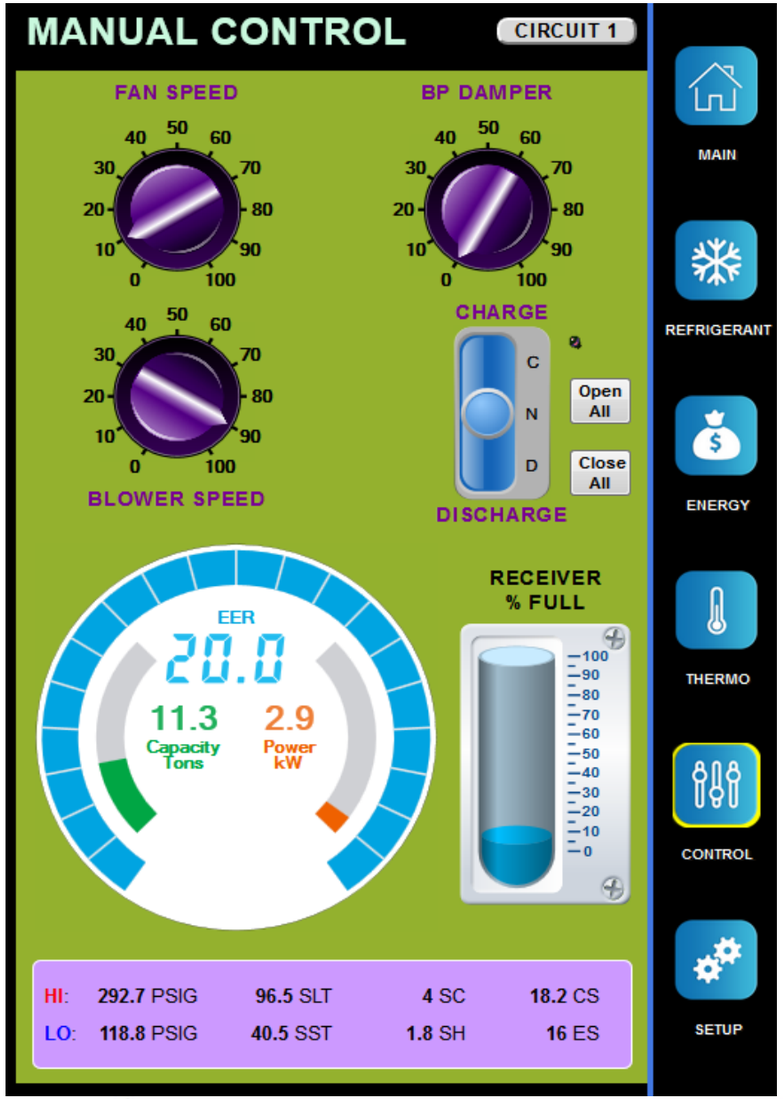
1. Airflows, temperatures, and refrigerant can be optimized
2. Variable-Volume Constant-Temperature (VVCT)
3. Increase latent capacity as needed
4. Variable SHR (VSHR)
5. Single-Zone VAV





EER Optimizer

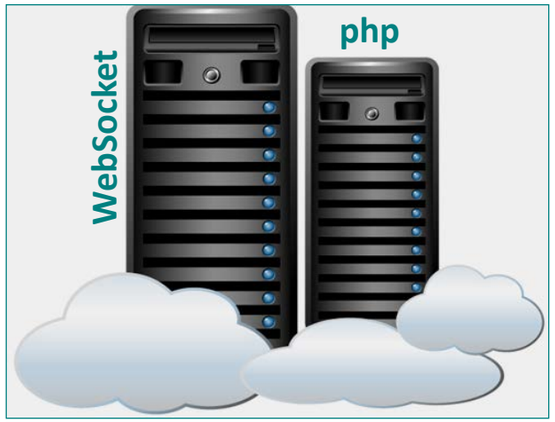
http://www.EERoptimizer.com/



- Controls all operating parameters
- Target is maximum EER while precisely meeting sensible and latent loads
- Continuous performance tuning
  - Supply Blower Speed
  - Condenser Fan Speed
  - Refrigerant Charge
  - Supply Air Temperature
  - Coil Temperature
  - Economizer Damper
- Continuous web reporting
  - EER, IEER, Tons Capacity
  - Faults, such as low refrigerant or fouled coil
  - Diagnostics detects issues before problematic

Data Connectivity

EER Optimizer



Cloud Servers

Database

Internet

Any Web Device

Tablet, Smart Phone, Laptop

VPN or commercial WAN

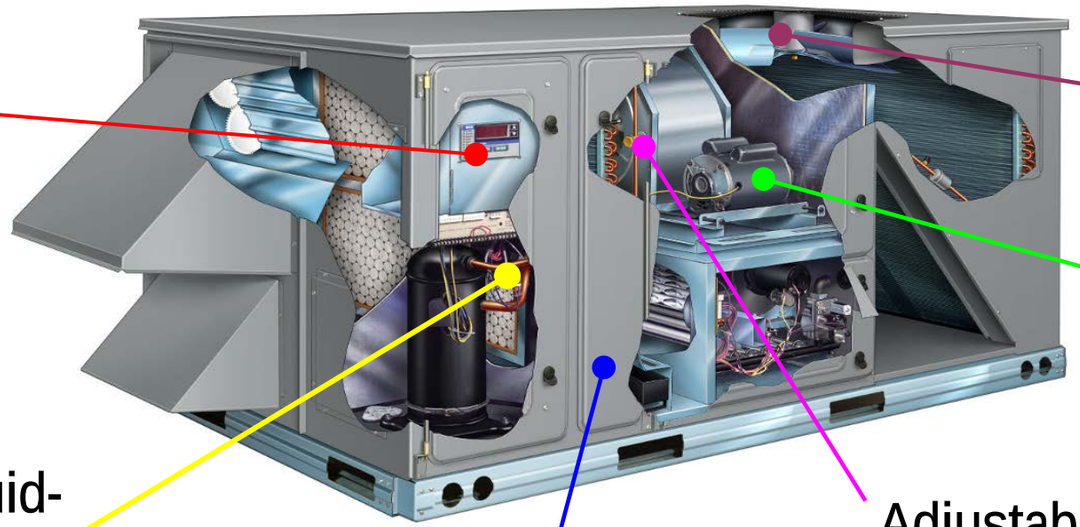
GUI

LAN

Controller

RTU

Supercharged Package Unit



CLIMASTAT™ EER Optimizer

Installation

South Carolina

Field Tests

Site 1: Retail Store
Beaufort, South Carolina
2627 cooling degree-days
Climate zone 3A Warm-Humid

South Carolina

Field Tests

20-ton dual-circuit
R-22 package DX unit
Gas heat
Manufactured 2/2003
Found in “poor” condition

Fresh air intake

Gas heating section

Compressors

California

Field Tests

Site 2: Classroom Building
Mojave, California
Elevation 2500 feet

Climate zone 3B Hot-Dry
3225 cooling degree-days
2597 heating degree-days

California

Field Tests

12½-ton dual-circuit
R410a package DX unit
Heat Pump
Installed 2010

Florida

Field Tests

Site 3: Electronics Development Laboratory
Cape Canaveral, Florida
3633 cooling degree-days, Climate zone 2A Hot-Humid

Florida

Field Tests

8½-ton dual-circuit
R410a package DX unit
9 kW-heat
Installed 1/2012

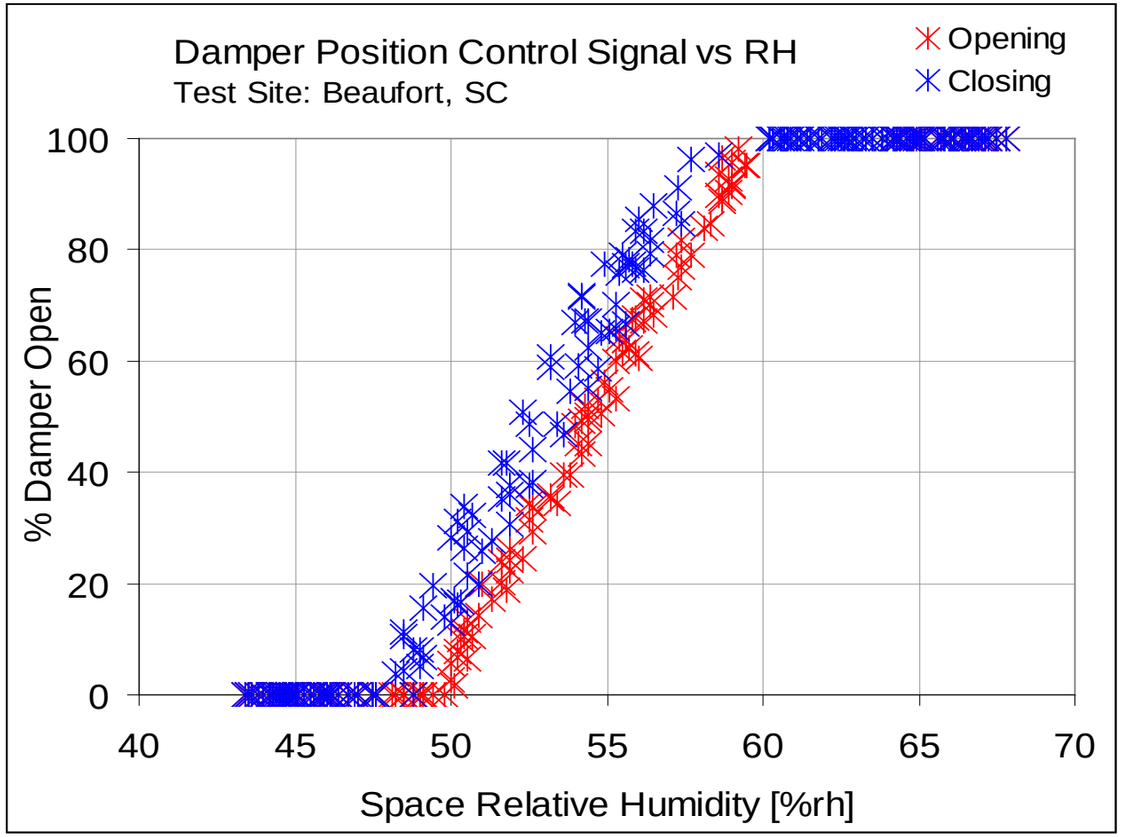
Performance Analysis

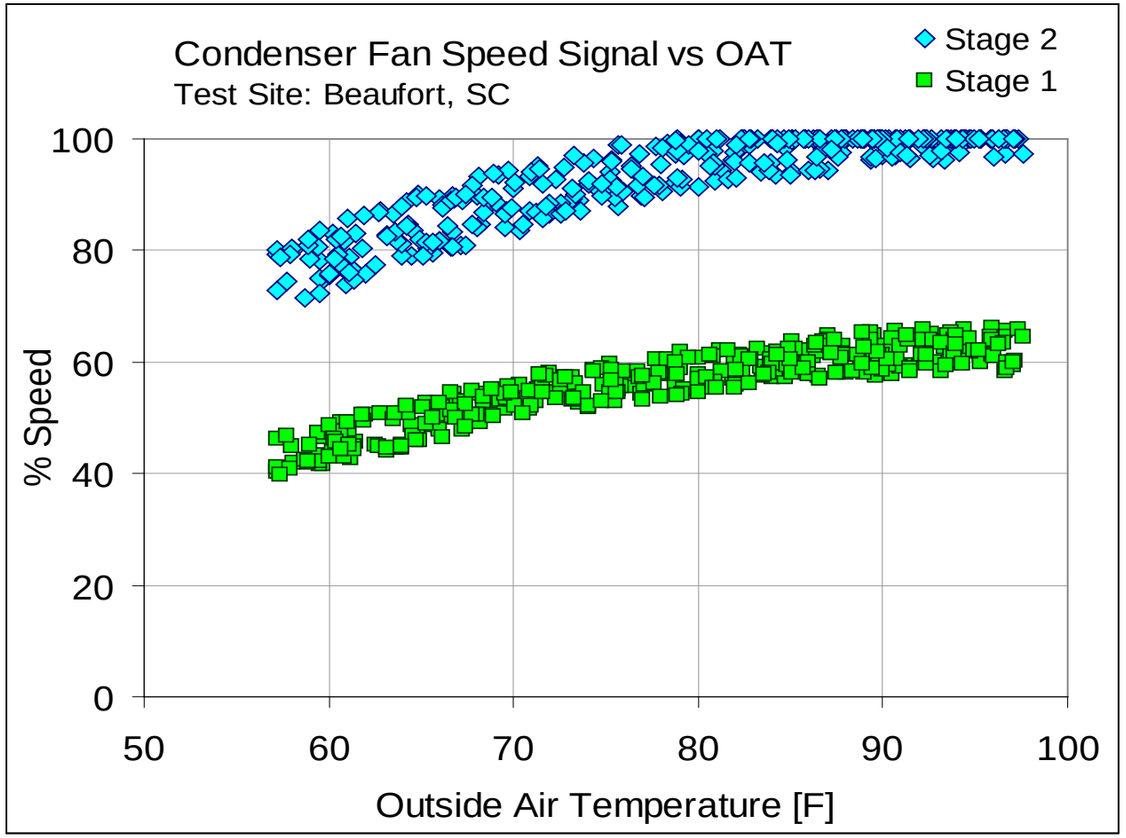
Performance measurement data available live via web links http://www.tinyurl.com/CCAFS-EDL

45 Sensors on each RTU

- Compressor Amps (2)
- Fan and Blower Power
- Total Unit Power
- Refrigerant Pressures (4)
- Refrigerant Temperatures (12)
- Refrigerant Flows (2)
- Air Temperatures
  - at thermostat, return, outdoor, coil, entering & leaving coil, unit discharge
- Air Humidity
  - coil entering, unit discharge, at thermostat, outdoor
- Space and Ambient CO_2 level
- Control point status

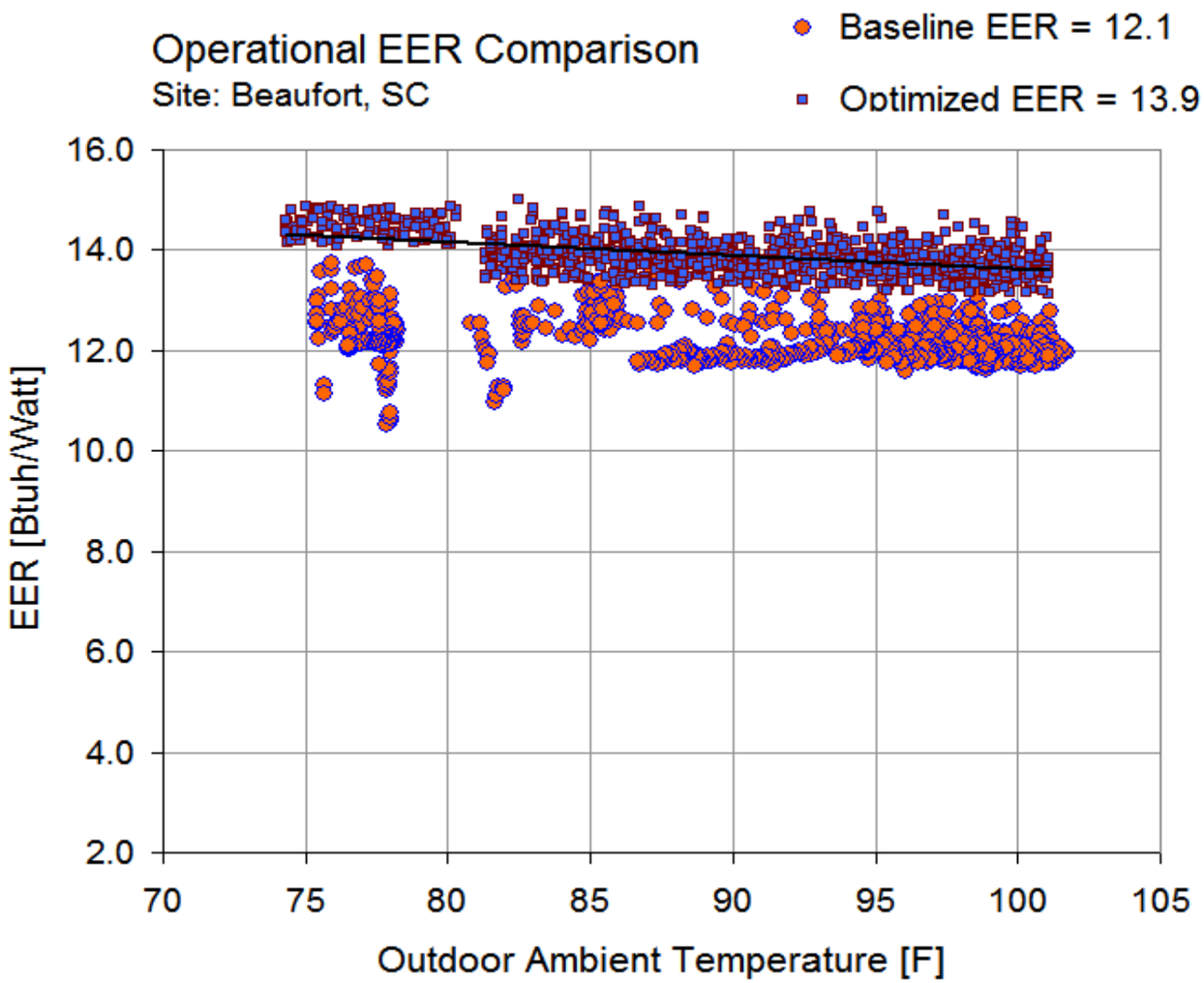
Field Test Results





The optimizing controller tuned the RTU's operation according to varying conditions as expected. Shown is control of damper position and condenser fan speed with change in humidity and temperature.

Field Test Results



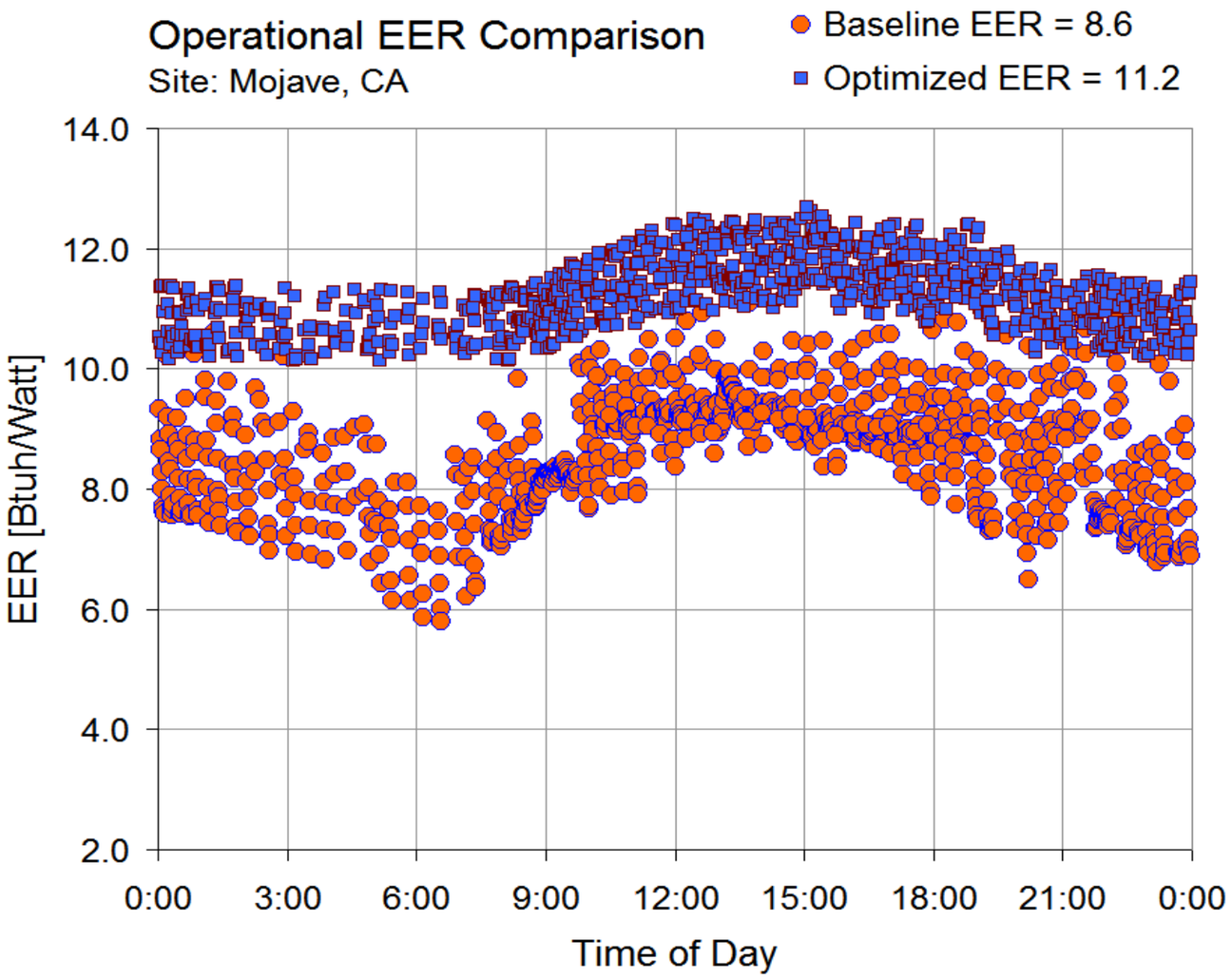
Beaufort SC Field Test Preliminary Result

- 15% IEER increase from 12.4 to 14.3
- 15% operational EER increase
- Elimination of startup efficiency loss
- Reduced compressor cycling
- 27% less energy kWh/CDD consumed

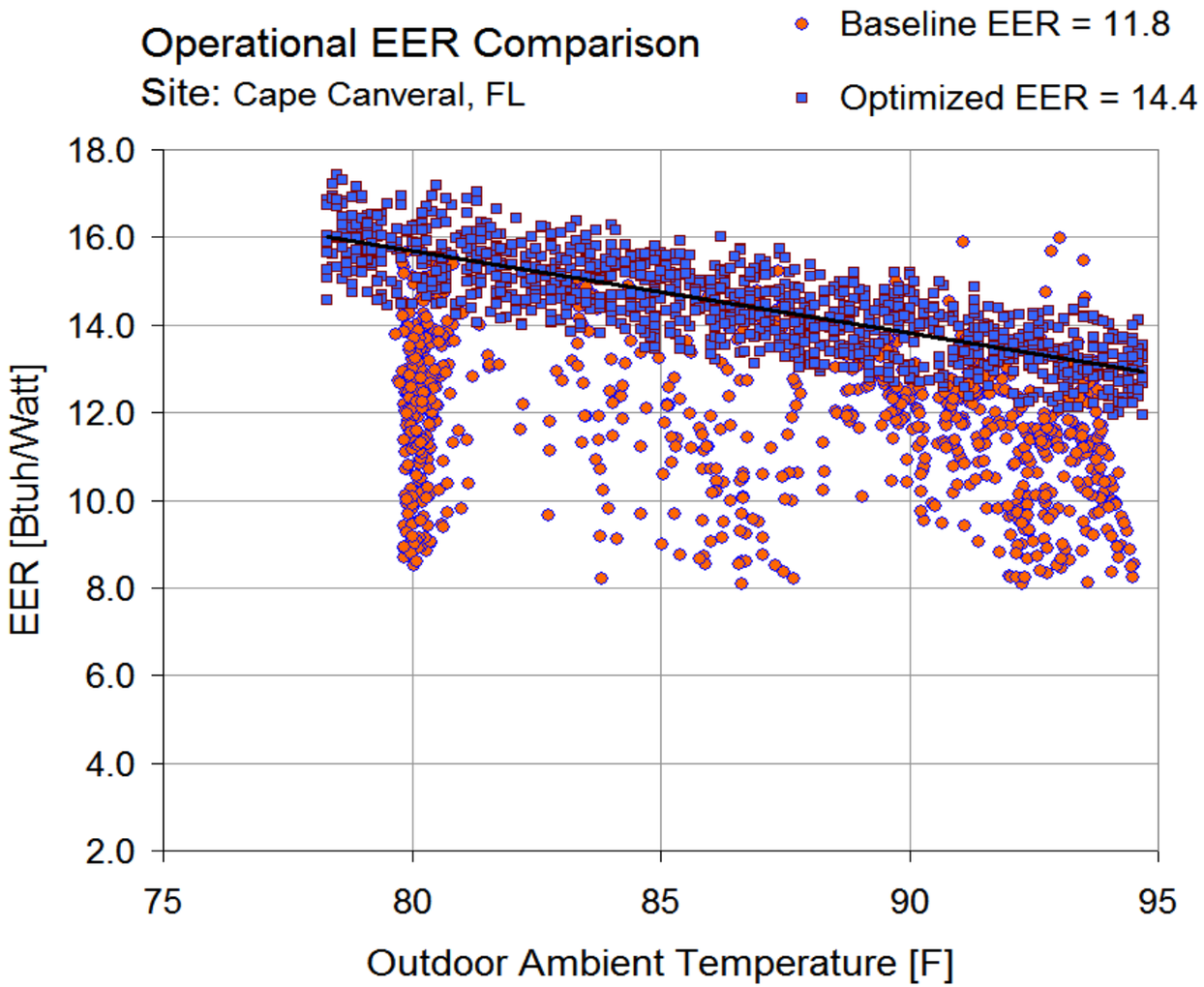
Field Test Results

Mojave CA Field Test Preliminary Result

- 37% IEER increase from 7.8 to 10.6
- 31% operational EER increase
- Elimination of startup efficiency loss
- Reduced variation with temperature
- 40% less energy kWh/CDD consumed



Field Test Results



Cape Canaveral FL Preliminary Result

- 22% IEER increase from 13.4 to 16.4
- 23% operational EER increase
- Elimination of startup efficiency loss
- Reduced compressor cycling
- 37% less energy kWh/CDD consumed
  - Not counting reheat energy savings
- Space humidity between 45 ~ 50%rh

Results Summary

Data Summary	Operational IEER		Average EER		Efficiency Gain	
Site	Baseline	Optimized	Baseline	Optimized	IEER	EER
Beaufort, SC	12.4	14.3	12.1	13.9	15%	15%
Mojave, CA	7.8	10.6	8.6	11.3	37%	31%
Cape Canaveral, FL	13.4	16.4	11.8	14.5	22%	22%

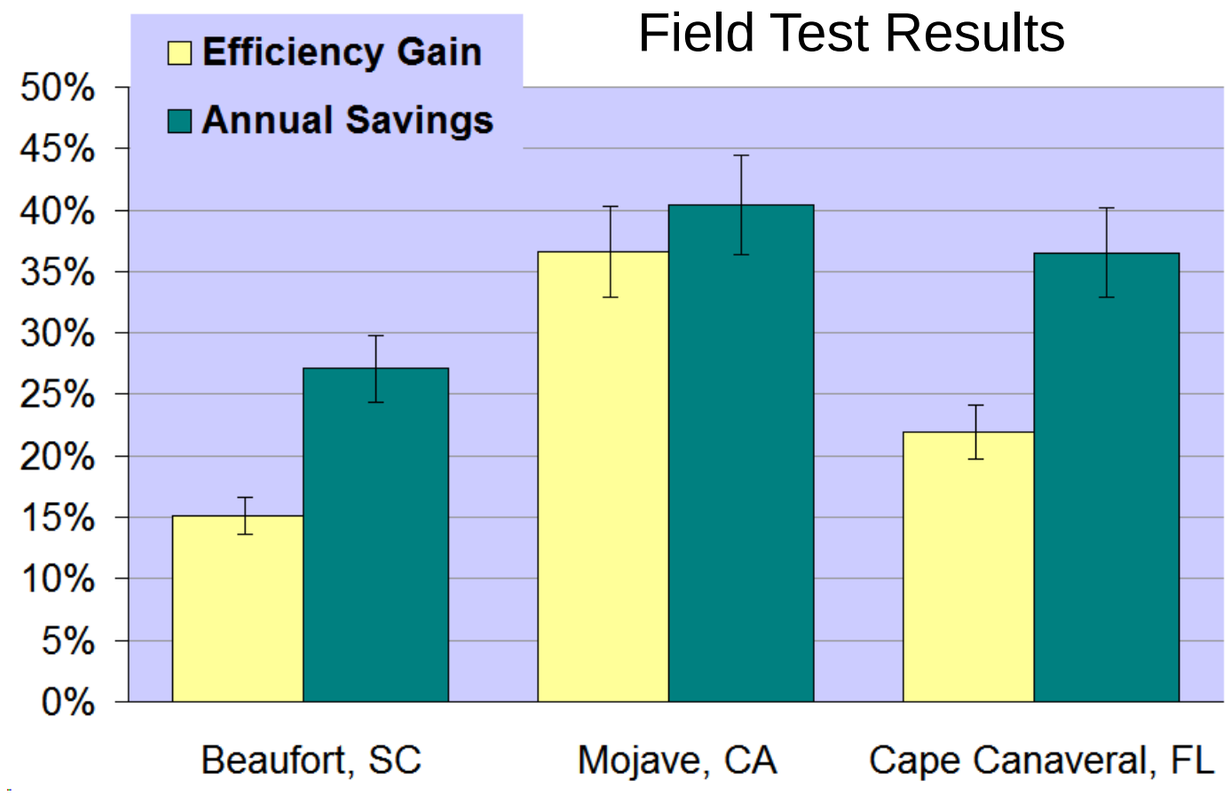
Beaufort, SC

Mojave, CA

Cape Canaveral, FL

Conclusion

- Web connection from anywhere
- Fault detection & diagnostics
- 15 to 37% operational IEER increase
- Elimination of startup efficiency losses
- 27% to 40% less energy kWh/CDD
- Improved dehumidification
- Cooler compressor operation
- Reduced compressor cycling



FEDERAL UTILITY PARTNERSHIP WORKING GROUP SEMINAR

November 3-4, 2015
Houston, TX

Modified Version of High Efficiency Dehumidification System (HEDS) ESTCP Presentation EW-201344

Hosted by:

FEMP Federal Energy Management Program

CenterPoint Energy

Original Presentation by:
Dahtzen Chu
U.S. Army Construction Engineering Research Laboratory
Scot Duncan, PE, Retrofit Originality, Inc.
Omar Chamma, Trane

What We'll Discuss

- This presentation will discuss several different methods that are currently utilized for Relative Humidity (RH) control in DoD facilities and some of their comparative strengths and weaknesses.
- The main focus of the discussion will be on the "High Efficiency Dehumidification System" or "HEDS" that is in the process of undergoing testing thru the ESTCP process.
- The appendices contain FAQ's and Psychrometric charts for typical reheat and recuperative designs.

Comparative Baselines at DoD and Nationally

Baseline for the demonstrated technology comes in several variations.

1. Simplest and most widespread comparative baseline system consists of an AHU with a chilled water or DX refrigerant sourced cooling coil that cools the air down to between 52F and 55F.

    1. Removes moisture from the air via condensation, then utilizes a heating coil, either sourced by hot water or an electric reheat coil to raise the supply air temperature to lower the Relative Humidity of the air entering the spaces, drying the spaces out.

2. AHU's equipped with Run Around coils for reheat duty in various configurations:

    1. Upstream of main Cooling Coil (CC) to downstream of main CC,

    2. Exhaust air to Supply air, (does not reduce plant energy in this configuration)

    3. Heat pipe coils configured as above,

    4. Air to Air heat exchangers as configured above.

3. Other comparative dehumidification systems consist of variations of high pressure AHU's equipped with some form of desiccant wheel that absorbs moisture from the supply air without requiring cooling to dry the air out via condensation of moisture. Recuperative energy requirements can be high.

Comparative Baselines at DoD and Nationally

Baseline in most DoD buildings/installations for the demonstrated technology comes in several variations.

1. The simplest and by far the most widespread comparative baseline system consists of an AHU with a chilled water or DX refrigerant sourced cooling coil that cools the air down to between 52F and 55F to remove moisture from the air via condensation, then utilizes a heating coil, either sourced by hot water or an electric reheat coil to raise the supply air temperature to lower the Relative Humidity of the air entering the spaces, drying the spaces out.

    a. Due to the high cooling, heating and electrical energy consumption of these designs and the fact that many installations shut their heating systems off during the summer, the reheat portion of the dehumidification process is typically shut down.

    b. This allows 100% water saturated, 100% Relative Humidity, very cold supply air to enter the occupied spaces. When this cold, water saturated air comes in contact with solids in a space, condensation can occur. Wherever there is condensation, there is the high likelihood of unwanted biological growth occurring, which will later require substantial expense to remediate.

Comparative Baselines at DoD and Nationally (cont.)

2. Other comparative dehumidification systems consist of variations of high pressure AHU's equipped with some form of desiccant wheel that absorbs moisture from the supply air without requiring cooling to dry the air out via condensation of moisture.

   The relatively new desiccant wheel based Dedicated Outdoor Air System (DOAS) system usually requires a substantial amount of ductwork, over and above that required for a HEDS unit, as the exhaust air, plus a substantial amount of added heat, are used to dry out the chemicals in the desiccant wheel so that the process can begin anew.

   The relative downsides of these desiccant wheel based systems may include a very high construction cost, higher operational costs, higher energy use, specialized and higher maintenance requirements that are typically not available in facility maintenance budgets, and maintenance manpower skills that are not typical at the installations.

Industry "State of the Art" is 100 Years Old

Typically installed dehumidification system in DoD facilities consists of an AHU equipped with a cooling coil sized to cool air down to condense moisture out of the air, then a reheat coil, using a new heating energy source of either heated water or an electric heater, to warm the air back up and lower the Relative Humidity.

Some newer designs take this same concept and package it into a "Dedicated Outdoor Air System" or "DOAS".

Still others of relatively recent design use a desiccant wheel based system to dry the air out.

Simplicity Advances the State of the Art

The HEDS design was born out of the global need for a simple to operate, simple to maintain, simple to understand, energy efficient, cost effective, sustainable way to reduce biological growth and promote occupant health, comfort and productivity.

At energy efficiency projects for a multitude of installations in a variety of climates, we found mold present in a widespread manner. The facility maintenance and operations staffs were all aware of the situation, they were all concerned about the mold growth and they were doing what they could to kill the worst case growths, but when the HVAC system is working against them continually, they were never able to win the battle, let alone win the war, against biological growth.

The usual culprits were poorly designed HVAC systems that were never designed for relative humidity control, the lack of heat to perform reheat duties to lower the RH of the supply air, and failed DOAS units due to complexity and lack of maintenance funds and skill sets.

Faced with the status quo of rampant mold growth in many facilities, the challenge was to develop a dehumidification system that did not need new, added energy for reheat and that could be maintained by an operator with the skill sets to maintain a normal chilled water based AHU.

Attribution

Many figures and substantial information for the older dehumidification technologies are excerpted from or based on several articles written by Donald P. Gatley, P.E. President, Gatley and Associates for HPAC Engineering Magazine in 2000. For more details on the older technologies, Mr. Gatleys' articles are available on-line.

Run Around Coil System Piping

Can hurt CHW system TD, no temperature control, much longer AHU, Higher air pressure drop, more fan energy, not scalable to FCU sizes

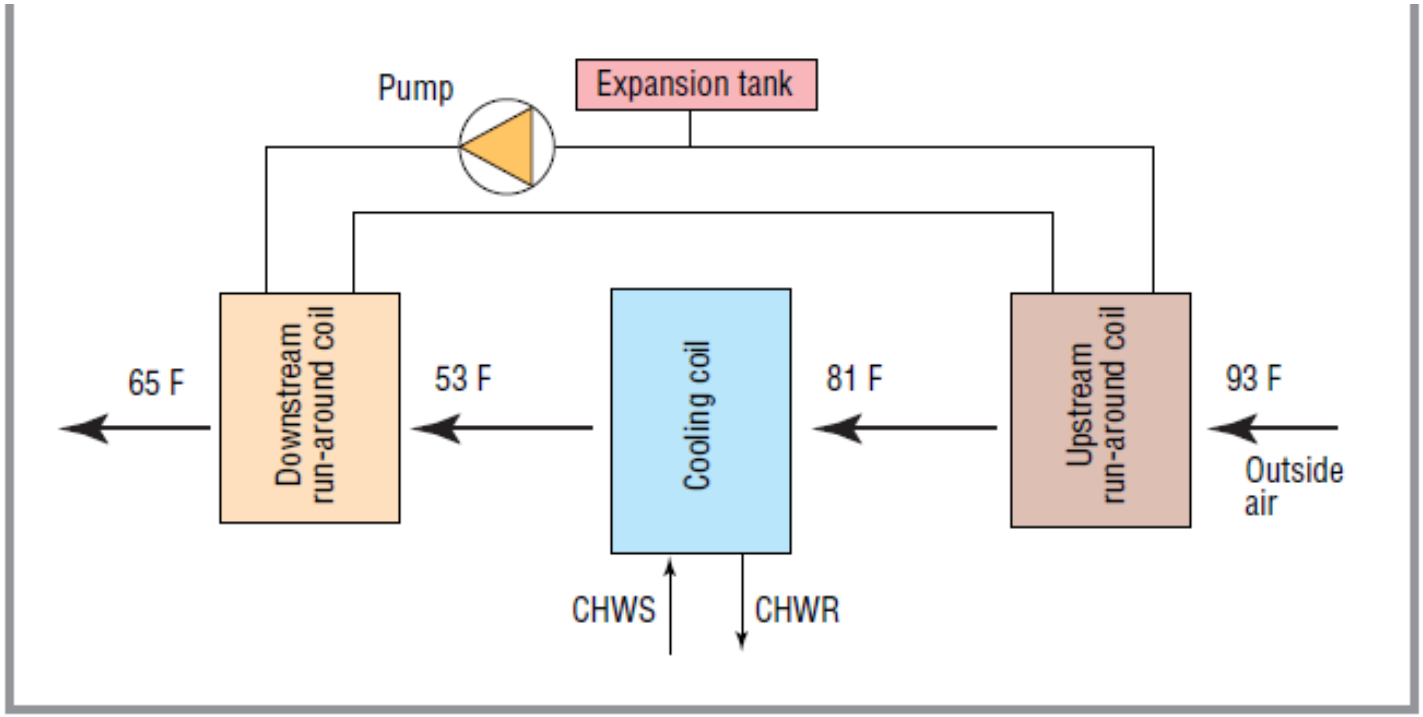


FIGURE 3. Run-around-coil piping.

Run Around Coil

Can hurt CHW system TD, no temperature control, much longer or taller AHU, Higher air pressure drop, more fan energy, not scalable to FCU sizes

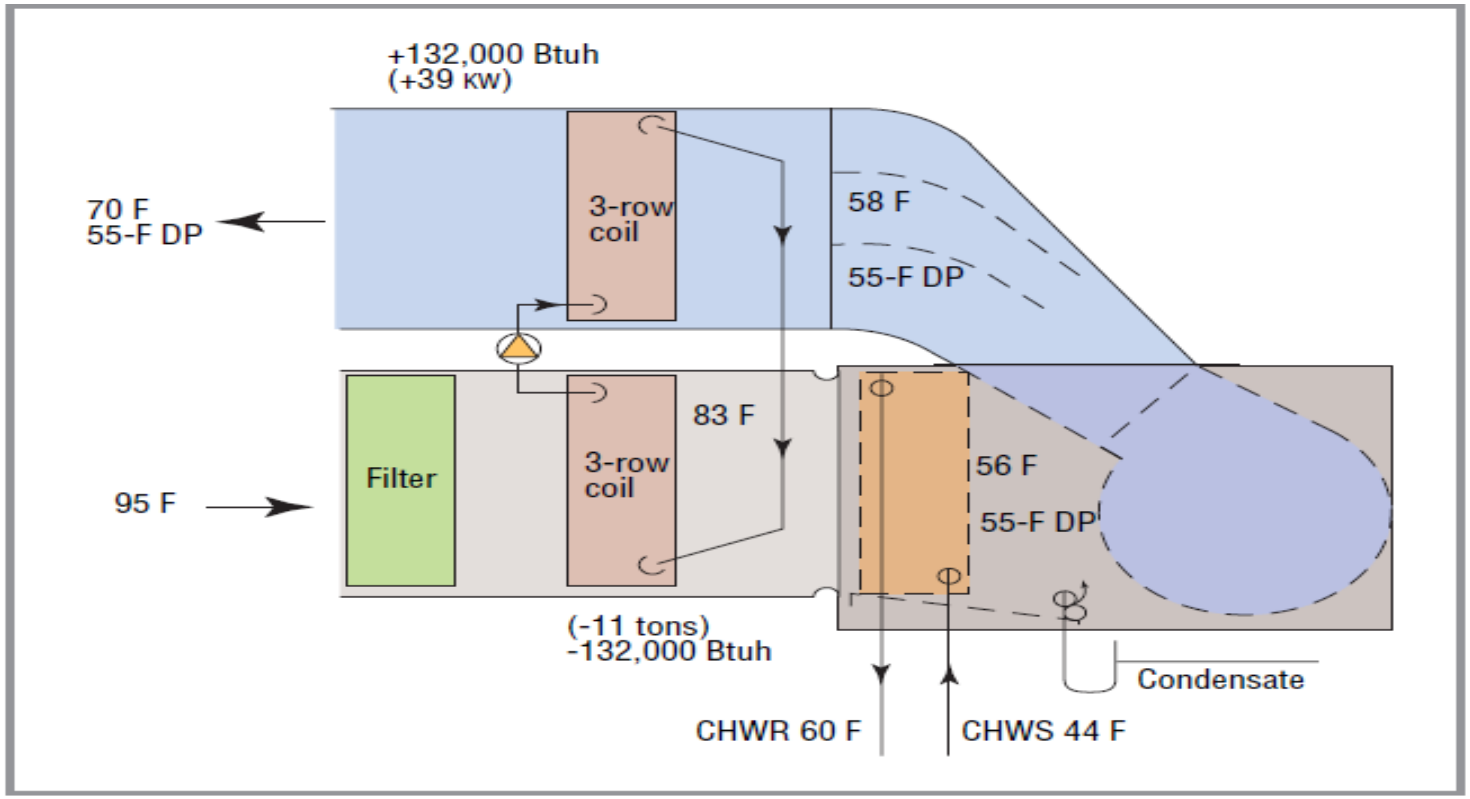


FIGURE 4. Run-around coil.

Heat Pipe Coils

Can hurt CHW system TD, no temperature control, much longer or taller AHU, Higher air pressure drop, more fan energy, not scalable to FCU sizes

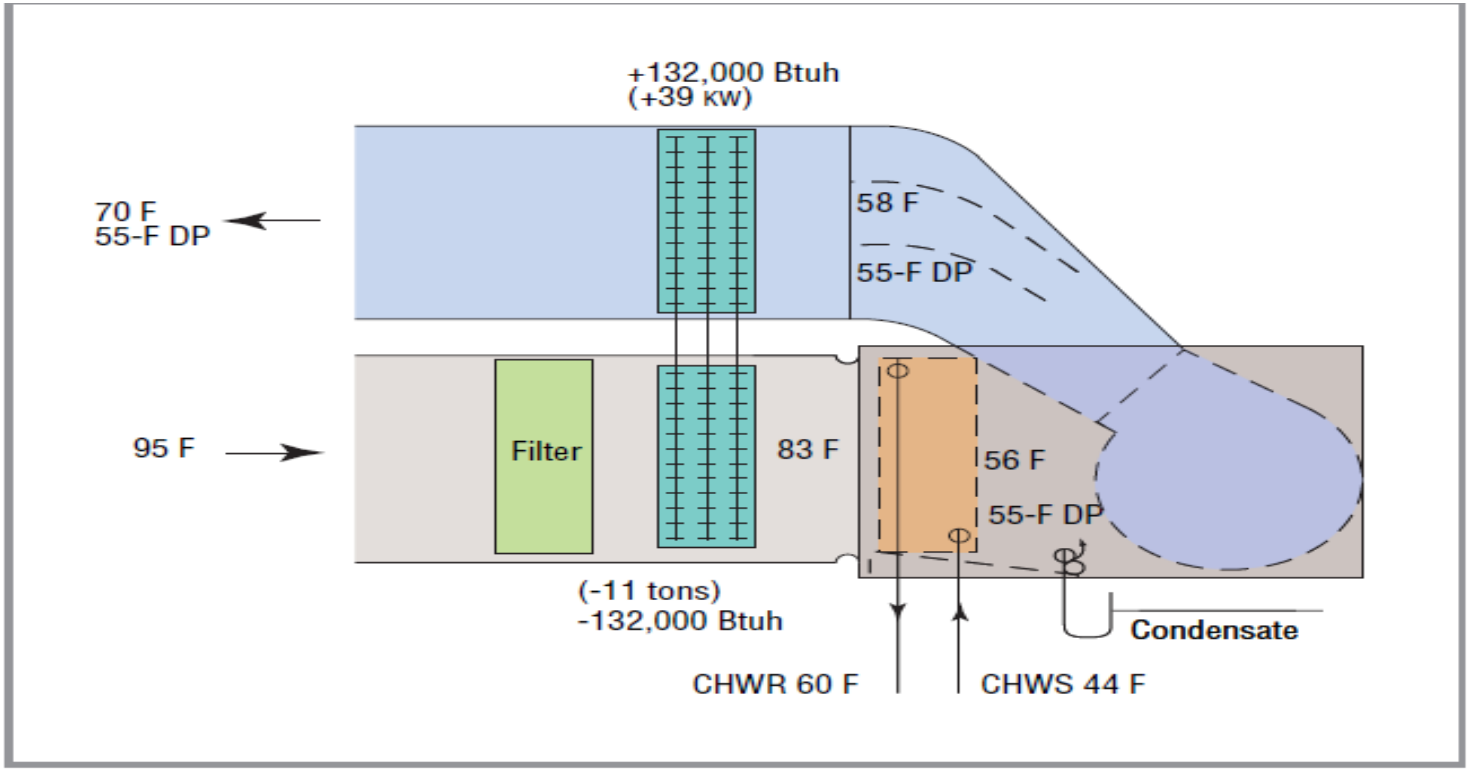


FIGURE 5. Heat-pipe coil.

Air to Air HX

Can hurt CHW system TD, no temperature control, lots more ductwork, longer or taller AHU, maintenance issues, Higher air pressure drop, more fan energy, not scalable to FCU sizes

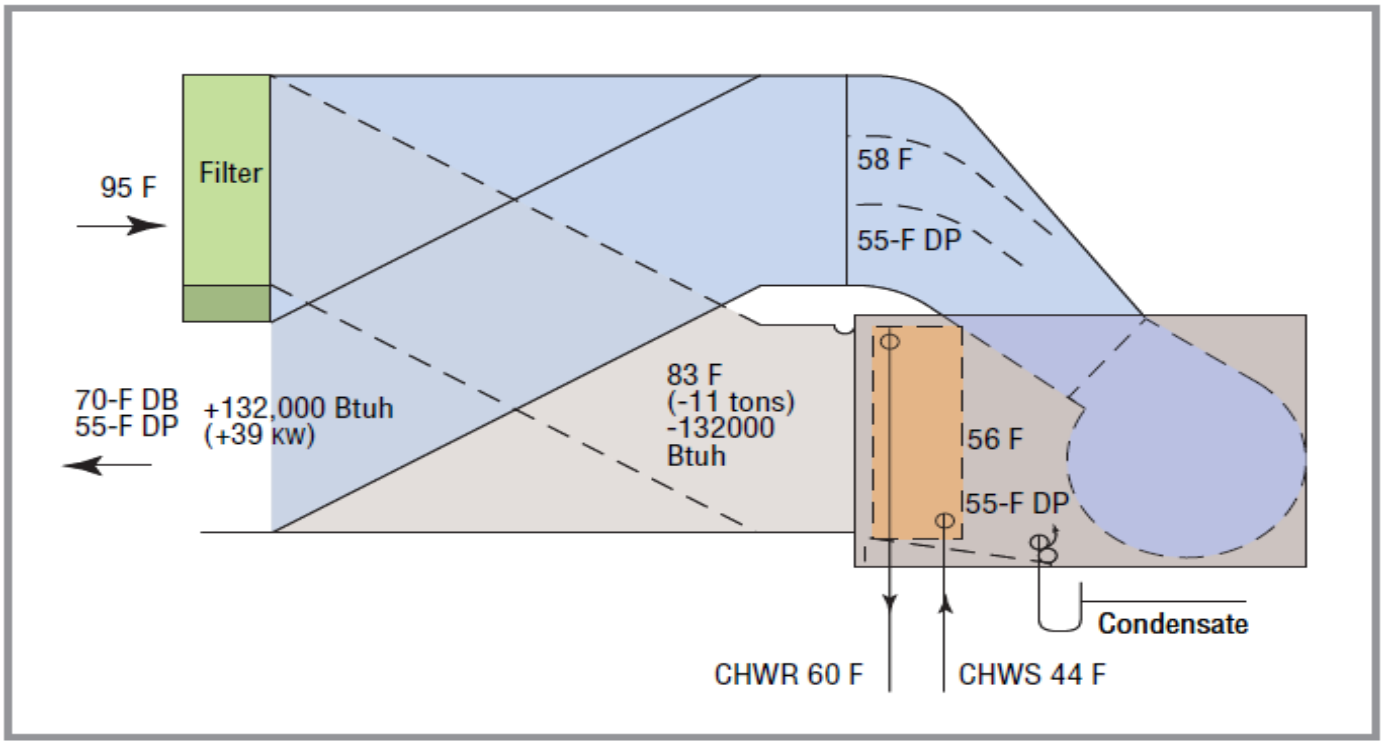


FIGURE 6. Air-to-air heat exchanger.

Rotary Wheel HX

Can hurt CHW system TD, no temperature control, much larger AHU, Higher air pressure drop, more fan energy, added regeneration heat energy with some designs, not scalable to FCU sizes

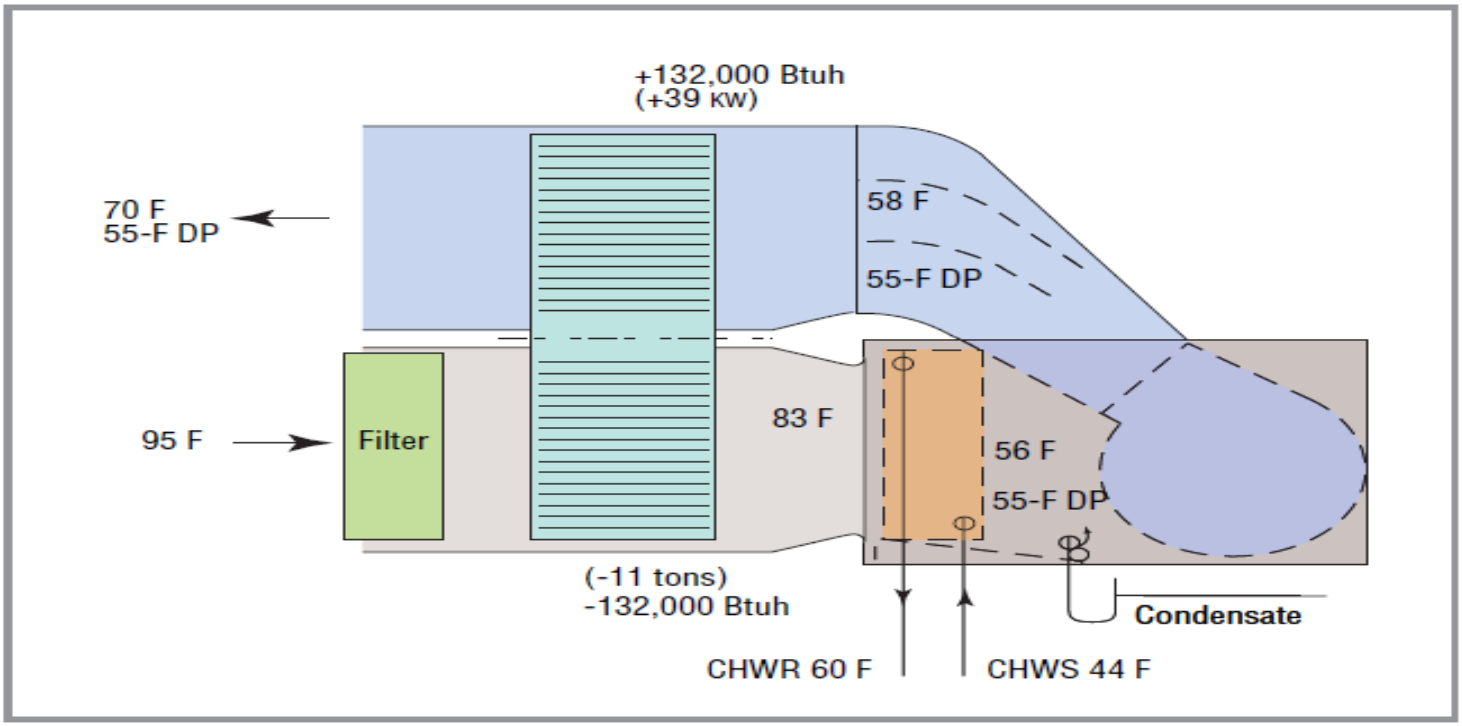
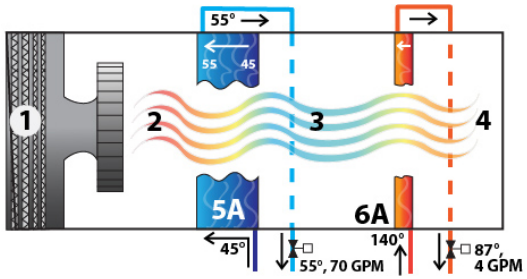


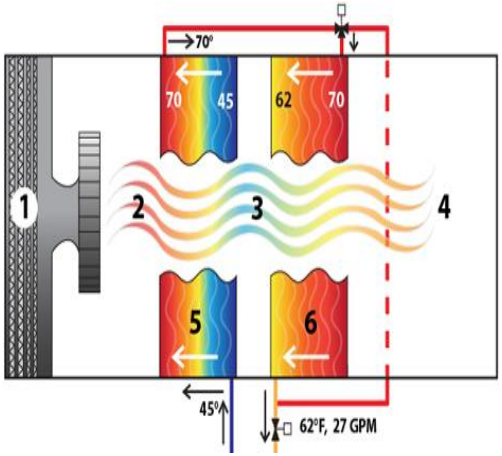
FIGURE 7. Rotary-wheel heat exchanger.

HEDS Comparison to "Normal" Dehumidification/ Reheat AHU



Traditional AHU Designed for Dehumidification Duty. Small cooling and reheat coils, high CHW flow rates, low CHW temperature differential and high AHU air pressure drops. 45°F CHW enters the cooling coil (5A) at 70 GPM and leaves the cooling coil at 55°F. A new source of 140°F water enters the reheat coil (6A) at 4 GPM and leaves the reheat coil at 87°F. The unit requires **479,319 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the design conditions in this example

Data Points 1 thru 4: [1] 10,000 CFM airflow [2] 78°F dry bulb temp, 65°F wet bulb temp [3] 55°F dry bulb, 55°F dewpoint, essentially 100% relative humidity [4] 65.3°F dry bulb, 55°F dewpoint, 55% RH



High Efficiency Dehumidification System (HEDS) AHU (53% Peak Day BTUH Savings) Very large cooling and cooling recovery coils, low CHW flow rates, high CHW temperature differential and low AHU air pressure drops. 45°F CHW enters the cooling coil (5) at 27 GPM and leaves the cooling coil at 70°F. This 70°F water then enters the CRC coil (6) at 27 GPM and leaves the CRC coil at 62°F while heating the air to 65°F. The HEDS unit requires **226,187 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the same conditions**, a BTUH savings of 53% and a CHW flow reduction of 62% in this example.**

Blue=Cold Temperatures, Yellow to Red = Warm to Hot Temperatures.

Brief Technology Comparisons

	Normal AHU	HEDS AHU	Sample Desiccant based Dedicated Outdoor Air System (DOAS)	Run-Around Coil AHU
Anticipated ability to provide a 10% to 15% overall construction cost advantage ?	No	Yes	No	No
Anticipated ability to provide an approximate 25% annual chiller plant energy consumption advantage?	No	Yes	No	No
AHU System internal air pressure drop for coils/media?	0.80" + for cooling coil 0.05" + for reheat coil	Less than 0.40" for cooling coil and cooling recovery coil combined	Approximately 2" or more	Approximately 2" or more for cooling, and pre- and post run-around coils
AHU Fan HP required?	Base Case	Lower than base case	Higher than base case	Higher than base case
Pump energy and maintenance required for run-around coil pump?	N/A	N/A	N/A	Yes
LEED points available?	No	Yes	Yes	Maybe
Cost Effective Use?	DOAS or Normal / recirculating installation	DOAS or Normal / recirculating installation	DOAS Only	DOAS or Normal / recirculating installation

Brief Technology Comparisons

	Normal AHU	HEDS AHU	Sample Desiccant based DOAS	Run-Around Coil AHU
Relative Overall HVAC System Cost?	Base Case	Approximately 15% higher to 15% lower than Base Case. Savings depends on type of HW and CHW generation and distribution systems.	Higher than Base Case	Higher than Base Case
Post-Unit Cooling Required?	No	No	Yes	No
Post unit reheat required for peak day relative humidity control?	Yes	No	No	Probably not but depends on upstream and downstream coil sizes
Entering air preheat required for peak day relative humidity control to lower unit entering air RH conditions?	No	No	In some cases - unit entering air must have a relatively low RH for one technology to work properly	No
Chiller Plant Energy use?	Highest	Lowest - probable 25% minimum annual reduction compared to "Normal" design.	Similar to "Normal" AHU, slightly lower for the DOAS part of the project.	Potentially lower than "Normal" AHU
Reheat System Energy use for Relative Humidity control?	Can be substantial	Minimal to zero	No, but only useful for DOAS applications	Lower than "Normal" AHU, higher than "HEDS" AHU.
Post-unit cooling to deliver "neutral" air to the loads?	No	No	Yes, in many cases	No
Post-unit cooling to deliver cooling air to the loads?	No	No	Yes	No

Brief Technology Comparisons

	Normal AHU	HEDS AHU	Sample Desiccant based DOAS	Run-Around Coil AHU
Maintenance Skill set required	Base Case	Same as Base Case	Higher than typical maintenance staffs are trained for	Same as Base Case
CHW System Typical Design Temperature Differential (TD)?	10°F to 15°F	20°F to 30°F	10°F to 15°F	10°F to 15°F
CHW System Typical Actual Operating summer Temperature Differential?	6°F to 12°F	14°F to 24°F	6°F to 12°F	6°F to 12°F, potentially lower
Low Delta T Syndrome?	Typical design strategies contribute to Low Delta T Syndrome	Typical design strategies solve Low Delta T Syndrome	Typical design strategies contribute to Low Delta T Syndrome	Typical design strategies contribute to Low Delta T Syndrome
Chiller Plant size (Tonnage)?	Base Case	Estimated minimum 20% chiller size reduction (lower loads, series chiller operation)	Slightly smaller than base case for DOAS applications	Slightly smaller than base case
CHW Pump HP and VFD Size? CHW TD is essentially doubled for HEDS, resultant CHW flow cut by 50%	Base Case	CHW Pump motor and VFD HP reduced by approximately 50%	No discernible size reduction from base case	No discernible size reduction from base case
Cooling Tower Size?	Base Case	Estimated minimum 20% cooling tower size reduction	No discernible size reduction from base case	No discernible size reduction from base case

Brief Technology Comparisons

	Normal AHU	HEDS AHU	Sample Desiccant based DOAS	Run-Around Coil AHU
Waterside Economizer annual runtime usage (Plate and Frame Heat Exchanger tied to cooling towers)	Base case, must be very cold outside to use waterside economizer	Big coils can double or triple waterside economizer run time at 0.10 to 0.15 kW/ton total Ch. plant efficiencies - 60% to 90% energy savings	Same as base case	Same as base case
Chiller plant/cooling tower water consumption?	Base Case	Probable 20% water consumption reduction - reduced loads, increased efficiency,	Slight reduction in water consumption	Slight reduction in water consumption
Condenser water piping, pump motor and VFD size? Approx 20% flow reduction with HEDS	Base Case	CDW Pump motor and VFD HP reduced by approximately 20% to 30% Possible pipe size reduction	No discernible size reduction from base case	No discernible size reduction from base case
Effect on CHW piping infrastructure during expansions?	May require substantial piping infrastructure upgrade costs	Can reduce piping infrastructure upgrade costs	May require substantial piping infrastructure upgrade costs	May require substantial piping infrastructure upgrade costs
Effect on CHW piping infrastructure during expansions?	May require substantial piping infrastructure upgrade costs	Can reduce piping infrastructure upgrade costs	May require substantial piping infrastructure upgrade costs	May require substantial piping infrastructure upgrade costs
Frees up CHW cooling capacity in existing CHW distribution piping system?	No	Yes - you can run approx. 2X to 3X the tons thru the existing CHW piping system if all or most units are HEDS units	Slightly	Slightly

HEDS Test Design and Objectives

Current dehumidification issues:

- Expensive
- Energy Intensive
- Maintenance Prone
- Complex
- Ineffective
- Health Hazard

Technical objectives of the HEDS project:

- Perform dehumidification/reheat without new reheat energy being required
- Downsize HVAC chiller
- Level of energy use reduced and cost savings
- Ability of systems to handle added loads without need for additional equipment
- HVAC expansion cost savings potential
- Determine potential performance gaps and cures
- Eliminate “Low Delta T Syndrome” (15°F to 30°F+ CHW TD’s, expected HEDS TD’s)
- Determine ability to use effectively with 2-pipe water distribution systems

Technology/Methodology Description

HEDS is a “Cooling Recovery System” designed to reduce space Relative Humidity (RH) and improve occupant safety, comfort and productivity.

- Recovers 20% or more of the heat obtained during the cooling and dehumidification process to maintain RH control.
- Eliminates the need for new reheat energy on peak load days.
- Cuts the peak day need for new cooling and reheat energy by approximately 50%, while simultaneously reducing water usage in the cooling process.

Exceptionally large face area and depth of cooling coil dry the air out resulting in a relatively high chilled water temperature leaving the coil (above 70°F on peak load days).

- The 70°F water leaving the cooling coil can be used in a “Cooling Recovery Coil” to raise the temperature of the 48°F to 55°F air leaving the cooling coil to between 62°F and 68°F.
- Lowers the RH of the air entering the space, reducing the potential for condensation to occur and thus reducing the potential for biological growth.

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- Lowers the RH of the air entering the space, reducing the potential for condensation to occur and thus reducing the potential for biological growth.
- Also reduces the load on the chiller plant by exactly the amount of reheat energy added to the air for RH control.

HEDS Advances the State of the Art

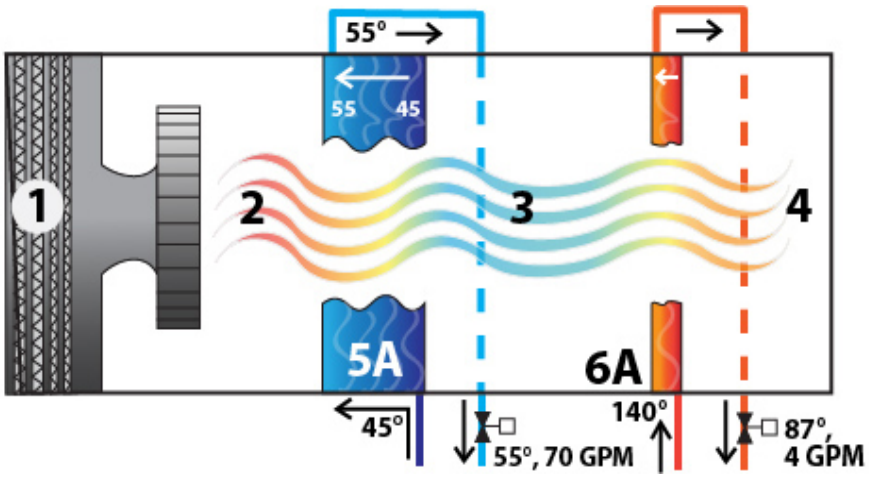
At its core, the HEDS unit is just an AHU with really big heat exchangers for the cooling coil and cooling recovery coil that allows the very low quality heat captured in the cooling coil of an AHU to be used as the reheat energy source for space RH control.

This demonstration will verify whether or not HEDS can:

- satisfy all of the criteria for advancing the state of the art in a leapfrog from the current state of the art
- be simple to operate – the standalone controls work without connections to the site DDC system in case of site DDC system failure
- be simple to maintain – it is a normal AHU with big, low air pressure drop coils
- be energy efficient – it has the potential to reduce cooing and heating energy use associated with dehumidification/reheat by over 50% on peak load days
- be cost effective – depending upon the facility, HEDS system could reduce construction costs required to properly meet the loads and perform dehumidification/reheat duties by millions of $
- be a sustainable, financially viable way to reduce biological growth and promote occupant health, comfort and productivity

Technology Snapshot – Typical Base Case

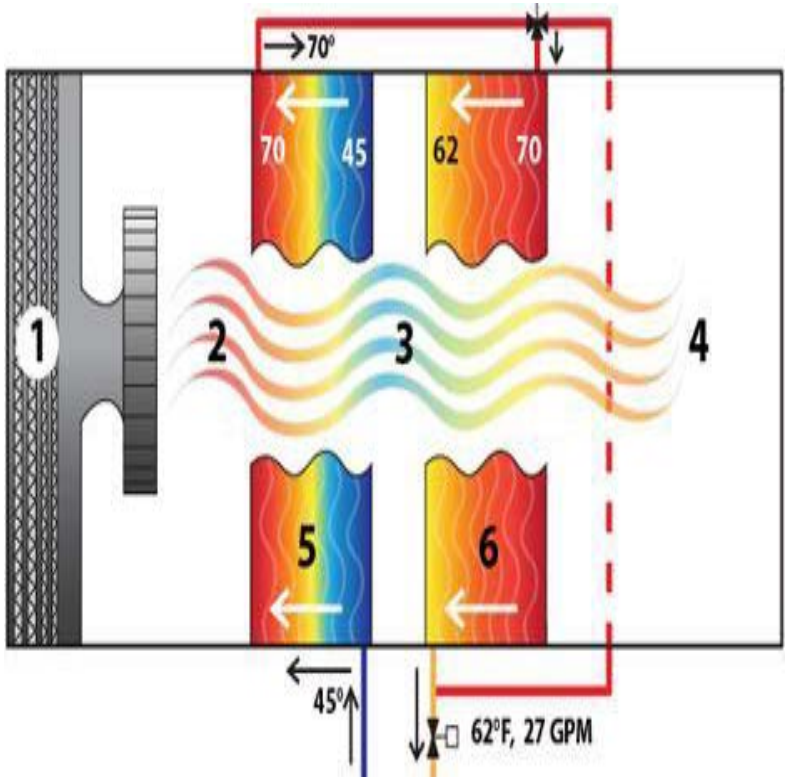
Conventional AHU - Requires new energy for reheat and greater chiller energy use



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

Technology Snapshot – HEDS Unit

HEDS AHU - Recovers at least 20% of cooling energy and eliminates 100% of reheat energy for RH control on peak load days



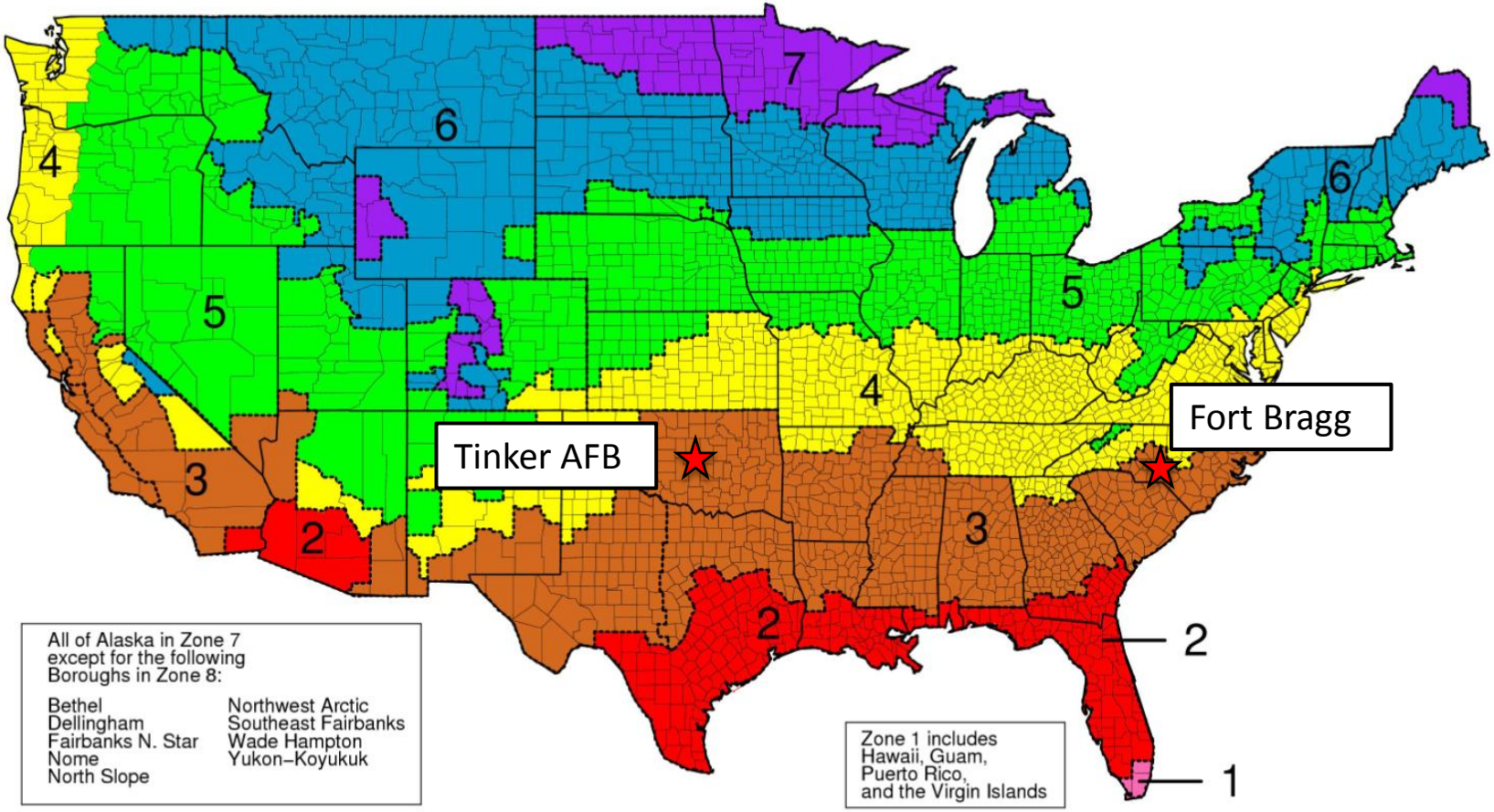
- Very large face area & depth cooling & cooling recovery coils
- Low CHW flow rates/high CHW TD
- High CHW temperature differential
- Low AHU air pressure drops due to large face area and low face velocity
- Delivers cool, dry air in an energy efficient manner
- Reduces Infrastructure, Operation and Maintenance Costs
- Eliminate "Low Delta T syndrome"
- Reduces pumping and chiller energy use
- Allows chillers to be piped in series to further improve chiller capacity and energy efficiency
- Reduces water consumption where evaporative cooling towers are used due to lower cooling plant loads and improved system efficiency
- Increased cooling capacity at lower CHW flows
- Increases CHW system infrastructure delivery capacity via approximately 2x the CHW system TD, saves infrastructure $$$.

Technology Lifecycle Cost Savings

The ESTCP process will help us determine the real world lifecycle savings potential of the HEDS AHU design.

1. Benefits of the HEDS design include
   a. Very simple design process,
   b. Simple installation process
   c. Simple operation and maintenance requirements
2. Reduced First and Lifecycle Cost Potential
   a. Ability to greatly extend the life of capacity constrained chilled water generation plants and chilled water distribution systems.
   b. Potential to save millions of $$$ in reduced infrastructure costs for facilities that are adding loads to the cooling loop.
3. Renewable/HEDS Benefits
   a. The energy efficiency benefits of a HEDS based system will allow renewable energy technologies to either be downsized, or be used to serve a greater overall percentage of an installations energy consumption.

Demonstration Sites



Existing Conditions: Tinker AHU

- Air Handling Unit shows water carry off from the cooling coils – solids build up on the fan shroud.
- Water in the airstream due to 100% saturated air conditions and cooling coil high air velocities.

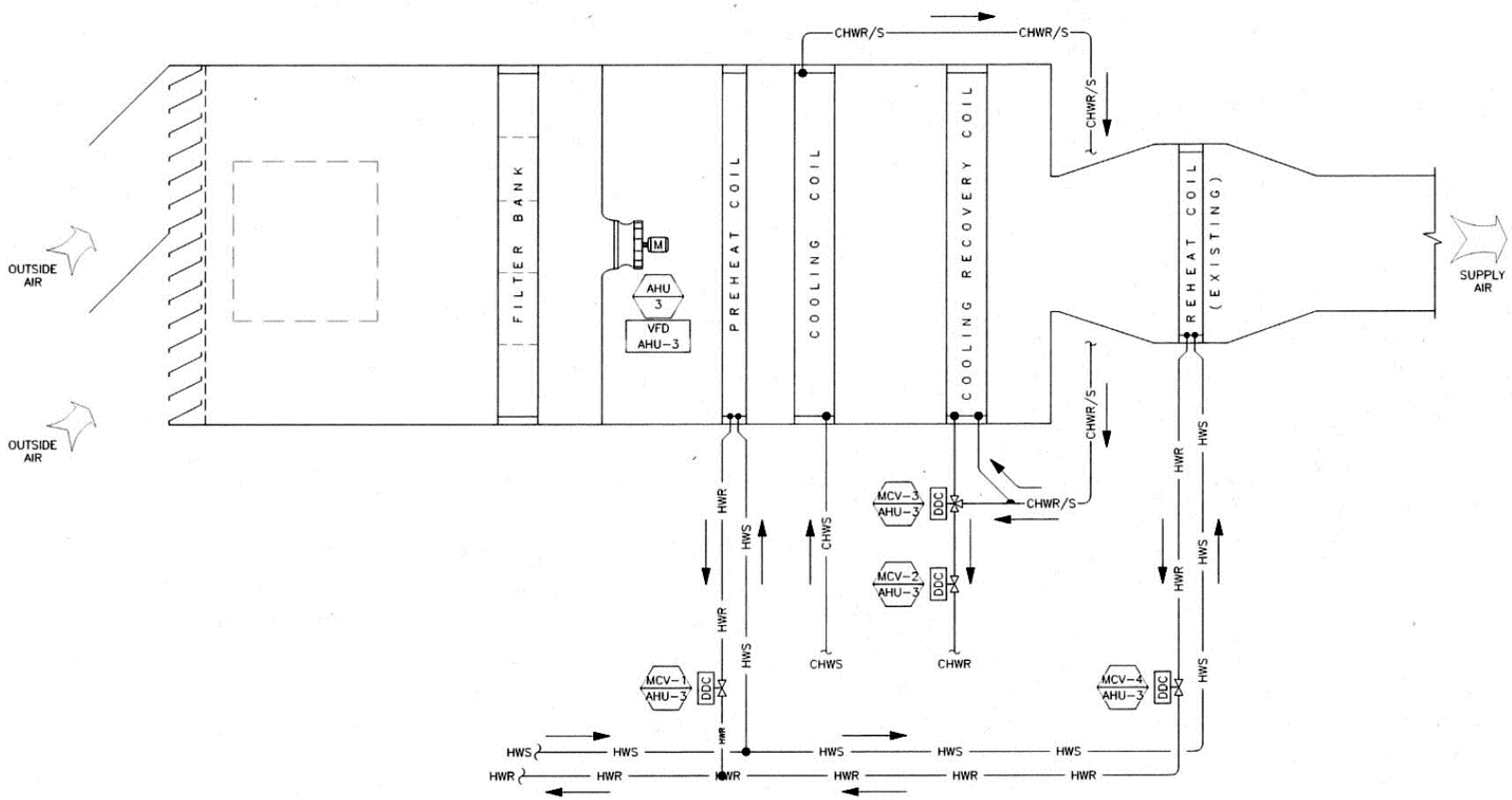
Tinker AFB Existing AHU on Rooftop

HEDS AHU will fit on the same structural support system

Ft Bragg DFAC Existing AHU In Mech Room

HEDS AHU will fit in the existing mechanical space – equipment pad extension required.

Representative HEDS AHU Layout
(Tinker Shown)



Expected Performance Improvements

Original Peak Day Computer Simulation Comparative Analysis (10,000 CFM unit)

Normal vs. HEDS

Coil APD	0.94” vs. LT 0.40”
CHW System Flow	70.3 GPM vs. 26.8 GPM
Load to Chiller Plant	28 Tons vs. 18 Tons
Nat Gas to Boilers BTUH	112,000 BTUH vs. Zero

Total Cooling + Reheat Energy Savings = 52.8%

Supporting Technical Data

As shown in the illustration and data points 1 through 4, the entering and leaving air conditions are identical between the two units. As shown in the table below, the HEDS design delivers the same results while using 52.8% less BTUH and 62% lower CHW flow for the design conditions shown.

Example System Summary Data taken from the “PACE” cooling and heating coil rating program.	5 HEDS Cooling Coil Performance	5A Normal Cooling Coil Performance	6 Cooling Recovery Coil Performance	6A Normal Reheat Coil Performance
Air Pressure Drop (in. W.C.)	0.17	0.89 (523%)	0.05	0.08 (160%)
Water Pressure Drop (ft.wtr)	8.9	7.0 (79%)	5.1	4.0 (78.4%)
Chilled Wtr Flow Rate (GPM)	26.8	70.3 (262%)		
Cooling Coil Face Velocity/ Rows (approx, site specific)	150 - 200 FPM/ 8 rows	550 FPM +/- 6 rows		
Entering Chilled Wtr Temp (°F)	45°F	45°F		
Coil Leaving Chilled Water Temperature (°F)	70°F or higher	55°F		
Cooling Required to Obtain 55°F Air Temp (BTUH)	338,690 28.22 tons	338,690 28.22 tons		
Heating Hot Water Flow Rate (GPM) (flow rate to CRC)			26.8	4.2 (15.7%)
Heating Coil Face Velocity/ Rows (approx, site specific)			150 - 200 FPM/ 6 rows	550 FPM +/- 1 row
Entering Heating Wtr Temp (°F)			70°F or higher	140°F or higher
Coil Leaving Heating Water Temperature (°F)			61.9°F	87°F
Heating Required to Obtain 65.3°F Air Temp (BTUH)			-112,503 -9.38 tons	112,503
Natural Gas BTUH at 80% Boiler System Efficiency			N/A	140,629

SUMMARY	HEDS with Cooling Recovery Coil	Normal AHU with Reheat Coil & Boiler Plant	Net BTUH Savings
Cooling Load at Coil (BTUH)	338,690	338,690	Load is Identical
Cooling Recovery Coil (BTUH)	-112,503	0	below
Net Cooling Load on Plant	226,187	338,690	-112,503/32.8%
Reheat Energy at 80% Boiler Efficiency	0	140,629	140,629/100%
Total Cooling + Heating BTUH	226,187	479,319	52.8%
Total net BTU per hour savings at these design conditions = 52.8%			

Technology Implementation/Available Products

What should DoD consider when implementing the technology?

1. Although the HEDS testing has not proceeded yet, when designing an HVAC system for comfort conditioning, RH control or process loads (such as paint hangars), adequate physical space needs to be allocated for the HEDS units.
2. In very tight mechanical spaces, the HEDS unit will not be able to be located in that space, as they are physically larger than a "normal" AHU. HEDS units will typically be smaller than a desiccant wheel based system that delivers the same conditions.

What products are on the market or will emerge soon?

1. There are no products currently on the market that offer the benefits of the HEDS design.
2. It is possible to build HEDS AHU's immediately, or to retrofit existing facilities that desire RH control for process, comfort or biological control with the HEDS design strategies.
3. We are hoping that the upcoming demonstration at Tinker AFB will demonstrate that the HEDS design can be a viable retrofit option to massively cut energy use for their 100% outside air paint hangars, which are the largest single energy users on the base when they are in operation. You can imagine the electrical and thermal demand of cooling and reheating 300,000 CFM of outside air in Oklahoma in the summer for one paint hangar.

Tinker AFB HEDS Unit Performance Specifications

ROOF TOP UNIT SUPPLY FAN SCHEDULE

SYMBOL	MANUFACTURER AND MODEL	LOCATION	SERVICE	SUPPLY FAN: TYPE	TSP (in. WC)	ACFM	FAN WHEEL DIAMETER	DRIVE TYPE	MOTOR RPM	BLADE TYPE	HORSEPOWER (HP)	NEMA NOMINAL FULL LOAD EFFICIENCY (%)	ELECTRICAL: VOLTS / PHASE / FLA 60 Hz.	EFFICIENCY (MERV RATING)	FILTER: FACE VELOCITY (FPM)	UNIT: OPERATING WEIGHT (LBS)	REMARKS
RTU 4	TRANE PERFORMANCE CLIMATE CHANGER	BLDG. 3 ROOF	FIRST FLOOR	PLUG	3.6"	10,000	25"	BELT	1,780	AF	10	93%	460V/3#/–	14	182	13,500	VARIABLE FREQUENCY DRIVE CONTROL – –

PRE–HEAT, COOLING, COOLING RECOVERY AND RE–HEAT COILS

	SYMBOL	COIL DUTY	LOCATION	SERVICE	ROWS / FPI	MAXIMUM FACE VELOCITY (FPM)	EADB (°F.)	EAWB (°F.)	EWT (°F.)	LADB (°F.)	LAWB (°F.)	LWT (°F.)	AIR PRESSURE DROP (in. wc)	GPM	WATER PRESSURE DROP (FL. WATER) @ 30% E.G.	CONTROL VALVE Cv	COIL SQUARE FEET	TUBE O.D.	TUBE WALL THICKNESS	FIN THICKNESS	TOTAL MBTU	SENSIBLE MBTU	COIL ACFM	REMARKS
	RTU–4 PREHEAT	PRE–HEAT COIL	BLDG. 3 ROOF	HEATING	4/8	210	40°F.	N/A	140°F.	107°F.	N/A	80°F.	0.07	24	1.7	–	49	1/2"	0.016"	0.008"	727	727	10,000	MAXIMUM HEIGHT BETWEEN "THROUGH THE COIL" DRAIN PANS FOR THE COOLING COILS IS 30".
CONDITION #1	RTU–4 COOLING	COOLING COIL	BLDG. 3 ROOF	COOLING	10/12	210	85°F.	69.5°F	45°F.	50.3°F.	50.2°F.	68.3°F.	0.28	50	6.9	–	48.3	5/8"	0.020"	0.008"	584	383	10,000	
CONDITION #1	RTU–4 CLG. RECVRY	COOLING RECOVERY COIL	BLDG. 3 ROOF	HEATING	6/10	210	50.3°F.	50.2°F.	68.3°F.	66.6°F.	58°F.	61.3°F.	0.11	50	8.4	–	49.1	1/2"	0.016"	0.008"	175.8	175.8	10,000	
CONDITION #2	RTU–4 COOLING	COOLING COIL	BLDG. 3 ROOF	COOLING	10/12	210	85°F.	69.5°F	45°F.	47.6°F.	47.5°F.	62.2°F.	0.29	76	14.3	–	48.3	5/8"	0.020"	0.008"	656	413	10,000	
CONDITION #2	RTU–4 CLG. RECVRY	COOLING RECOVERY COIL	BLDG. 3 ROOF	HEATING	6/10	210	47.6°F.	47.5°F.	62.2°F.	60.8°F.	54°F.	56.5°F.	0.11	76	8.6	–	49.1	1/2"	0.016"	0.008"	143	143	10,000	
	RTU–4 REHEAT	EXISTING RE–HEAT	BLDG. 3 ROOF	HEATING	← EXISTING REHEAT COIL IN EXISTING SUPPLY AIR DUCTWORK. →																			

NOTE: CONDITION #1 AND CONDITION #2 HAVE DIFFERENT FLOW RATES AND TEMPERATURE VALUES.

FEMP Federal Energy Management Program
CenterPoint Energy

Fort Bragg HEDS Unit Performance Specifications

AIR HANDLING UNIT SUPPLY FAN SCHEDULE

SYMBOL	MANUFACTURER AND MODEL	LOCATION	SERVICE	TYPE	TSP (in. WC)	ACFM	SUPPLY FAN: FAN WHEEL DIAMETER	DRIVE TYPE	MOTOR RPM	BLADE TYPE	HORSEPOWER (HP)	NEMA NOMINAL FULL LOAD EFFICIENCY (%)	ELECTRICAL: VOLTS / PHASE / 60 Hz.	FLA	FILTER: EFFICIENCY (MERV RATING)	FACE VELOCITY (FPM)	UNIT: OPERATING WEIGHT (LBS)	REMARKS
AHU 1	TRANE PERFORMANCE CLIMATE CHANGER	BLDG. MECH. ROOM	KITCHEN	PLUG	3.7"	10,000	25"	BELT	1,780	AF	15	93%	208V/3ø/–	14	182	11,000	VARIABLE FREQUENCY DRIVE CONTROL – –

PRE–HEAT, COOLING, COOLING RECOVERY AND RE–HEAT COILS

	SYMBOL	COIL DUTY	LOCATION	SERVICE	ROWS / FPI	MAXIMUM FACE VELOCITY (FPM)	EADB (°F.)	EAWB (°F.)	EWT (°F.)	LADB (°F.)	LAWB (°F.)	LWT (°F.)	AIR PRESSURE DROP (in. wc)	GPM	WATER PRESSURE DROP (FT. WATER) NO GLYCOL	CONTROL VALVE Cv	COIL SQUARE FEET	TUBE O.D.	TUBE WALL THICKNESS	FIN THICKNESS	TOTAL MBTU	SENSIBLE MBTU	COIL ACFM	REMARKS
	AHU–1 PREHEAT	PRE–HEAT COIL	1	HEATING	4/8	210	40°F.	N/A	140°F.	107°F.	N/A	80°F.	0.07	24	1.7	–	49	1/2"	0.016"	0.008"	727	727	10,000	MAXIMUM HEIGHT BETWEEN "THROUGH THE COIL" DRAIN PANS FOR THE COOLING COILS IS 30".
CONDITION #1	AHU–1 COOLING	COOLING COIL	1	COOLING	10/12	210	87°F.	72°F	45°F.	51.9°F.	51.8°F.	70.8°F.	0.29	50	6.9	–	48.3	5/8"	0.020"	0.008"	647	389	10,000	
CONDITION #1	AHU–1 CLG. RECVRY	COOLING RECOVERY COIL	1	RE–HEATING	6/10	210	51.9°F.	51.8°F.	70.8°F.	69.0°F.	59°F.	63.4°F.	0.11	50	8.4	–	49.1	1/2"	0.016"	0.008"	185	185	10,000	
CONDITION #2	AHU–1 COOLING	COOLING COIL	1	COOLING	10/12	210	87	72°F	45°F.	48.1°F.	48.0°F.	64.4°F.	0.30	76	14.2	–	48.3	5/8"	0.020"	0.008"	738	430	10,000	
CONDITION #2	AHU–1 CLG. RECVRY	COOLING RECOVERY COIL	1	RE–HEATING	6/10	210	48.1°F.	48.0°F.	64.4°F.	63.3°F.	54.5°F.	60.1°F.	0.11	76	17.4	–	49.1	1/2"	0.016"	0.008"	164	164	10,000	

NOTE: CONDITION #1 AND CONDITION #2 HAVE DIFFERENT FLOW RATES AND TEMPERATURE VALUES.

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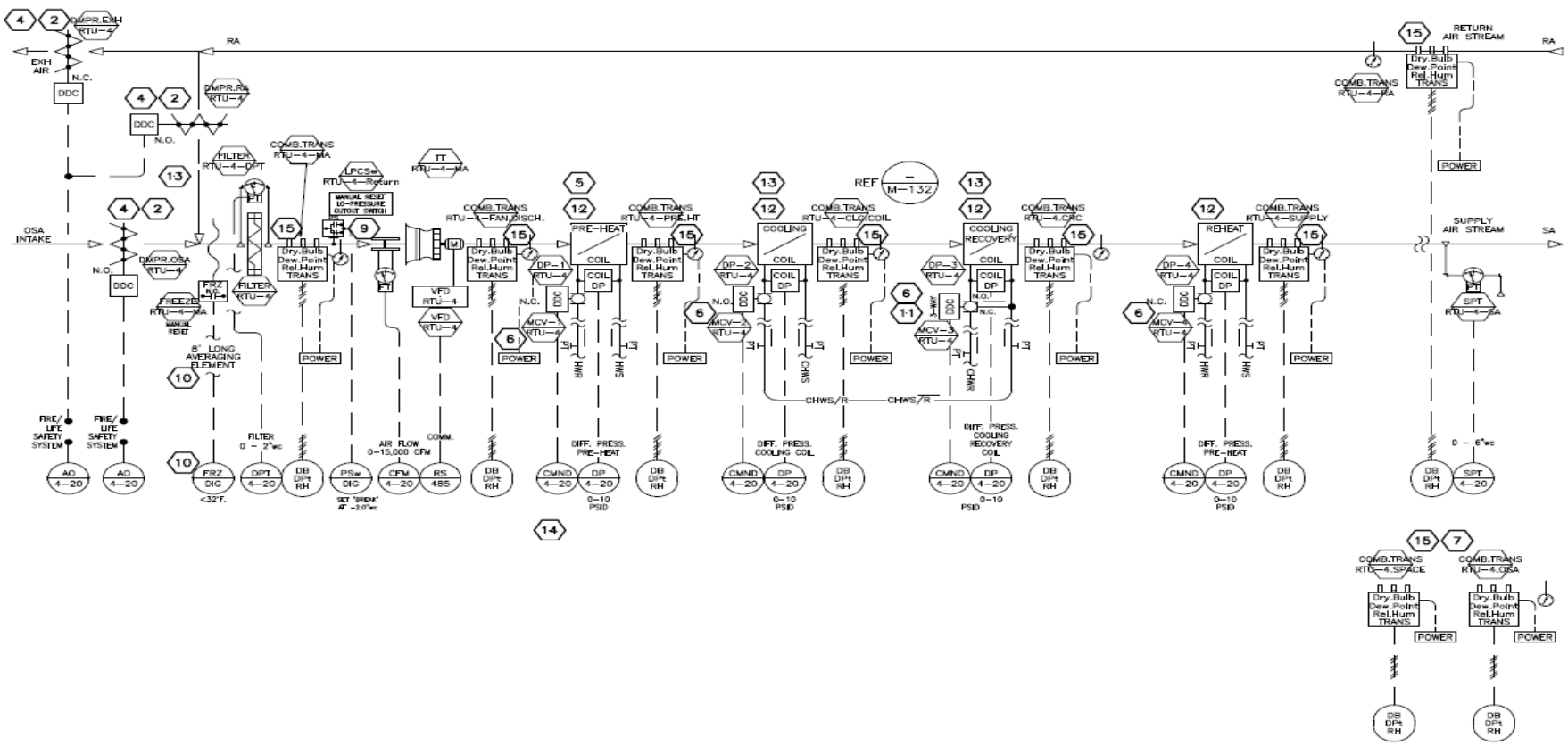
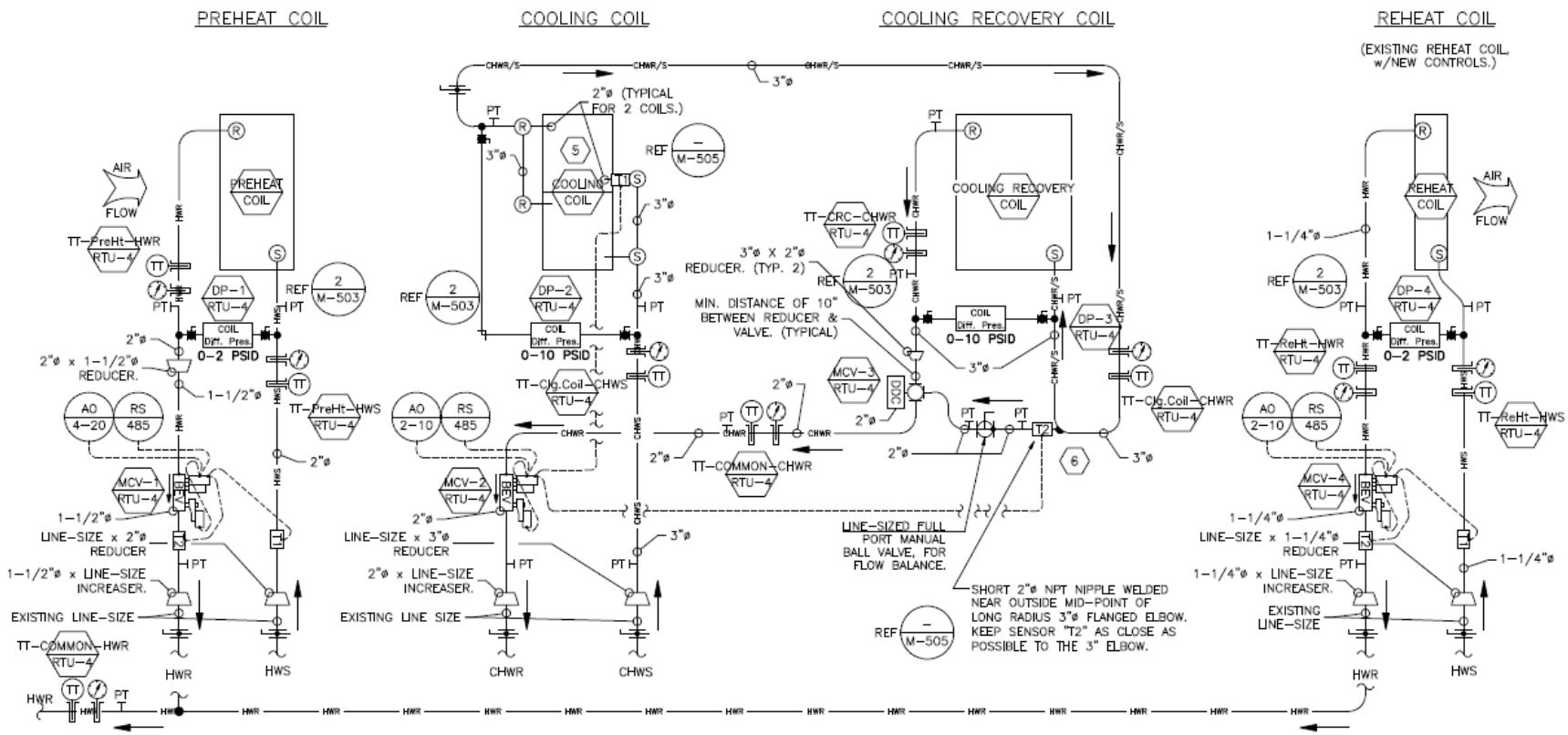
HEDS Test Airside Instrumentation



FEMP Federal Energy Management Program

CenterPoint Energy

HEDS Test Waterside Instrumentation



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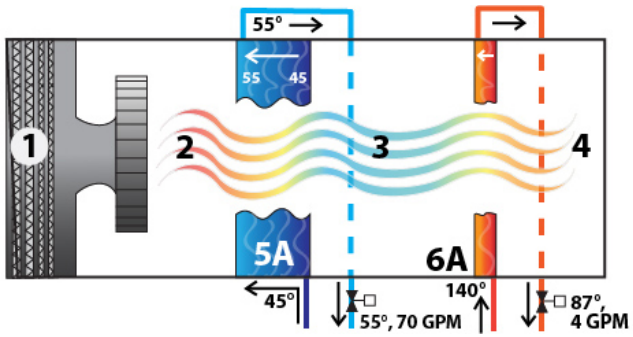
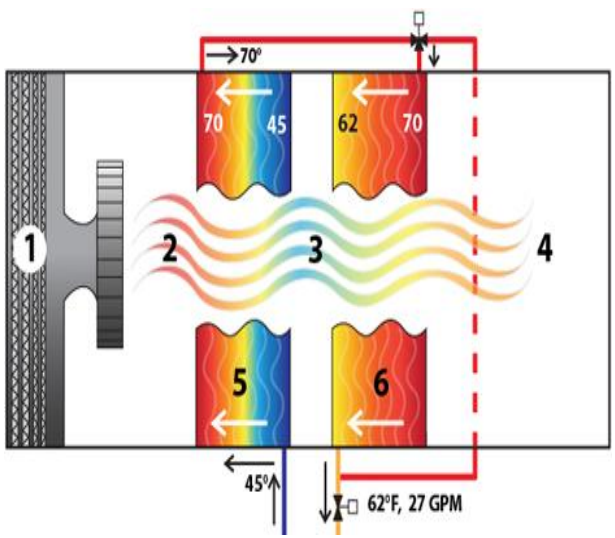
Section 1.5 Appendices, Supporting Technical Data & FAQs Cont.



Traditional AHU Designed for Dehumidification Duty. Small cooling and reheat coils, high CHW flow rates, low CHW temperature differential and high AHU air pressure drops. 45°F CHW enters the cooling coil (5A) at 70 GPM and leaves the cooling coil at 55°F. A new source of 140°F water enters the reheat coil (6A) at 4 GPM and leaves the reheat coil at 87°F. The unit requires **479,319 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the design conditions in this example

Data Points 1 thru 4: [1] 10,000 CFM airflow [2] 78°F dry bulb temp, 65°F wet bulb temp [3] 55°F dry bulb, 55°F dewpoint, essentially 100% relative humidity [4] 65.3°F dry bulb, 55°F dewpoint, 55% RH



High Efficiency Dehumidification System (HEDS) AHU (53% Peak Day BTUH Savings) Very large cooling and cooling recovery coils, low CHW flow rates, high CHW temperature differential and low AHU air pressure drops. 45°F CHW enters the cooling coil (5) at 27 GPM and leaves the cooling coil at 70°F. This 70°F water then enters the CRC coil (6) at 27 GPM and leaves the CRC coil at 62°F while heating the air to 65°F. The HEDS unit requires **226,187 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the same conditions**, a BTUH savings of 53% and a CHW flow reduction of 62% in this example.**

Blue=Cold Temperatures, Yellow to Red = Warm to Hot Temperatures.

Frequently Asked Questions

FAQs

One of our team members started designing "Large Temperature Differential" (LTD) cooling systems in 1985, with initial systems designed to deliver 76°F chilled water return temps when the coils were provided with 39°F chilled water from a chilled water Thermal Energy Storage (TES) system. The LTD design reduced the TES tank size by 65% due to the very large CHW temperature differential. Most LTD coils provide 70°F to 74°F CHW return temps on design days, so there is enough low quality heat available for reclaim to be used as a reheat source for Relative Humidity control. 25 years of experience with large cooling coils delivering high CHW return temperatures contributed to the design of the HEDS.

Q: Is HEDS acceptable to be used in a retrofit, or only new installs?

A: The biggest target market is the retrofit market, where the most problems exist and the most obvious benefits are to be had.

In a retrofit application, we are hoping that HEDS will solve the high RH/ mold/ mildew problems that exist, substantially cut energy and water waste, solve the "Low Delta T" problem, solve heating and cooling capacity problems, solve undersized infrastructure problems, reduce manpower and maintenance costs, and lower the overall lifecycle costs for DoD facilities.

If HEDS is designed into new construction or facility expansion projects, we are hoping that lower overall installation costs will occur, as well as lower overall lifecycle costs.

NOTE: the answers are based on studies and evaluations, the ESTCP project is needed to prove the performance and potential limitations in the real world.

FAQ's, Cont.

Q: Will HEDS really provide chiller plant downsizing? A: Yes, based on the evaluations completed so far. To reduce the possibility of condensation forming, the COE would like to deliver approximately 65°F dry bulb temperature air at 55°F dewpoint conditions, which results in a supply air RH of around 55%. On a sample barracks project of approximately 150 rooms, the cooling load to dehumidify the air to 55°F dewpoint, starting at 78°F dry bulb and 65°F wet bulb calculates out to approx. 147 tons. To raise the supply air temperature from 55°F to 65°F to obtain 55% RH air conditions, heat totaling 486,000 BTUH must be added. With a "normal" dehumidification/reheat design, 486,000 BTUH of heating hot water, or 142 kW of electric strip heaters would be required to warm up the air. With the HEDS unit, the "Cooling Recovery Coil" uses the chilled water that leaves the cooling coil at approximately 70°F as the source of heating water that is used to raise the air temp to 65°F. Simultaneously with the rise in air temperature, there is a corresponding drop in the chilled water return temperature in the CRC, equal to the same 486,000 BTUH that was transferred into the supply air. 486,000 BTUH equates to approximately 41 tons, so the net load on the chiller plant equates to approximately 147 tons cooling load, minus the 41 tons of cooling energy that was recovered in the reheat process, for a net chiller plant load of 106 tons. This should allow the chiller plant associated with a HEDS design to be reduced in capacity by approximately 25% to 30% while still meeting peak load days.

FAQ's, Cont.

Q: Can HEDS reduce Infrastructure Costs? A: Yes, based on the evaluations completed so far. A benefit of HEDS is that the chilled water flow rate required to meet peak day cooling/dehumidification needs will be reduced by approximately 50% to 60% by a combination of reduced cooling plant loads and increased chilled water system temperature differentials provided by the very large cooling coils.

On sites that may be stretching the limits of their piping infrastructure, the ability to meet the same cooling loads with a 50% to 60% reduction in the flow rate can mean that the avoided costs from not having to replace the piping infrastructure can cover the most or all of the costs of HEDS retrofit projects. While not a HEDS project, one of our team members has been working with the University of Southern California since 1992, and has helped raise their CHW system temperature differential from 8°F to 9°F during peak summer months in 1992, up to 25°F to 27°F today. This has allowed USC to avoid replacing their underground piping, as the installed piping can now move 300% more BTU's per gallon due to the higher chilled water temperature differential. This is a savings of over $15,000,000 for the campus.

Q: Can HEDS improve efficiencies of added facilities? A: Yes. When new facilities are being added, or facilities are being rehabilitated or expanded, the HEDS design can be incorporated to reduce lifecycle costs. If a chiller plant has reached the maximum capacity that it can deliver, the piping infrastructure may also be maxed out as described above. If the plant and piping system capacity is maxed out, there are two remedies – 1) add more chiller, cooling tower, pumping and piping capacity, and potentially an addition to the chiller plant building to house the new equipment, which can all add up to tens of millions of dollars just to add one more building, or 2) make better use of the installed equipment and piping by decreasing the cooling loads on the plant and increasing the system temperature differentials to decrease piping system congestion by using the HEDS design.

FAQ's, Cont.

Q: Can HEDS help to solve the "Low Delta T Syndrome"?

A: Yes. One of the key drivers for the Low Delta T Syndrome is undersized cooling coils. By nature of the HEDS design, the heat transfer surface area of the cooling coils is more than 300% greater than a typical 6 row, 10 fins per inch coil at the normal 550 feet per minute face velocity.

Q: Can HEDS handle added loads without additional equipment and reduce expensive upgrades?

A: Yes. As described above, if HEDS is incorporated, it will free up additional capacity in the cooling plants and the chilled water distribution piping systems.

Q: Does HEDS require a 2-pipe system, or will it also work with a 4-pipe system?

A: HEDS works with both system types. One of the beauties of the HEDS design is that it can provide cooled and dehumidified air with a 2-pipe system, without requiring electric reheat or complex and hard to maintain desiccant wheel based equipment. With a 2-pipe system in the winter, the hot water return (HWR) temperature approaches the coil entering air temperature, since there is so much heat transfer surface area available and the air is moving at such a low velocity thru the coils. This means that with a 180°F hot water supply (HWS) temperature, you will end up with a 100°F to 120°F temperature differential, delivering substantial efficiency gains to the HW system. With a 4-pipe system, the Cooling Recovery Coil (CRC) can either be piped to operate as a heating coil in the winter (via a Belimo 6-way valve or the equivalent), or a heating coil can be utilized in the unit. If the CRC is used as a heating coil, the chemical treatment systems for the HW and CHW should be checked for compatibility

FAQ's, Cont.

Q: How will the HEDS design work with an existing boiler during the heating season?

A: If the HEDS system is used in a 2-pipe system, the hot water system temperature differential will be larger than with a typical coil selection, allowing a few different things to occur – substantial pump energy savings due to the larger HW system temperature differential that occurs due to the much larger coils, potential infrastructure savings when facilities are added – the existing piping infrastructure can carry at least 25% more BTU's per gallon of water delivered. With a 4 pipe system, either a typical heating coil can be installed, or, if the hot water and chilled water systems have compatible chemical treatment systems, the CRC or cooling coils can be used as heating coils with a switchover valve system, similar to the Belimo 6-way valves. When it is time for boiler upgrade or augmentation, condensing type boilers that can deliver efficiencies in the high 90% range can be used, since it would be possible to serve the heating loads with 100°F to 120°F hot water supply temperatures vs. needing 180°F to 200°F required by typical designs.

Q: Is a separate heating coil also needed downstream of this arrangement?

A: In a 2-pipe system, the cooling coil or CRC can be used as the heating coil, so a downstream heating coil is not required for heating. The Tinker HEDS unit is using the existing reheat coil as needed, the Ft. Bragg HEDS unit does not have a reheat coil – mimicking the installed unit.

In a four pipe system, if the CRC or cooling coils are not used in a switchover design to act as heating coils in the winter, there will be the need for either an upstream or downstream heating coil to provide heat to the facility. We will be monitoring the data to determine if a downstream heating coil is needed when it is cool and muggy outside and the internal cooling loads are low, but still exist.

FAQ's, Cont.

Q: Since the return temperature for the chilled water is increasing above a standard ten degree delta t, does this mean that the chiller also needs to be evaluated to see if it can handle this large spread of water temperatures without causing issues?

A: Typically not. We have been using 30°F to 36°F CHW system TD's since the mid 1980's in new and retrofit projects using chillers designed for 10°F to 15°F TD's with the two basic mechanical designs out there – primary/secondary, (Pri/Sec) and primary-only variable flow, (POVF), sometimes called "Variable Primary Flow" or "VPF".

Both of these designs automatically accommodate for higher than "normal" chilled water distribution system temperature splits by recirculating some of the cold supply water back into the chiller return line when site TD's greatly exceed chiller design TD - this lowers the effective TD that the chillers see. With a Pri/Sec system, as the secondary CHW loop flow drops off due to the higher system TD, the primary loop flow remains the same, which recirculates more chilled water from the supply into the return line, creating the desired TD thru the chiller. As an example, if there was a 500 ton load that was operating at a 20 degree TD, (use 45°F/65°F as example) and the chiller was originally designed for a 10 degree TD, the secondary CHW flow would be 600 GPM. The design primary CHW flow would be 1,200 GPM – consisting of 600 GPM of recirculated 45 degree supply water, and 600 GPM of 65 degree return water for a blended temperature of 55 degrees at 1200 GPM into the chiller.

Similarly, a POVF/VPF system will reduce flow thru the chiller as the site TD increases and the site flow is reduced. At some point in time, the minimum CHW flow limit thru the chiller evaporator is reached, and the minimum CHW evaporator flow bypass valve will start to open, sending some of the cold supply water back to blend with the CHWR and the return water temperature entering the chiller will be reduced.

To dramatically improve chiller plant efficiency, chiller plants with high potential TD's can be slightly modified to allow a "series or parallel" piping arrangement with the addition of a few valves and some control logic. These valves allow the chillers to run in parallel when the TD's are normal, and in series when the TD's get to about 15°F to 18°F. This allows the upstream chiller to operate at an increased efficiency of at least 25% due to lower lift required on the upstream chiller.

An example of these design strategies is a low temperature CHW TES based system we designed for a Pacific Gas and Electric facility, the SRVCC. The peak day CHW loop TD ever recorded was 45°F, consisting of 32°F CHWS temperature and 77°F CHWR temperature. The chillers were designed for a 15°F split each, using POVF and the series-parallel design, we create chilled water at 32°F at less than 0.60 kW/ton for the entire chiller plant electrical consumption, including chillers, CHW pumps, CDW pumps TES pumps and CT fans.

Typical, existing, old chillers can usually operate with CHW flow rates of less than 50% of design flow, if the flows are varied at less than 10% every couple of minutes. Cutting the flow in half results in a TD of double the design TD.

Policies and Standards

The following are recommendations to DoD policies and standards to improve adoption of the technology:

1. Mandate proper designs for high RH localities

    1. Mandate that all spaces that are air-conditioned in areas with the potential for high relative humidity be designed with HVAC systems that are specifically designed to control the relative humidity in the space. “Areas with the potential for high relative humidity” will need to be better defined.

2. Mandate no new energy be used for the reheat portion of RH Control, and no new energy for regeneration of desiccant based systems.

    1. Mandate that 100% of the reheat energy used to control relative humidity on peak load days be taken from the return side of the chilled water loop, that a net cooling load reduction at the chiller plant equal to the reheat energy required for relative humidity control be experienced, and that no new reheat–related energy, over and above that required by the chiller plant be used in the control of relative humidity of the spaces. Mandate that only recovered energy can be used to regenerate Desiccant systems.

3. Mandate that the AHU maintenance required be no greater than for a “normal” AHU. (Need to define “Normal”.)

Psych Chart for "Normal" Dehumidification/Reheat AHU

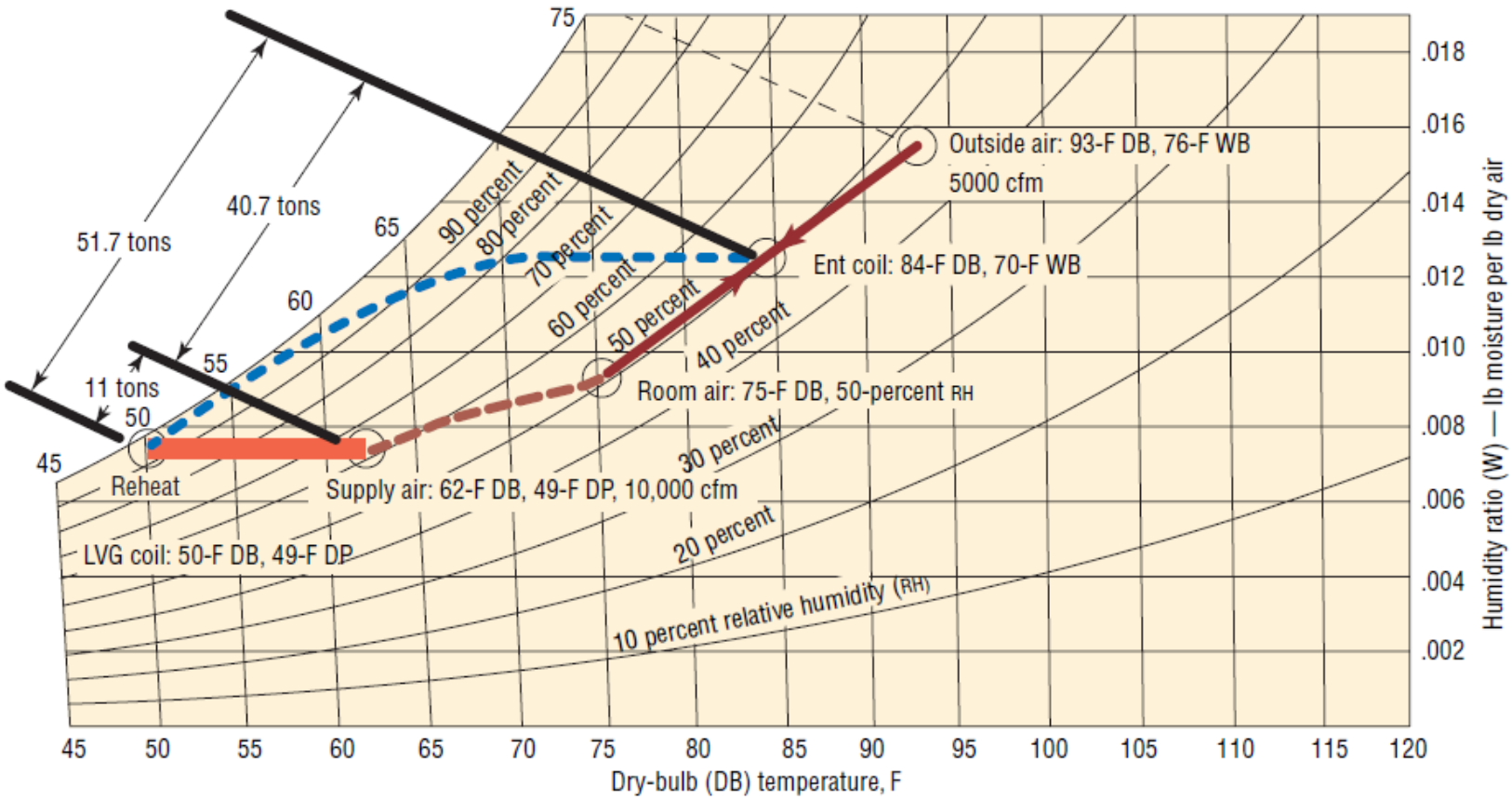


FIGURE 1. Psychrometric chart of a reheat system.

Psych Chart for an Energy Recovery System

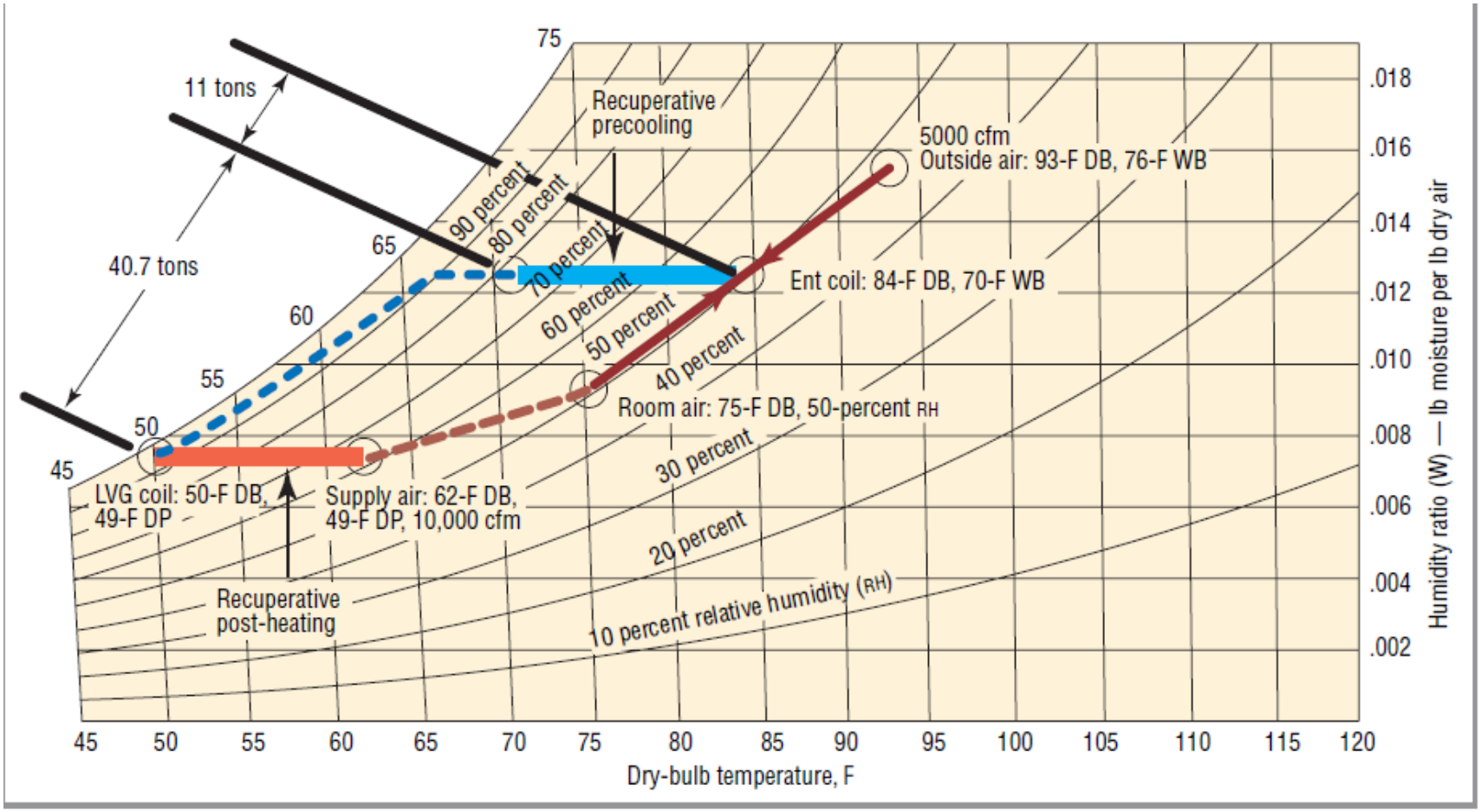


FIGURE 2. Psychrometric chart of a recuperative reheat system.

THIS CONCLUDES OUR PRESENTATION FOR TODAY.

Please join us tomorrow from <u>1200-1330</u> when we will be talking about Building Optimization including HVAC retrofit and strategies for energy efficiency and indoor air quality