COOLNOMIX® at Fort Bliss and Joint Base Anacostia-Bolling

Validating the Energy Savings of A Compressor Control Retrofit

Tech Transfer Session

Bryan Urban, Fraunhofer USA
Josef Mueller and Joe Milando, Cool Green Power

Energy Exchange Tech Theater
Wed. Aug. 16, 2017
Department of Defense Energy and Water Technology Proving Ground

**Validate Emerging Energy Technologies**
Through Field Demonstrations at U.S. Military Installations

- Planning
- Installation
- Monitoring
- Analysis
- Tech Transfer
PROJECT TEAM

VENDOR

CoolGreenPower™
More Savings, Smarter Cooling

EVALUATOR

Fraunhofer
USA

DoD DEMO SITES

Fort Bliss
El Paso, TX
(Dry Climate)

Joint Base Anacostia-Bolling
Washington DC
(Humid Climate)
TECHNOLOGY BACKGROUND
COMMERCIAL BUILDING
SITE ENERGY END USE
4.5% REFRIGERATION
$580M

Est. annual DoD spend on cooling and refrigeration.

$60M savings opportunity
COMPRESSORS use a major fraction of cooling energy.
ENERGY SAVINGS OPPORTUNITY

OVERSIZED
Most HVAC&R systems are oversized for typical conditions, leading to inefficient part-load operation.

BETTER CONTROLS
Relay-based controls could reduce compressor runtime to prevent overcooling.

SAVINGS
Could provide energy savings of +15%
Up to $60M/yr potential for DoD.
COOLNOMIX®

A Sensor-based Compressor Control Retrofit
What is COOLNOMIX®?

COOLNOMIX® is a hardware-based retrofit add-on that saves energy by controlling compressor runtime on AC and Refrigeration systems with excess part-load capacity.
THERMOSTAT
  wall temperature

COOLNOMIX
  supply air temp.
  return air temp.
  relay

COMPRESSOR
COOLNOMIX® TECHNOLOGY

SIMPLE
Relay control installs in-line with thermostat.

FAST
1-2 hour install by HVAC technician.

SECURE
No network connections. No controls integration required.

AFFORDABLE
<$1,000 installed

SAVES ENERGY
Wired sensors measure supply and return air temperature to optimize compressor runtime to save energy.

CONTROLS COMFORT
Sensors reduces overcooling to save energy, while maintaining desired setpoints.
COOLNOMIX® COMPATIBILITY

Works With Vapor-Compression Systems

COOLING
Packaged Rooftop Units
Walk-in Refrigeration Units
Ducted Systems with Air Handling Units
Wall-mounted Split Systems

REFRIGERATION
Food and Beverage Refrigeration
Retail Refrigerated Display Cases
DOD/ESTCP DEMONSTRATION
KEY DEMO TARGETS

ENERGY SAVINGS
15%+ reduction in end-use energy consumption.

COMFORT
Maintain comfortable setpoint temperatures.

SCALABILITY

and…DON’T BREAK STUFF
REFRIGERATION TEST SITES

JBAB

Bolling Club Dining Facility

Potomac Lanes Bowling Center - Food Service

Ft. Bliss

Dining Facility
WHEN THINGS GO WRONG
LESSONS LEARNED
UNDERSIZED?
No daytime cycling
DIRTY FILTERS
LOOSE FAN BELT
REFRIGERANT CHARGE
TOO HOT
TOO COLD
JUST RIGHT
DISCONNECTED WIRES
Air conditioner unit settings

16C 61F
17C 62F
18C 64F
19C 66F
20C 68F
21C 70F
22C 72F
23C 73F
24C 75F
25C 77F
26C 79F
27C 80F
28C 82F
29C 84F
30C 86F
31C 88F

SETPOINTS
DO NOT TOUCH
UNDER ANY
CIRCUMSTANCES
TECH TRANSFER DISCUSSION
## TECH TRANSFER DEVELOPMENT

### TECHNICAL
- Screening tool
- Revise manuals
- Installation checklist
- Commissioning checklist
- Install kit

### DIFFUSION
- Webinars
- Blog posts
- Newsletters
- Fact sheets
- Specs list
- Purchasing templates
PROCUREMENT WITHIN DoD

Discretionary Funding
small purchases

DD FORM 1391
specs and performance data
informed by final technical report

GSA Schedule / Vendor Lists

Other?
AWARENESS: DIFFUSION ACROSS DoD

ESTCP Outreach
webinars, blog, podcast, social media

IMCOM newsletter

Energy Exchange Conference

Direct Outreach to Energy Managers
DIFFUSION OUTSIDE of DoD

TECHNICAL CONFERENCES

UTILITY EFFICIENCY PROGRAMS

ESCOS

GSA

Others?
ESCOs

Great vehicle for installing at DoD at scale

but… risk averse

Needs high confidence in savings and avoids “unproven” emerging technologies

Looking for deemed savings, backed by utility incentives

ESTCP results may help with engagement
UTILITY EFFICIENCY PROGRAMS

Goal: qualify for incentive and rebate programs

Challenge: requires high confidence in energy savings to qualify.

Large scale pilots needed.

Results from ESTCP may be used to gain credibility with utility programs and secure a large scale pilot program.
## Technology Transfer

<table>
<thead>
<tr>
<th>Target Audience</th>
<th>Planned Tech Transfer Tool/Action</th>
<th>Status of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoD End-Users,</td>
<td>Seek approval for GSA Schedule</td>
<td>Planning stage, interviewing GSA consultants</td>
</tr>
<tr>
<td>− Energy Managers</td>
<td>Identify Energy Managers for direct outreach</td>
<td>Assigned resource to DoD outreach</td>
</tr>
<tr>
<td>− Facility Managers</td>
<td>Pilot ESTCP Technology Adoption Documents</td>
<td>Under development</td>
</tr>
<tr>
<td>− Data Center Managers</td>
<td>- Fact Sheet: a 1-2 page teaser on “why they should care”</td>
<td>Under development</td>
</tr>
<tr>
<td></td>
<td>DoD specific Web section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly DoD Webinar</td>
<td></td>
</tr>
<tr>
<td>GSA Technology Deployment</td>
<td>Distribute Fraunhofer final report to GSA Green Proving Ground (GPG) leaders</td>
<td>Planning stage</td>
</tr>
<tr>
<td></td>
<td>Conduct webinar for GPG leaders to validate that COOLNOMIX should be included in the GPG Technology Portfolio for broad deployment</td>
<td></td>
</tr>
</tbody>
</table>
## Technology Transfer

<table>
<thead>
<tr>
<th>Target Audience</th>
<th>Planned Tech Transfer Tool/Action</th>
<th>Status of Implementation</th>
</tr>
</thead>
</table>
| ESPC Contractors (e.g.,ESCOs) | Qualify as an Energy Conservation Measure  
Become listed as an approved measure with IMCOM  
Performance validation by ESCO AmecFosterWheeler at USPS Cocoa | Planning stage  
Planning stage  
May – Sep 2017 |
| UESC | Submission to utility incentive programs – e.g., California ET program, ComEd SmartIdeas | Underway |
| Outsourced HVAC&R maintenance firms | Setup and support firms as resellers / installers | Conversations with initial firm managing seven bases |
## Technology Transfer

<table>
<thead>
<tr>
<th>Target Audience</th>
<th>Planned Tech Transfer Tool/Action</th>
<th>Status of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Incentive Programs</td>
<td>Air conditioning evaluation with a California utility.</td>
<td>Extended test will complete in Jan – Feb 2018</td>
</tr>
<tr>
<td>Utility Incentive Programs</td>
<td>As part of their DeployMass program, the MA Clean Energy Center has formally approved independent tests at four school districts in Massachusetts</td>
<td>Fall 2017 with reports by year end.</td>
</tr>
</tbody>
</table>
Social Media Content

Videos

- Explaining how the technology works:
  http://www.coolgreenpower.com/how-coolnomix-works-1/

- Describing the benefits of the technology
  http://www.coolgreenpower.com/about-coolgreenpower-coolnomix-1/

- Requesting permission to create video interviews with energy managers at JBAB and Ft. Bliss plus ESTCP Technology Transfer office

Press releases

Work with PR expert to create news stories

Twitter, Facebook and LinkedIn content based upon preliminary results and final results as well as new site installations and uses of the product

- Work with ESTCP for the ESTCP twitter feed

We would welcome working with the Program Office on a blog and or PODcast
Packaged and ducted air conditioning comprises a large portion of cooling on DoD bases.

Walk-in refrigeration is common among dining facilities for storing food and beverage.
EXISTING SOLUTIONS FALL SHORT...

EXPENSIVE
Hardware retrofits, like variable speed motors are labor and capital intensive.

COMPLEX
Integration of advanced controls with existing control systems is difficult. May require network connections.

IMPRECISE
Other controls lack sensors, so climate control is not guaranteed.

SLOW
Long payback periods. Risky investment for older equipment.
FINDINGS TO DATE

Verified Install Time
♦ Install takes 1-3 hours by a trained HVAC technician
♦ Base technicians completed six installs in three days, including training, commissioning

Verified Compatibility and Reliability
♦ COOLNOMIX® running reliably for over one year at both bases
♦ COOLNOMIX® compatible with most cooling and refrigeration equipment
♦ Caused no problems with existing equipment

Data Confirms COOLNOMIX® Operation
♦ Observed relay action (compressor cycling) as designed
♦ Temperature control appears to be functioning as designed

Energy Analysis
♦ To be completed end of 2017

Energy managers interested in pursuing initial rollout once final report completed.
## PERFORMANCE OBJECTIVES

<table>
<thead>
<tr>
<th>Objective</th>
<th>Metric</th>
<th>Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Cooling Electricity Usage</td>
<td>weather-normalized seasonal cooling energy usage (kWh/CDD)</td>
<td>≥15% reduction in weather and humidity normalized unit energy consumption relative to pre-retrofit baseline</td>
</tr>
<tr>
<td>B. System Economics</td>
<td>%, $, years</td>
<td>simple payback: &lt;5 year (threshold) &lt;2 year (stretch target)</td>
</tr>
<tr>
<td>C. Climate Control</td>
<td>% time at target temperature/humidity conditions</td>
<td>refrigeration: food kept at 32-40°F, no freezing, no food spoilage AC: setpoints maintained as frequently as pre-retrofit (typ. 72°F), no adverse humidity impact</td>
</tr>
<tr>
<td>D. Ease of Installation</td>
<td>time to install (hrs), satisfaction</td>
<td>install in 3 hrs untrained, 1 hr trained; compatibility with target systems; staff satisfied</td>
</tr>
<tr>
<td>E. Reliability</td>
<td>% uptime, maintenance staff satisfaction</td>
<td>% of time system is working, does not reduce reliability of existing equipment</td>
</tr>
<tr>
<td>F. Short-Cycle and Frost Prevention</td>
<td>claimed features perform as designed</td>
<td>≥ 3min cycle duration, no frost accumulation</td>
</tr>
<tr>
<td>G. Facility Satisfaction</td>
<td>staff satisfaction</td>
<td>system acceptable to personnel, DoD staff to report any issues with performance or food spoilage</td>
</tr>
<tr>
<td>H. Warranty Compatibility</td>
<td>yes/no voids warranty by manufacturer</td>
<td>system does not void manufacturer’s warranty</td>
</tr>
</tbody>
</table>
TEST DESIGN AND OBJECTIVES

**Test method:** Weather-normalized, activity-adjusted, seasonal ON/OFF testing.

Demonstrate at least **15% energy savings** relative to the baseline.

Demonstrate ability to maintain space conditions and end-user satisfaction relative to pre-retrofit conditions.

Demonstrate scalability through ease of installation, reliability, and compatibility with existing hardware.

- Validate Technology
- Findings and Guidelines
- Technology Transfer
- User Acceptance
TECHNICAL APPROACH

Two Demo Sites / distinct climates for diverse climatic operating conditions over several seasons

Hot/Dry: Ft. Bliss, El Paso, TX
Hot/Humid: Joint Base Anacostia-Bolling, Washington, DC

Two Applications per Site:

Air Conditioning (x3 units): Single Zone Rooftop Units
Refrigeration (x3 units): Walk-in Refrigeration Units

Multiple-tests of each type are important to confirm repeatable results and will enable parallel testing. Single zone provides better ability to isolate energy-related effects.

Monitoring Program:

Collect performance data for multiple seasons [summer, fall, winter]
Run ON/OFF experimental design. System will be bypassed for 50% of each season to evaluate effects
ENVIRONMENTAL MONITORING

Data Collection Systems

Split Core Current Transformers for submetering power draw & energy consumption of AC, Compressor, and Fan

Temperature & Relative Humidity sensors for monitoring space conditions, verifying that space conditioning requirements are satisfied

Occupancy Sensors, Activity Sensors [door opening/closing on Walk-In Refrigeration], to correlate energy use with local activity
Electricity Monitoring in AC & R Units

1 min. sampling
150 days of logging

Real Power
Current
Voltage
(for each phase)

Submetering Data Logger

3x Current Transformers + Voltage to measure real power
Monitoring of Rooms in AC Applications

Temperature, Humidity, Light & Occupancy Near Thermostats

Door Open / Close

COOLNOMIX Bypass Switch

Temperature in Supply and Return Air
Environmental Monitoring: Refrigeration

Light, Occupancy, and Temperature Loggers

Door Open/Close Logger
Environmental Monitoring: Refrigeration

Temperature & Relative Humidity

Front and rear of evaporator

Sampling 2-5 min.
150 days per logger

Loggers & COOLNOMIX both measure supply and return air temperature
Both locations experienced hot summers. (good)

Humidity was much greater in DC than Texas (also good).

But… Texas had more rain than normal.
Electricity for All Test Sites

Red indicates that some units may be undersized (not cycling). More on this later.
Degree Day Regressions (Preliminary)

ON/OFF Testing

Differences in slope (kWh/CDD) will be used to calculate energy changes.

Note: these results are illustrative and are based on incomplete testing data.
Clear occupancy patterns measured, to be used for activity normalization (e.g., weekday vs. weekends)
Undersized AC: Temperature

Indoor Temp

No daytime cycling

Supply Air

GSA Motor Pool
Undersized AC: Temperature

Same unit on colder day: daytime cycling occurs

Critical: must be able to identify units with excess capacity.
Refrigeration: Power & Temperature

Fewer capacity issues.
Cycling coincides with temperature data.
Temperatures in acceptable range.
Publications

Participation
- Exchange Conference 2016

Planned Publications
- Revised guides and best practices
- Final Report
- Cost and Performance Report
- Industry Publication (e.g., conference paper)
- Trade Show Participation (e.g., Exchange Conference, ASHRAE, etc.)
- DoD Webinar / Tech Transfer