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Army Reserve Approaches Realtime HVAC and O&M Optimization with Niagara

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Army Reserve Enterprise Building Control System Overview

Energy managers are responsible for geographically dispersed locations

- Current: 135 buildings (4.1M sq ft) and 1,296 advanced meters are connected to the EBCS.
 - <u>650 devices</u>
- Target: By FY28, over 500 buildings to be integrated into EBCS
 - 90% of buildings over 50K sq ft

What	Remote control and monitoring of facilities, advanced building analytics, and a standardized and secure platform for data-driven solutions.
Where	Geographically dispersed installations that are accessible from anywhere via the Army Reserve Network.
Why	Simplify management of complex building control systems and allow remote access control to improve occupant comfort, optimize facility operations, and reduce operating costs.



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EBCS Strategic Roadmap

The Army Reserve continues to add additional capabilities within EBCS to deliver greater energy efficiency, lower operation and maintenance costs, and improve air quality and occupant comfort.

- Basic: provide energy and cost savings through schedule and setpoint adjustments.
- Intermediate: remote monitoring and benchmarking capabilities. (Reduce quipment downtime, avoid facility interruptions)
- Advanced: combine building data with meter data to deliver real-time displays and ongoing feedback.



TDID



Niagara Analytics

Leveraging the built-in analytics capabilities native to the Niagara Framework (AnalyticService), an extensive suite of stock and custom-built analytic algorithms can be deployed to operate automatically.

Optimization Algorithms

- Differential & Static Pressure Reset
- Temperature Reset
- Economizer Control
- Scheduling
- Simultaneous Heating and Cooling
- Unoccupied Setpoint
- VAV Airflow Minimums

PNNL's Re-tuning Approach

www.buildingretuning.pnnl.gov

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O&M Algorithms

- Leaky Hot Water Valve
- Leaky Chilled Water Valve
- Duct Static Pressure Failure
- VAV Airflow Failures
- Flow Calibration (cfm)
- CO2 Sensor Failure
- Chilled Water Temperature Calibration
- Analog Control Failure (+/-%)
- Zone Temperature Sensor Failure
- Chiller Cycling Frequency
- VFDs in HAND
- Monitoring Equipment Runtimes



Water Leak Detection

Water leaks can be extremely problematic & "normal" water use can be difficult to benchmark.

- High unintended water use
- Emergency O&M
- Damages

Ex: Toilet leak over weekend (SAT 7:30AM - 5:30PM)

- 22 kgal; \sim 40 GPM (avg hand faucet is 0.5 2.0 GPM)
- Damage to rooms below required major renovation



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Water Leak Detection



Savings Potential: Notification of leak could have saved:

- 13,800 kgal
- \$110,000 in water costs
- Significantly less building damage







Predictive O&M Pilot Project

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AHU	Boilers & HWS	Chillers & CWS
 Focus Coil scaling (performance efficiency) Valve leaks Fan/motor issues Dirty filter (VAV) Coil scaling (performance efficiency) (VAV) Valve leaks 	 Focus Reduce excessive air Avoid condensate & corrosion; scaling and soot deposits Loop leaks Pump issues Measurements Boiler status 	 Focus Avoid scaling & fouling Chiller efficiency Compressor issues Pump issues Measurements Chiller status Pump status and speed
Measurements • Airfow and temps • Valve positions • Fan status and speed • Filter dp sensor • Vibration sensor	 Pump status and speed HWS & HWR temps DP sensor Combustion analyzer Makeup water flowrate Vibration sensor 	 CWS & CWR temps DP sensor Vibration sensor

Predictive O&M: Coil Performance Example

Points from equipment controllers linked directly to Program Block

		CoolingCoil Program				
		Execute				
		SFStatus	true	: {ok}		
		CWS_Status	false {ok} (@ 16		
>		CFM	7138.00	{ok}		
¬ /	•	MAT	68.04	{ok}	AHU1 CW Coi	il Performance
	•	DAT	68.78	{ok}	Numeric Writable	-
	•	CWS 66.0	4 {alarm,unackedAl	arm}	Out	0.0 {
		Design_Eff	0.75	{ok}	In10	
		Perf	0.00) {ok}	In16	
		Qair_design	0.00	{ok}		
		Qmax_design	0.00	{ok}		
		**CWS off du	ring scre	en ca	pture	

AIR HANDLING UNIT SCHEDULE	
UNIT NO.	AHU-1-T
LOCATION	MECH ROOM
AREA SERVED	OFFICE/CLASS
MANUFACTURER	MCQUAY
MODEL NO.	CAH-025
ARRANCEMENT	HORIZONTAL
CFM	11200
OUTLET VELOCITY (FPM)	1591
WHEEL TYPE	AF
WHEEL DIA (IN.)	24
OUTDOOR AIR (%)	28.0
OUTDOOR AIR (CFM)	3150
EXTERNAL S.P. (IN. W.G.)	1.0
TOTAL S.P. (IN. W.G.)	2.8
FAN RPM	1416
MOTOR HP	10
VAV CONTROL	YES

	CHILLED WATER COOLING COIL	
	NUMBER OF COILS	2
	SIZE (IN.)	24×73
	ROWS	8
	FINS PER INCH (MAXIMUM)	10
	FACE VELOCITY (FPM)	460
_	AIR PRESSURE DROP (IN. W.G.)	52.4
	ENTERING AIR TEMP. D.B. (°F)	79.5
	IENTERING AIR TEMP. W.H. (*E)	66.0
	LEAVING AIR TEMP. D.B. (°F)	53.0
	LEAVING AIR TEMP. W.B. ("F)	52.1
	GPM	71.1
	TOTAL COOLING (MBH)	464.6
	SENSIBLE CODLING (MBH)	332.4
	ENTERING WATER TEMP. (*F)	44.0*
	LEAVING WATER TEMP. (°F)	58.2°
	WATER PRESSURE DROP (FT, W.G.)	11.2
	GLYCOL (%)	30

if(getSFStatus().getValue() == true && getCWS_Status().getValue() == true)

//Effectiveness_design

double Qair_design = 11200*1.08*(79.5-53); double Qmax_design = 11200*1.08*(79.5-44); double eff_design = Qair_design/Qmax_design; getDesign_Eff().setValue(Qair_design/Qmax_design);

//Effectiveness_actual

double Qair = getCFM().getValue()*1.08*(getMAT().getValue()-getDAT().getValue());



Predictive O&M: Coil Performance Example





Rapid Automated Functional Test (RAFT)

Active test for troubleshooting and control loop tuning

- Triggered on demand to test a part of the system
- Repeatable with a pass/fail output and additional diagnostics including PI tuning parameters



Rapid Automated Functional Test (RAFT)



RAFT Test on Outdoor Air Damper





Realtime Optimization (RTO): Extremum Seeking Control

General-purpose plug-and-play algorithm that automatically adjusts system variables (e.g., supply air temp setpoint) in real time to optimize *performance*.

<u>Note:</u> "Performance" can be energy, utility costs, carbon emissions, and other metrics.



Model-free algorithm





RTO/ESC Example: Economizer

- Traditional economizer strategies rely on outdoor and return temperature and humidity sensors.
- Utilizing a model-free ESC approach only rely on the mechanical components
 - For the economizer example, these components are the outdoor damper and cooling valve







RTO/ESC: Water-side

Extend application of RTO/ESC technology to new systems with potentially larger energy impacts. Constant adaptation and optimization of systems for resilience as well as **water and energy** efficiency.

- Chilled water systems with cooling towers
- Heating systems, incl. boilers and heatpumps







ControlScore

First-of-a-kind BCS scoring tool significantly streamlines building control performance evaluation:

- User-friendly bird's eye view of all building control systems.
- Standardized scores to benchmark control systems performance at different levels.
- Deployable to all buildings on EBCS

Next Steps:

- Develop solution to migrate ControlScore online
- Collaborate with controls vendors to test implementing algorithms in field controllers
 - Performance tracking & reporting should be standard outputs of BCS
- Incorporate semantic modeling into tool framework







Live Demo





Backup Slides



EBCS Graphics – User Interface







EBCS Graphics – Landing Page







EBCS Graphics – Analytics Graphs







EBCS Graphics – Analytics Graphs

Brief description of ideal operations for each measure.

> AHU01 supply fan reduces to 34% and does not shut off at night.



AHU01 exhaust fan runs continuously at ~32%.





Niagara Analytics- VAV Discharge Air Flow







Niagara Analytics- Hot Water Setpoint

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Niagara Analytics- Duct Static Pressure Setpoint

Alert if unit is ON and duct static sp hash1 changed within 2 hrs Dect. State. SP Dect. State.				
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Niagara Analytics-Duct Static Pressure Setpoint vs. Pressure







Water Leak Detection: Benchmarking







Predictive O&M Pilot Project

"Measurements that detect the onset of system degradation . . . Results indicate current and future functional capability (Sullivan, Pugh, Melendez, &Hunt, 2010).

> Predictive maintenance: Continuous <u>performance/health</u> monitoring



Performance/health degradation is a sign that component is ready for maintenance

Sullivan, G. P., Pugh, R., Melendez, A. P., & Hunt, W. D. (2010). *Release 3.0 Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency*. Prepared by Pacific Northwest National Laboratory for the Federal Energy Management Program, U.S. Department of Energy.





Predictive O&M: Coil Performance Example

100% effective coil would generate leaving air temperature as cold as entering chilled water temperature.



$$Coil \ effectiveness, design = \frac{(H_{in,design} - H_{out,design})}{(H_{in,design} - C_{in,desgin})}$$
$$Coil \ effectiveness, actual \cong \frac{(H_{in,actual} - H_{out,actual})}{(H_{in,actual} - C_{in,actual})}$$

 $Coil \ performance \cong \frac{Coil \ effectiveness, actual}{Coil \ effectiveness, design}$

H_{in}, H_{out}, C_{in}, C_{out} are dry bulb temperatures. Enthalpy will improve effectiveness calcs. Actual coil effectiveness is approximate as it also depends on water flow, airflow, &DAT setpoint.



Predictive O&M: Vibrations Example







RTO Implementation Example







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