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NS2024

APRIL 15 - 17 | ANAHEIM, CA

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25 Years

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POWER OF PARTNERSHIP

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

Stephanie Johnson, Pacific Northwest National Laboratory

Eric McKay, Pacific Northwest National Laboratory

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Stephanie Johnson

Building Energy Performance Engineer

Pacific Northwest National Laboratory

Eric McKay

Enterprise Building Control System (EBCS) Sustainment Coordinator

Pacific Northwest National Laboratory

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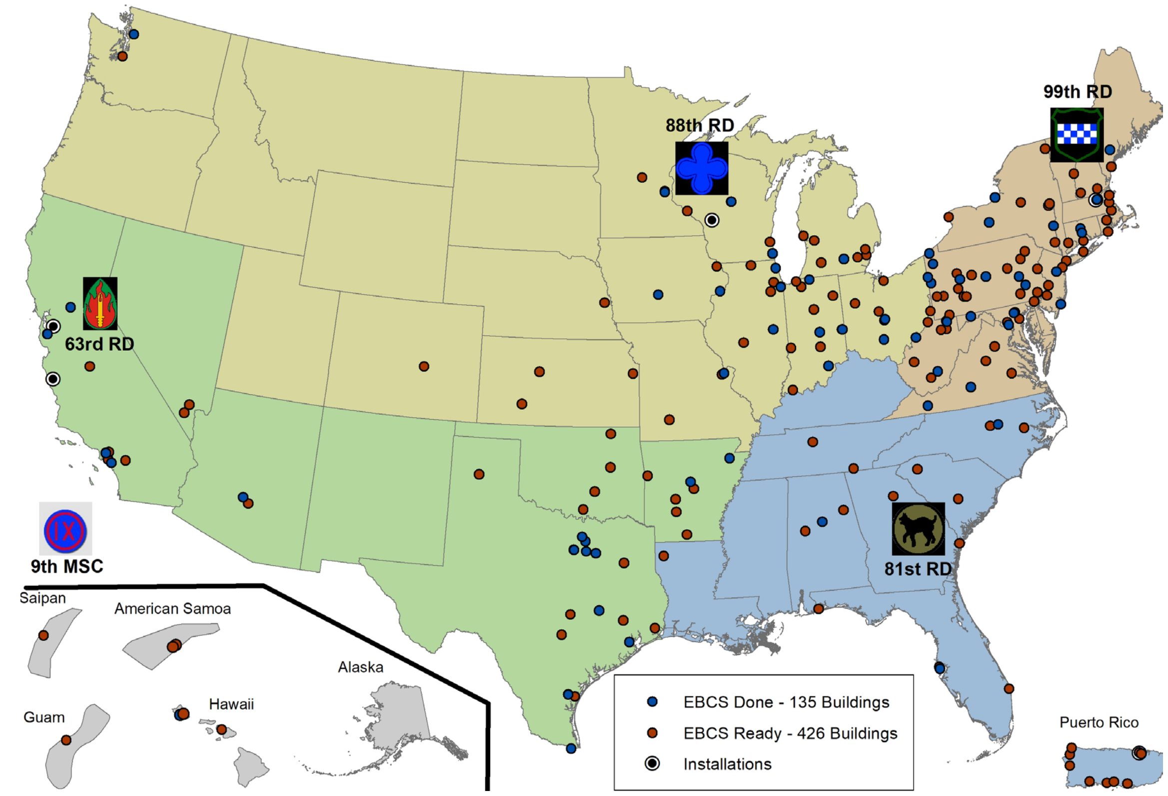
Army Reserve Enterprise Building Control System Overview

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.*
  - *650 devices*
- ***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.

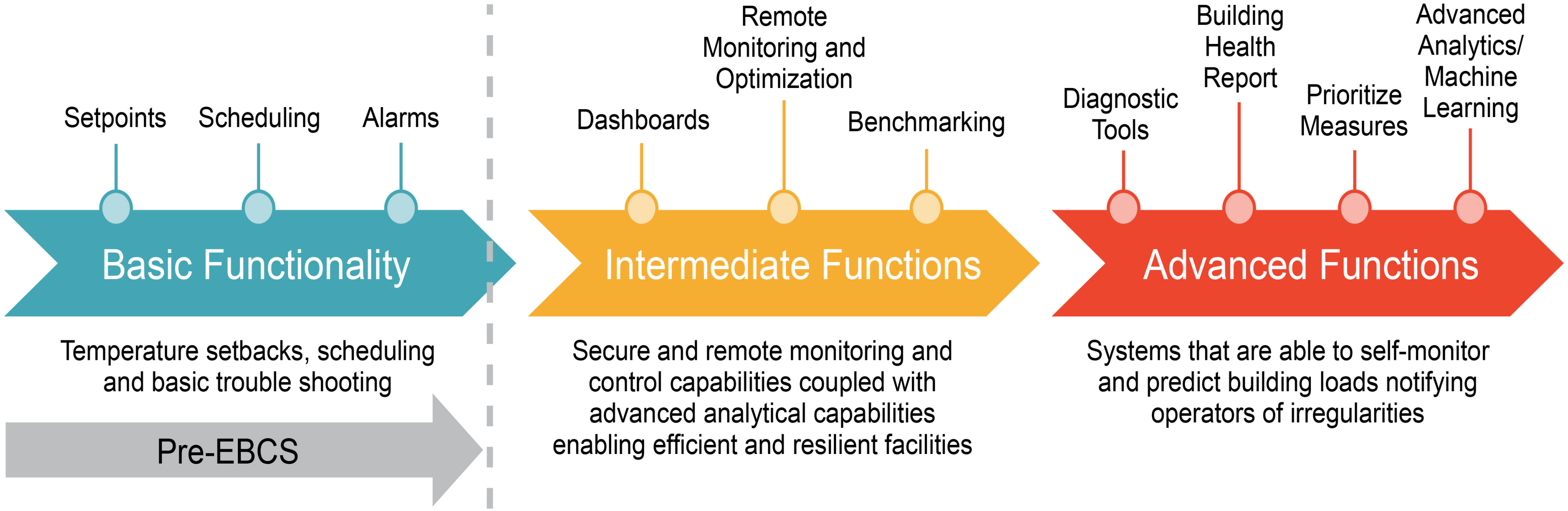
FY23 Integration Status (HVAC Only)



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.



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

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

PNNL's Re-tuning Approach
www.buildingretuning.pnnl.gov

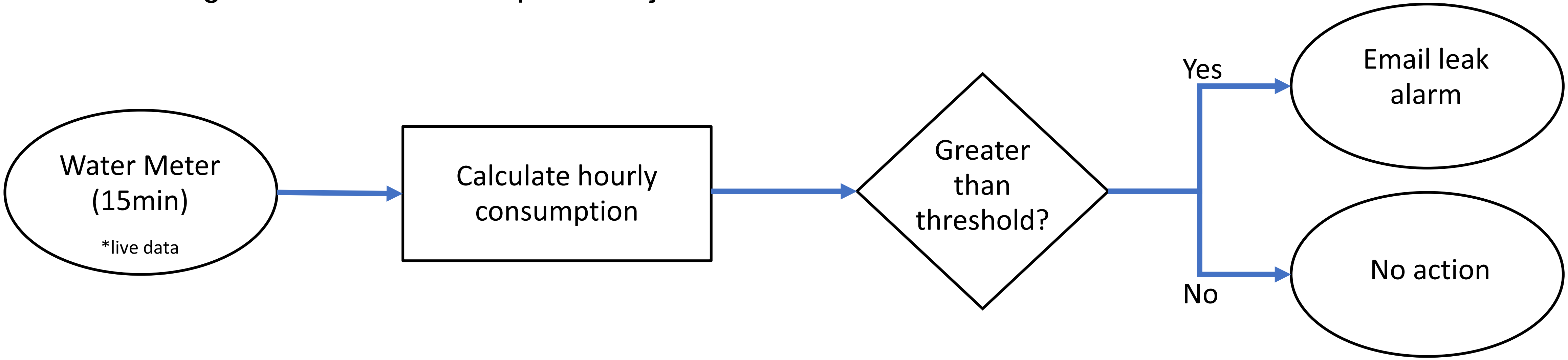
Water Leak Detection

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

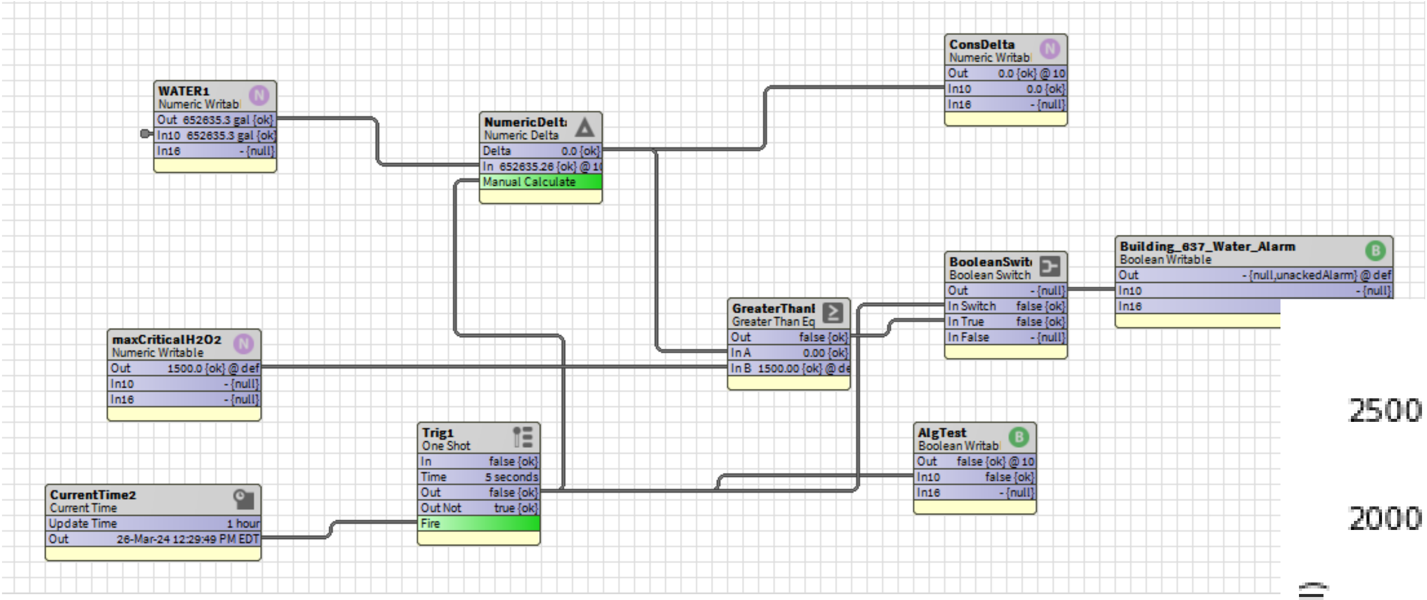
- High unintended water use
- Emergency O&M
- Damages

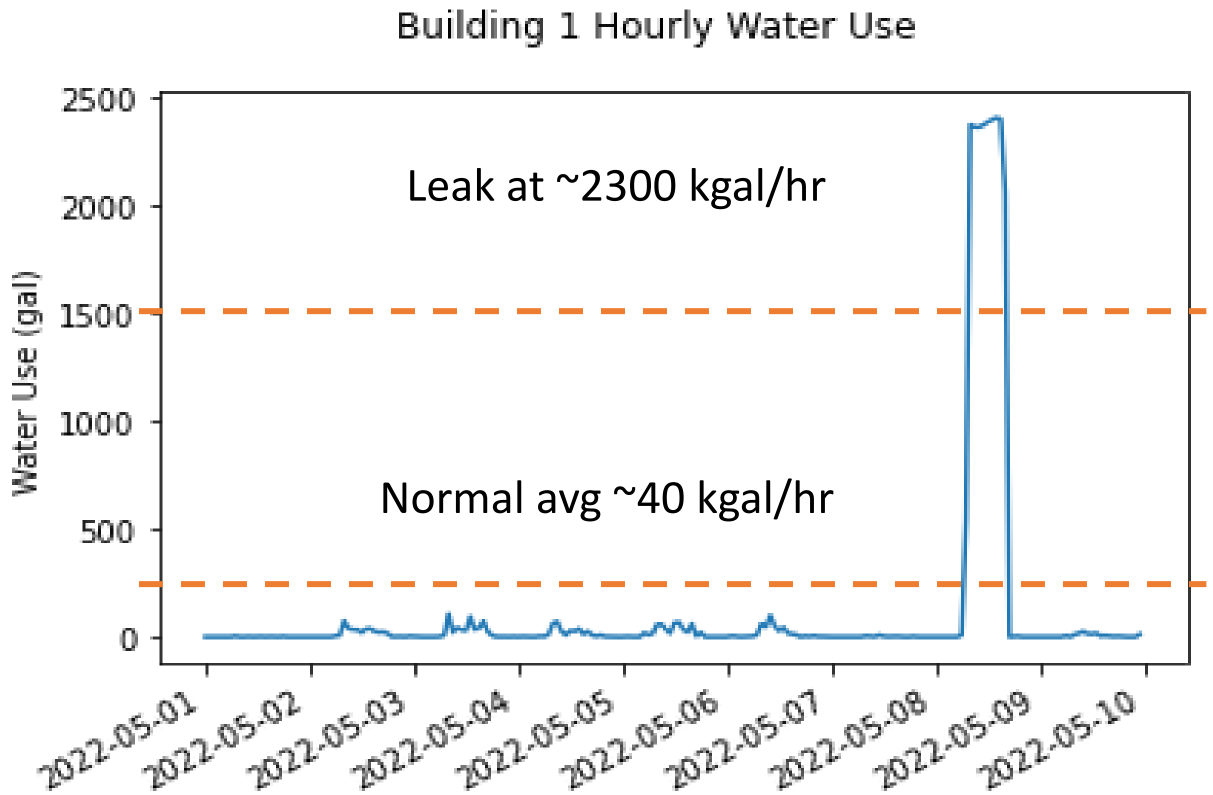
Ex: Toilet leak over weekend (SAT 7:30AM – 5:30PM)

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



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

Existing BAS may…		Predictive O&M will…
Alert when something is wrong	→	Alert before something is wrong

AHU

Focus
- Coil scaling (performance efficiency)
- Valve leaks
- Fan/motor issues
- Dirty filter
- (VAV) Coil scaling (performance efficiency)
- (VAV) Valve leaks

Measurements
- Airflow and temps
- Valve positions
- Fan status and speed
- Filter dp sensor
- Vibration sensor

Boilers & HWS

Focus
- Reduce excessive air
- Avoid condensate & corrosion; scaling and soot deposits
- Loop leaks
- Pump issues

Measurements
- Boiler status
- Pump status and speed
- HWS & HWR temps
- DP sensor
- Combustion analyzer
- Makeup water flowrate
- Vibration sensor

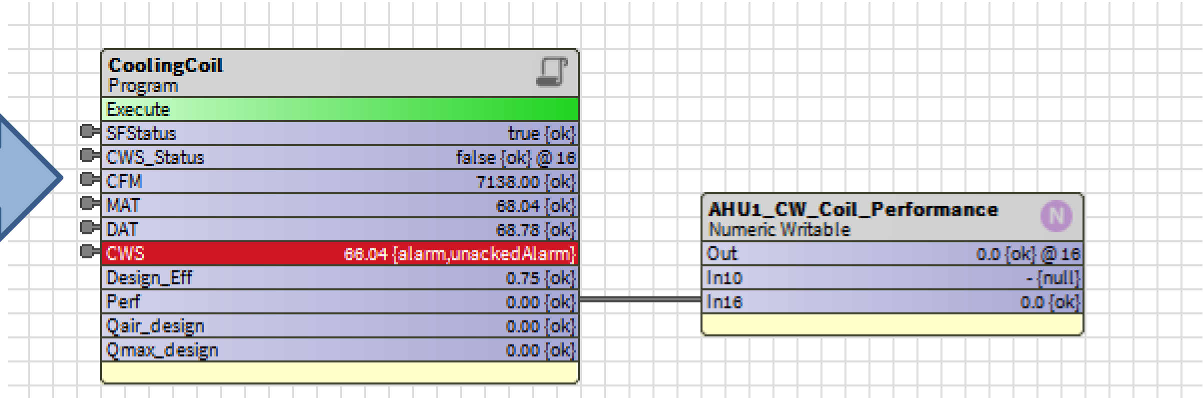
Chillers & CWS

Focus
- Avoid scaling & fouling
- Chiller efficiency
- Compressor issues
- Pump issues

Measurements
- Chiller status
- Pump status and speed
- CWS & CWR temps
- DP sensor
- Vibration sensor

Predictive O&M: Coil Performance Example

Points from equipment controllers linked directly to Program Block



**CWS off during screen capture

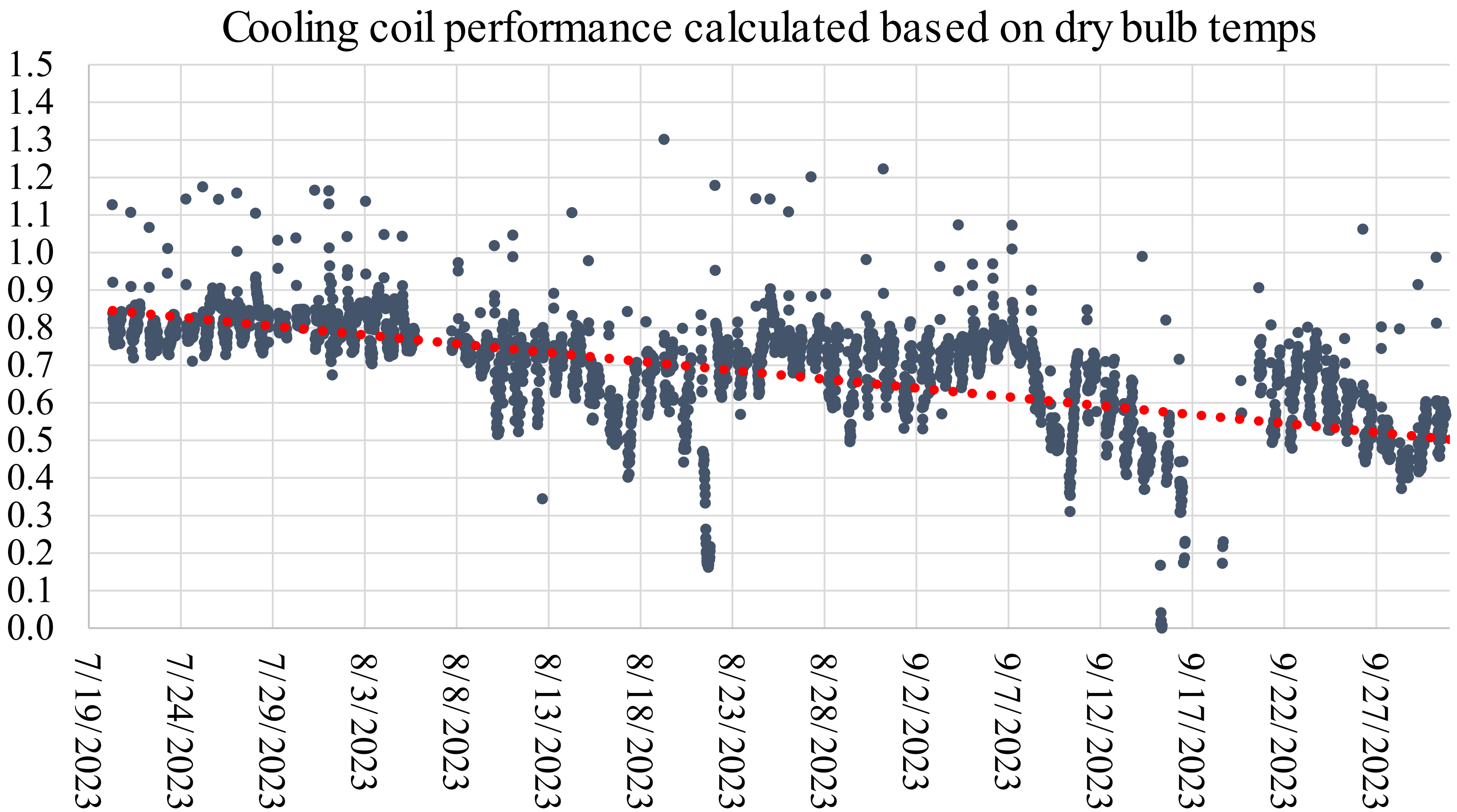
```
if(getSFStatus().getValue()== true && getCWS_Status().getValue()== true)
{
//Effectiveness_design
double Qair_design = 11200*1.08*(79.5-53);
double Qmax_design = 11200*1.08*(79.5-44);
double eff_design = Qair_design/Qmax_design;
getDesign_Eff().setValue(Qair_design/Qmax_design);

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

AIR HANDLING UNIT SCHEDULE	
UNIT NO.	AHU-1-T
LOCATION	MECH ROOM
AREA SERVED	OFFICE/CLASS
MANUFACTURER	MCQUAY
MODEL NO.	CAH-025
ARRANGEMENT	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.)	24x73
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
ENTERING AIR TEMP. W.B. (°F)	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 COOLING (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

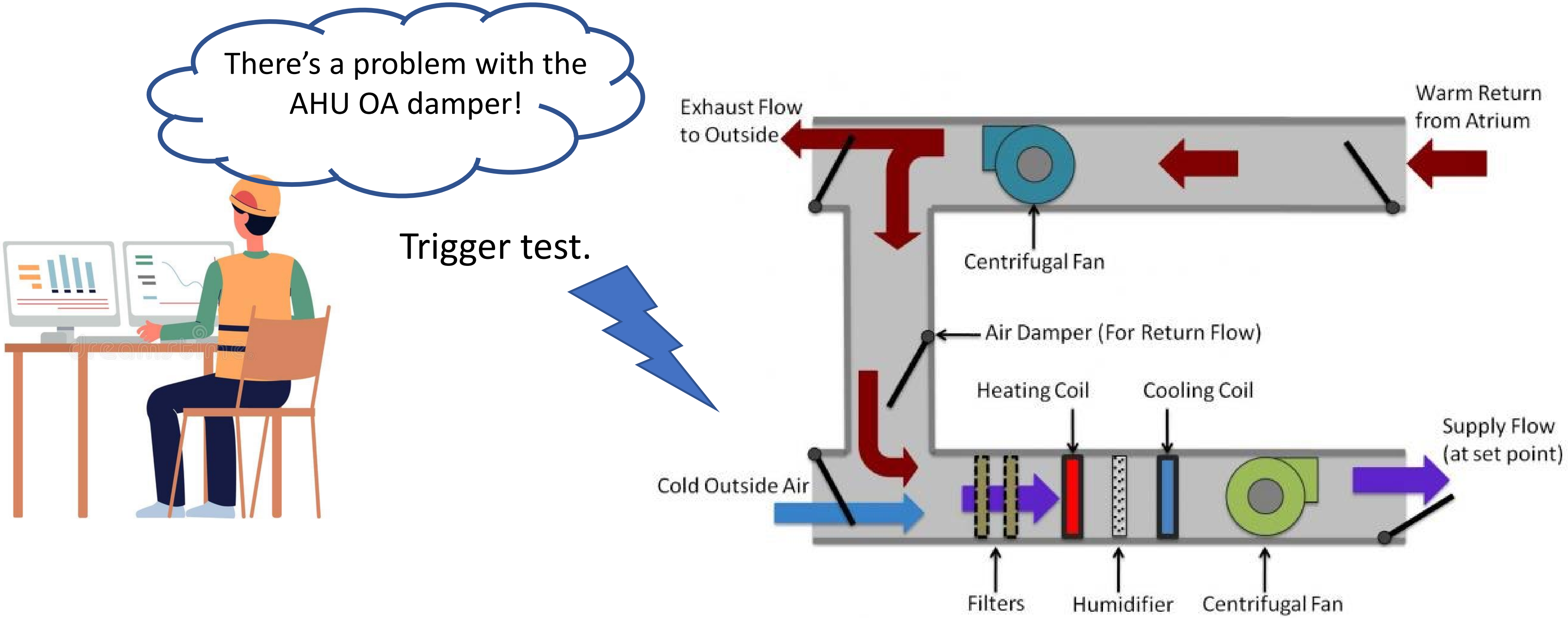
Predictive O&M: Coil Performance Example



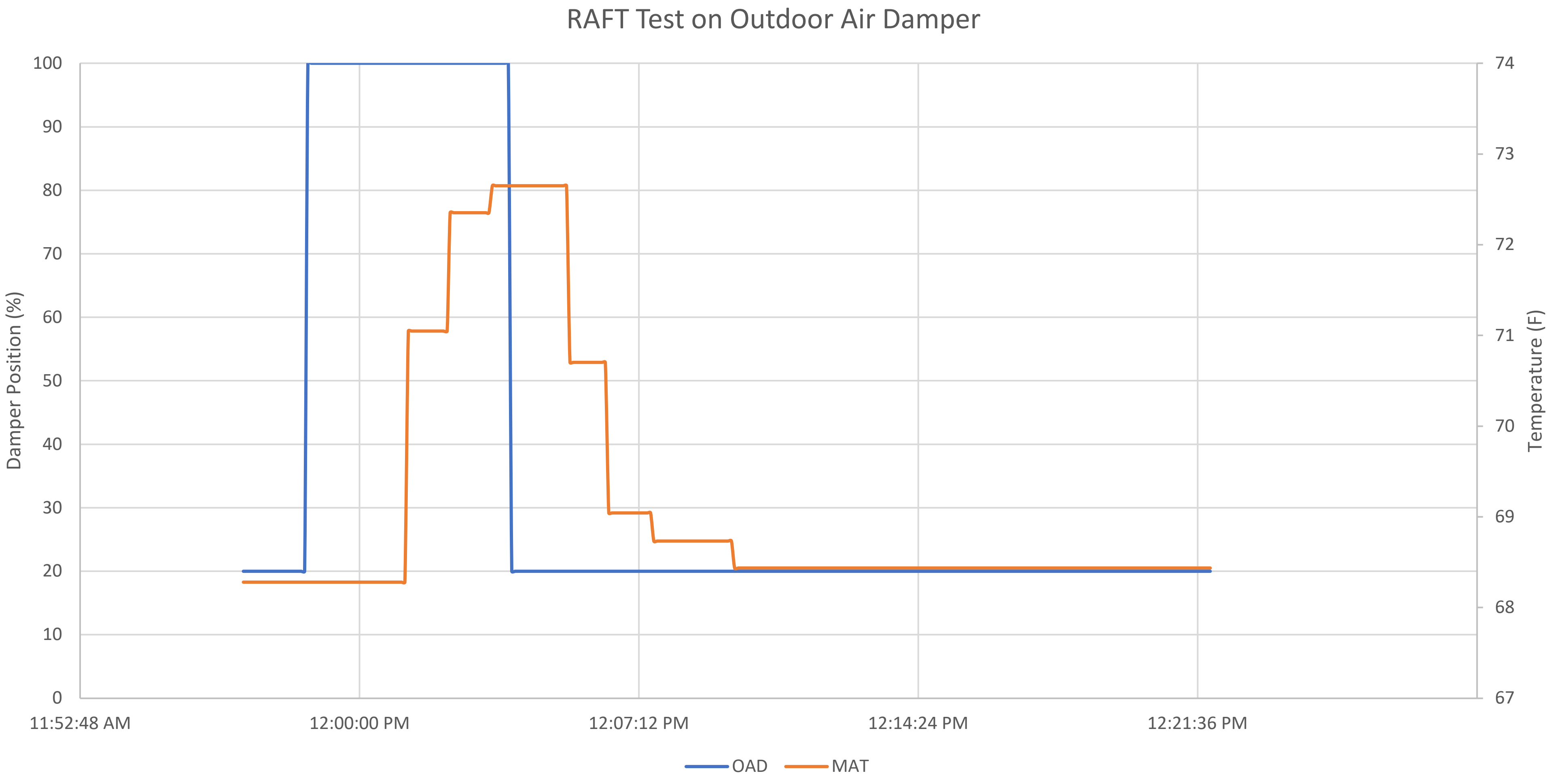
Rapid Automated Functional Test (RAFT)

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



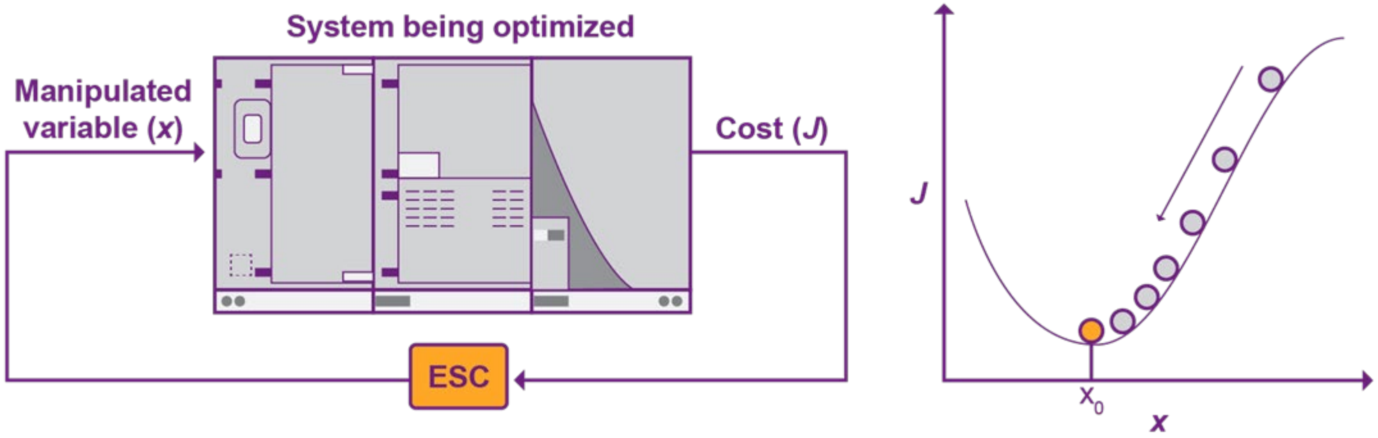
Rapid Automated Functional Test (RAFT)



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*.

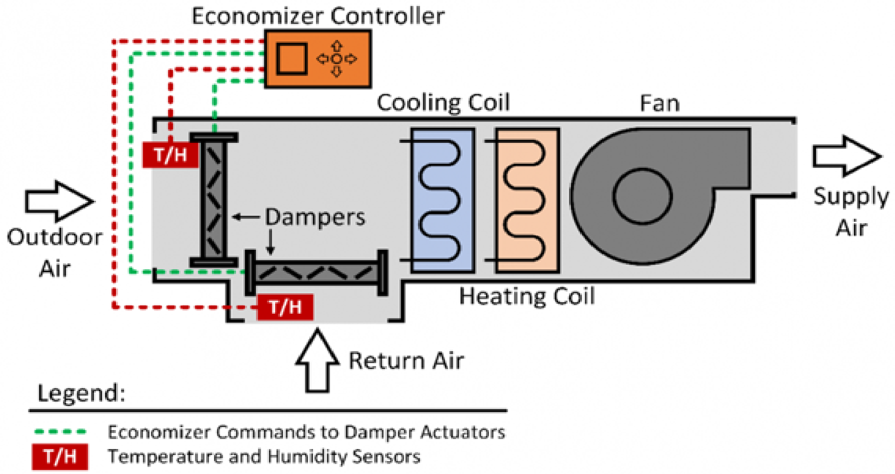
Note: "Performance" can be energy, utility costs, carbon emissions, and other metrics.

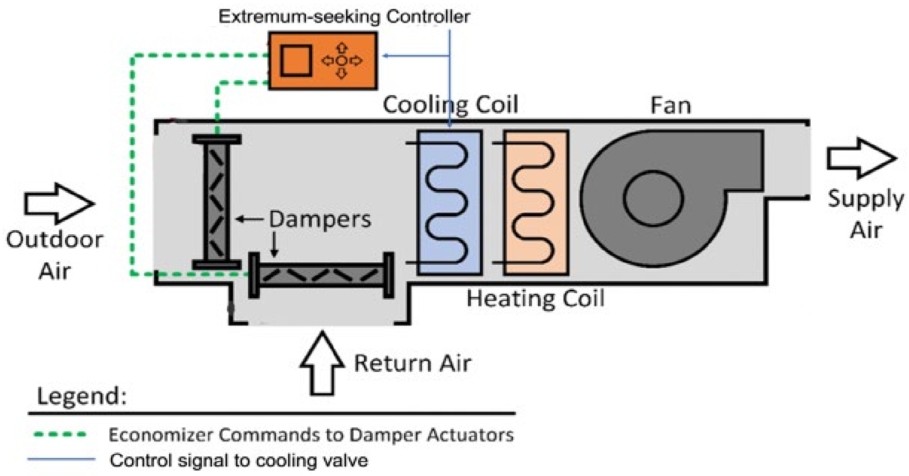


Model-free algorithm

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

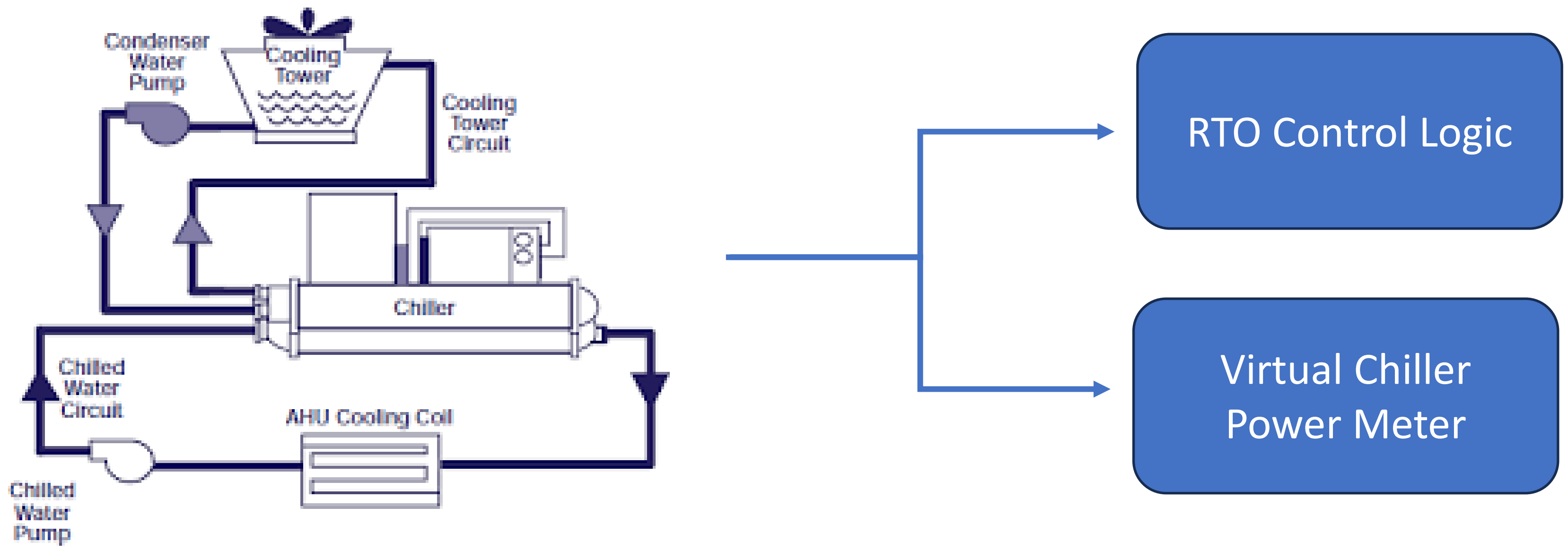




RTO/ESC: Water-side

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.

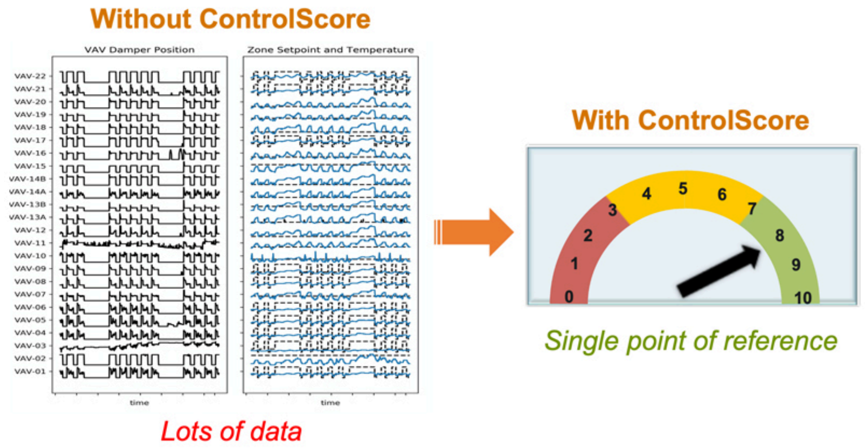
- *Chilled water systems with cooling towers*
- *Heating systems, incl. boilers and heatpumps*

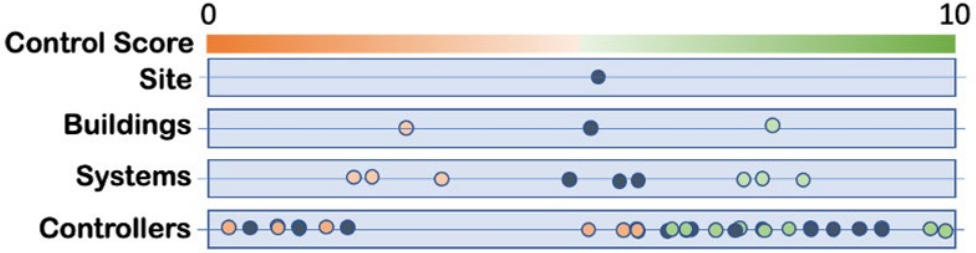


ControlScore

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

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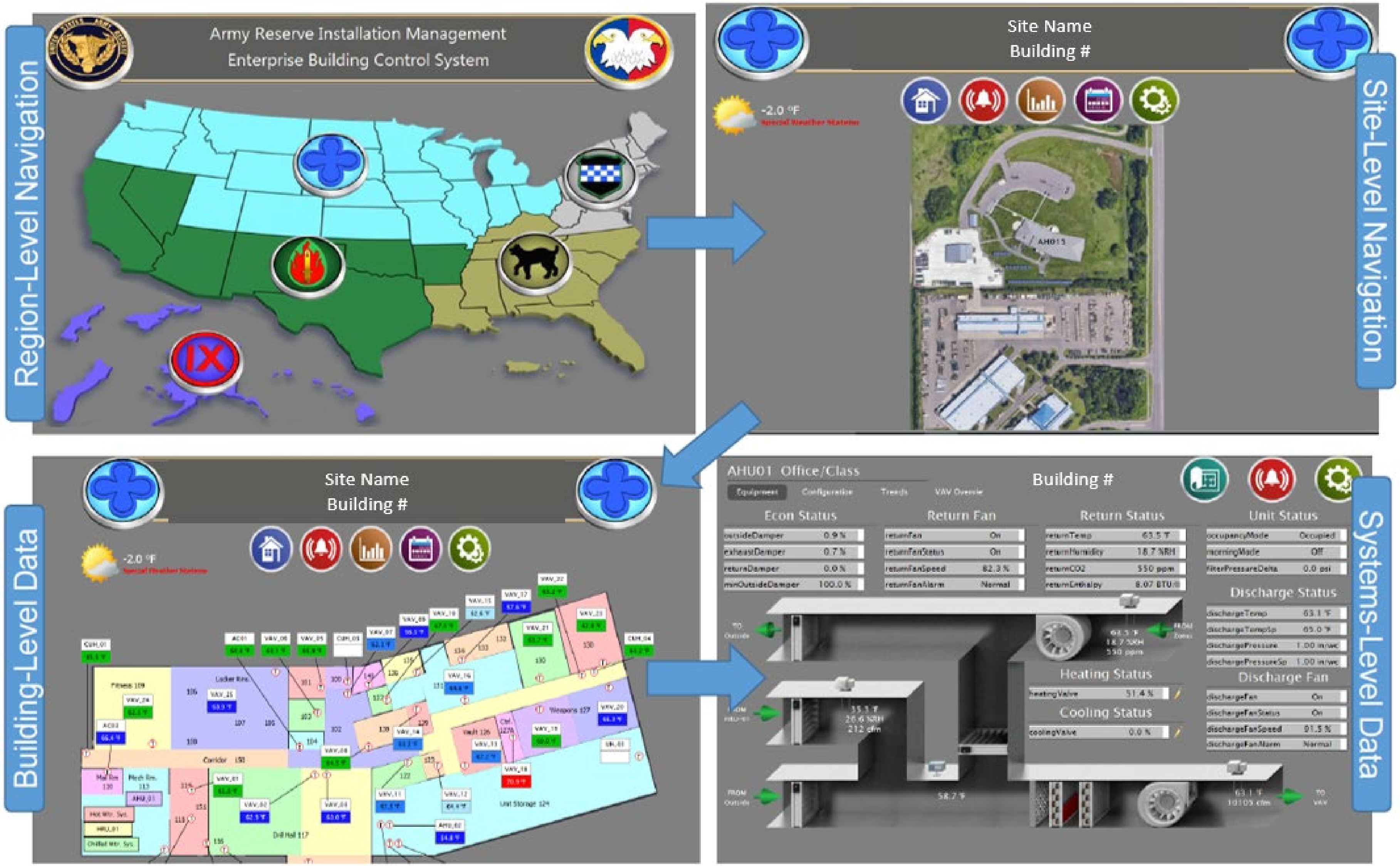
Backup Slides

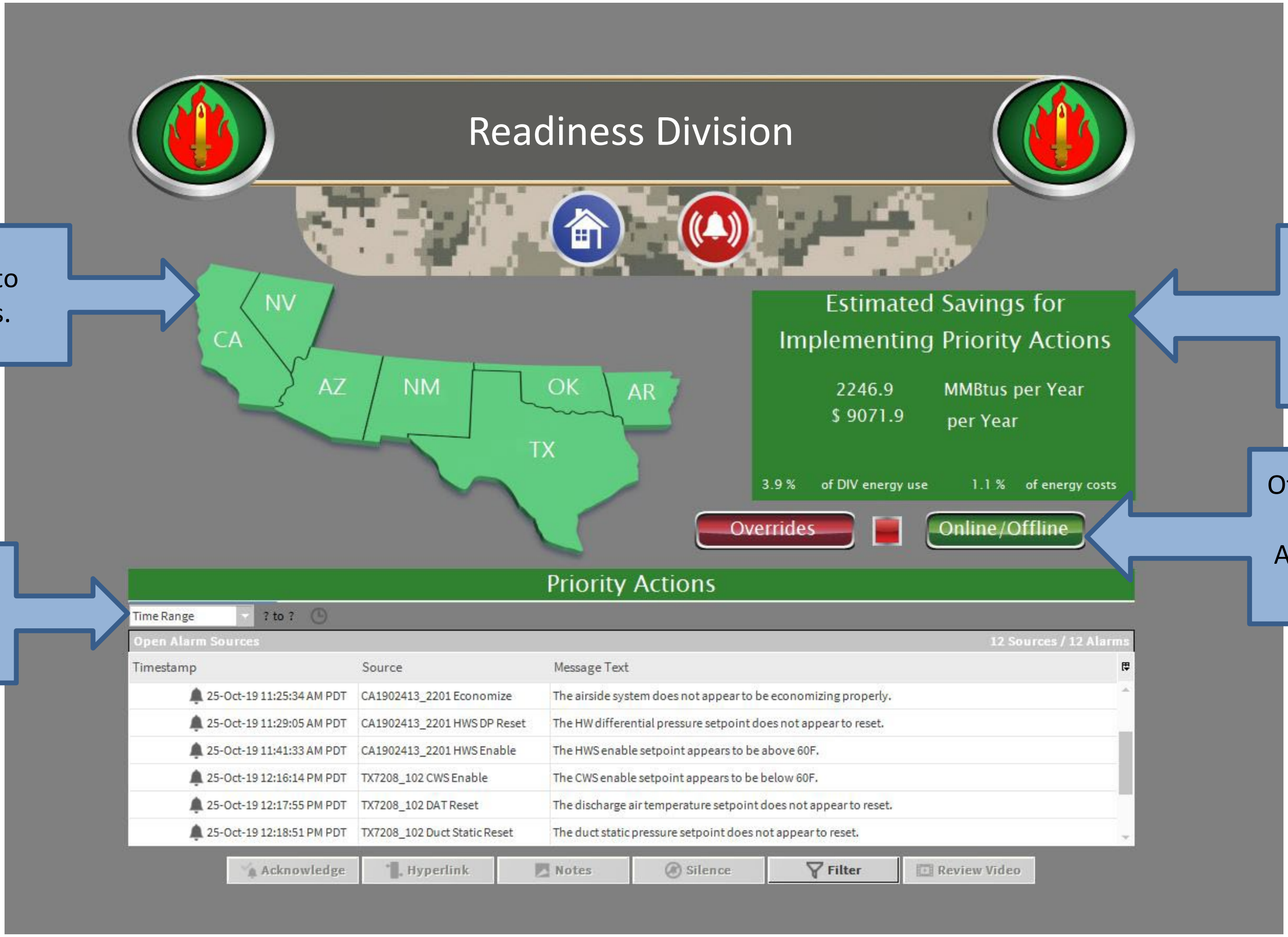
EBCS Graphics – User Interface



EBCS Graphics – Landing Page

Navigation to State Pages.

Prioritized List of Actions.

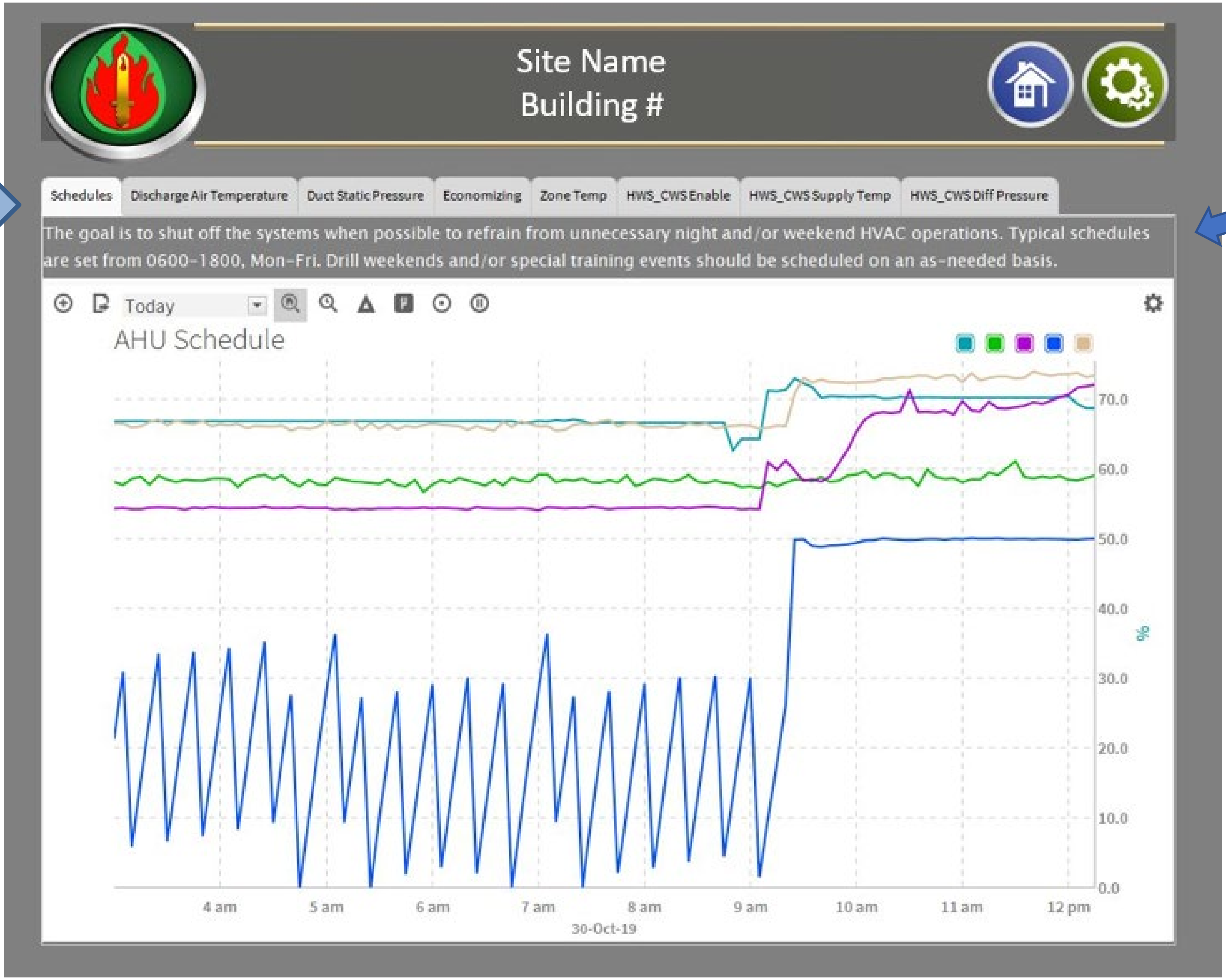


Estimated Savings Potential from Identified Measures.

Offline Equipment and All Places where Automated Control is Overridden.

EBCS Graphics – Analytics Graphs

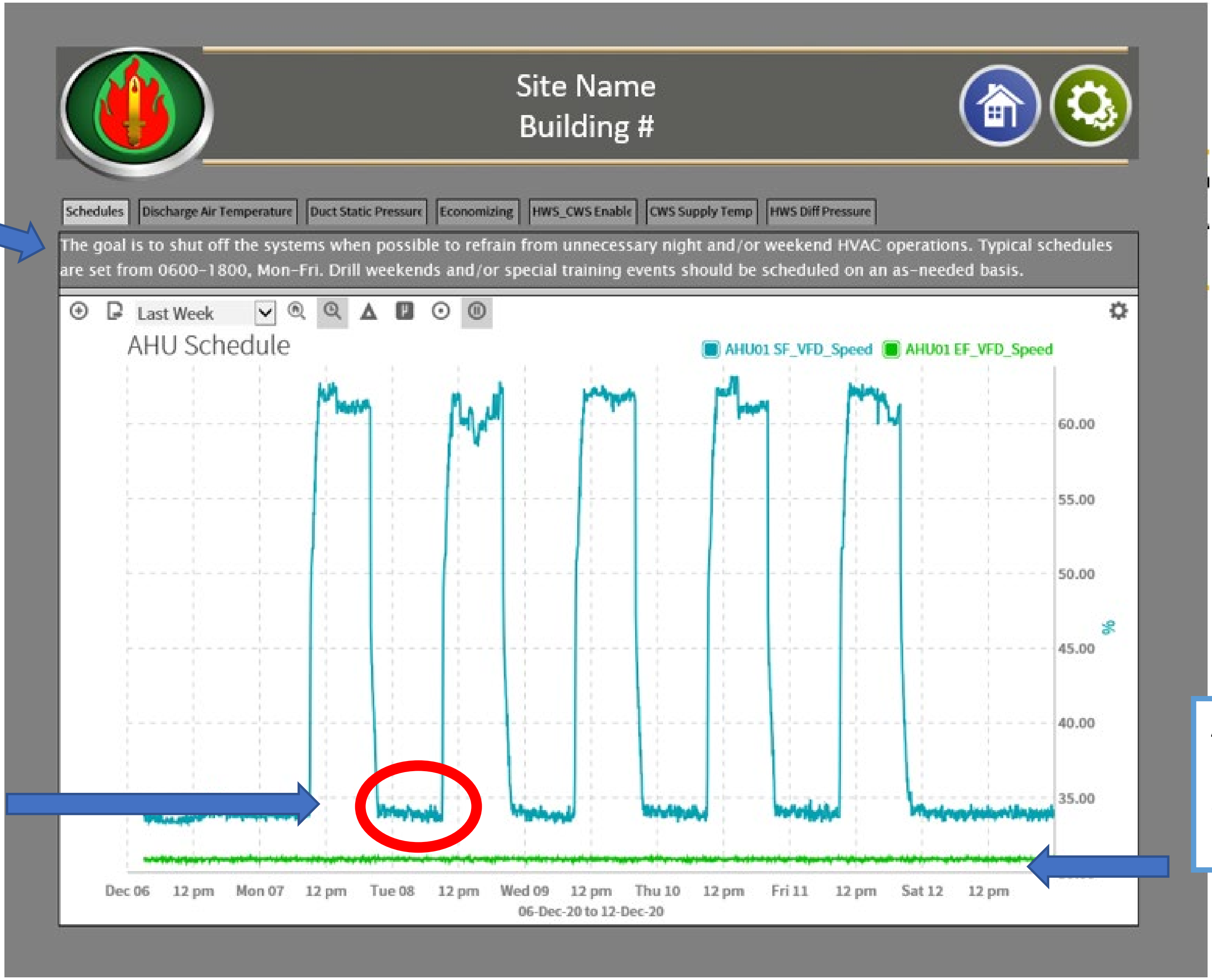
A user should walk through each tab and address any issues identified.



Brief description of ideal operations for each measure.

EBCS Graphics – Analytics Graphs

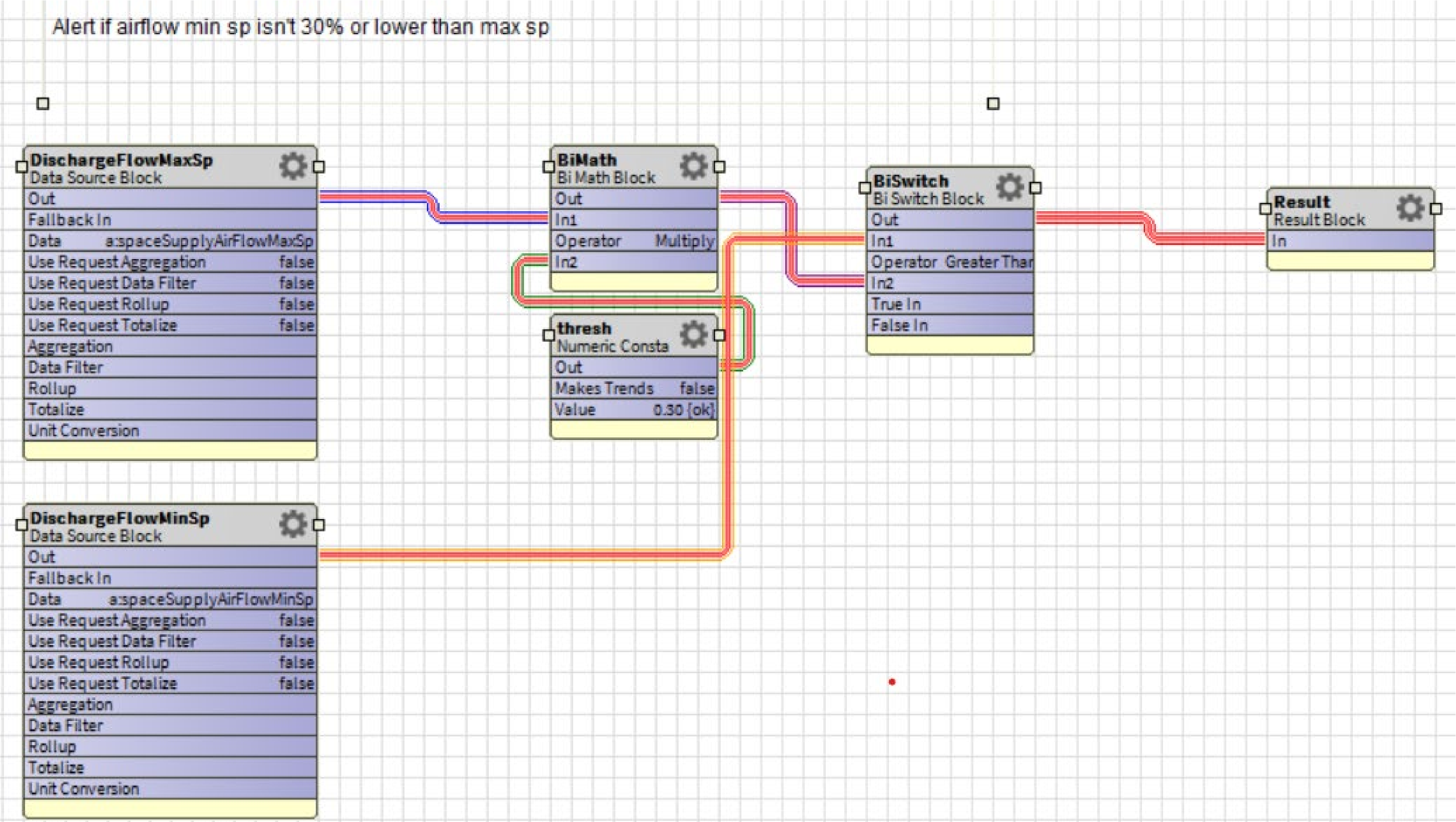
Brief description of ideal operations for each measure.



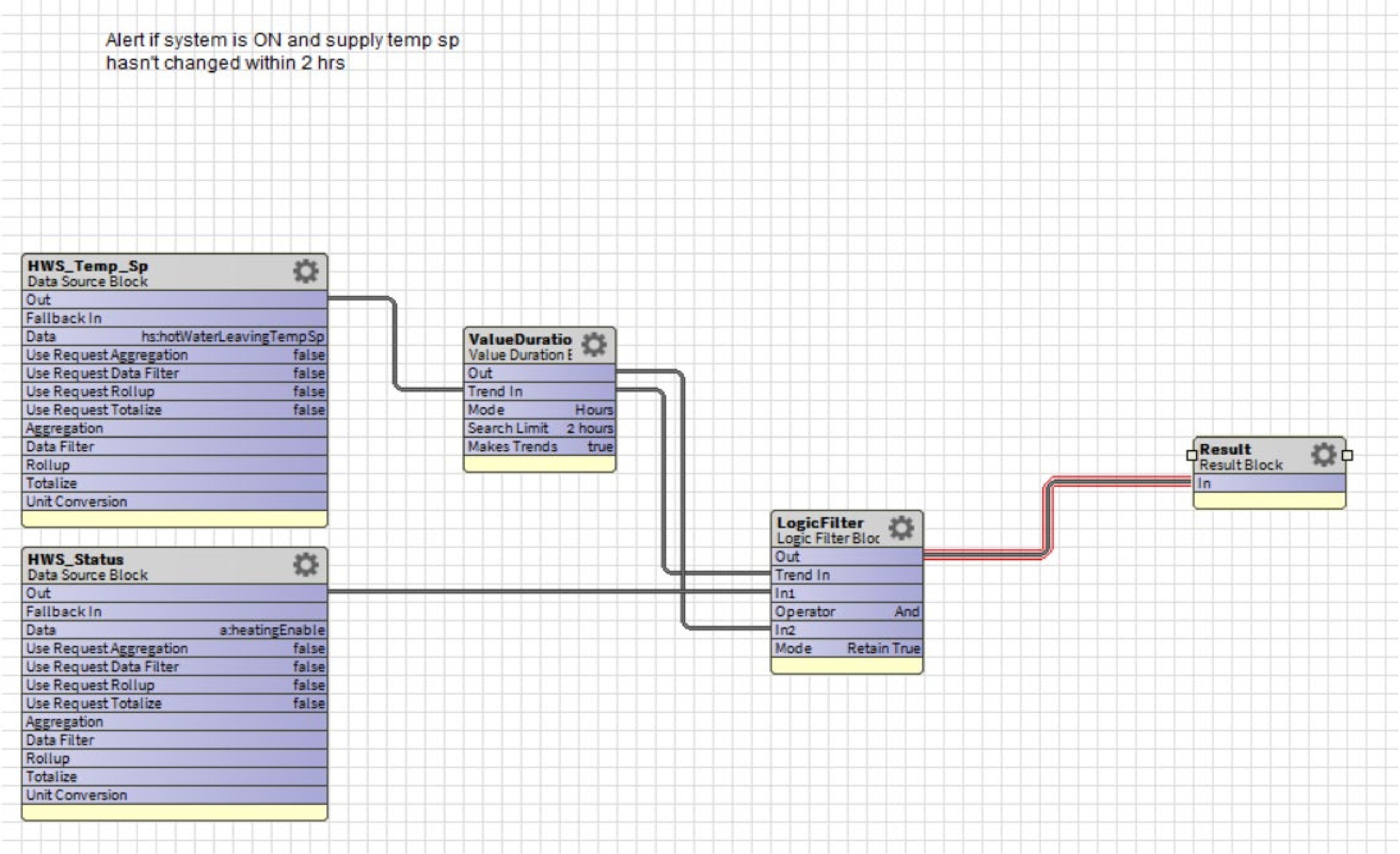
AHU01 supply fan reduces to 34% and does not shut off at night.

AHU01 exhaust fan runs continuously at ~32%.

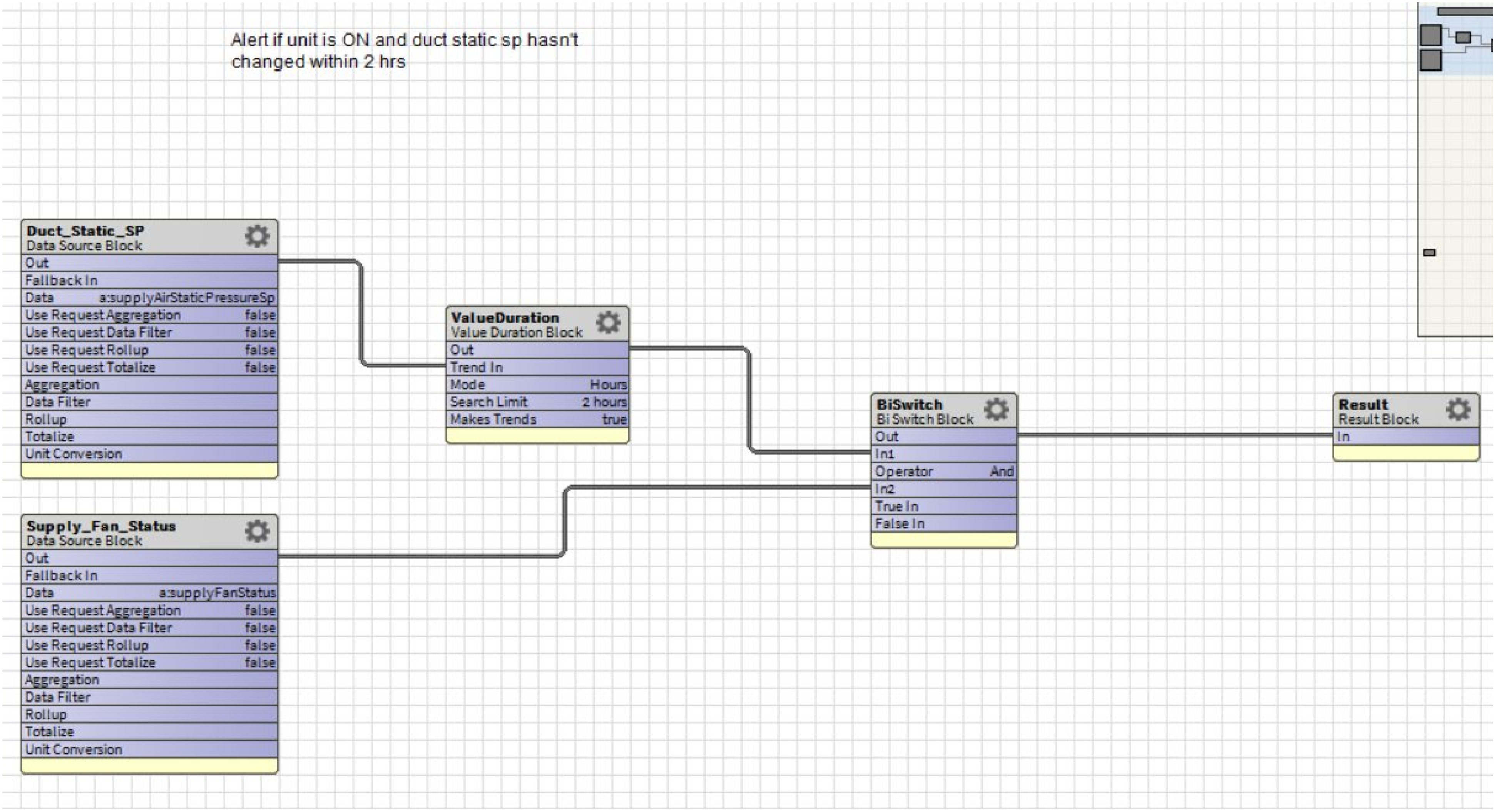
Niagara Analytics- VAV Discharge Air Flow



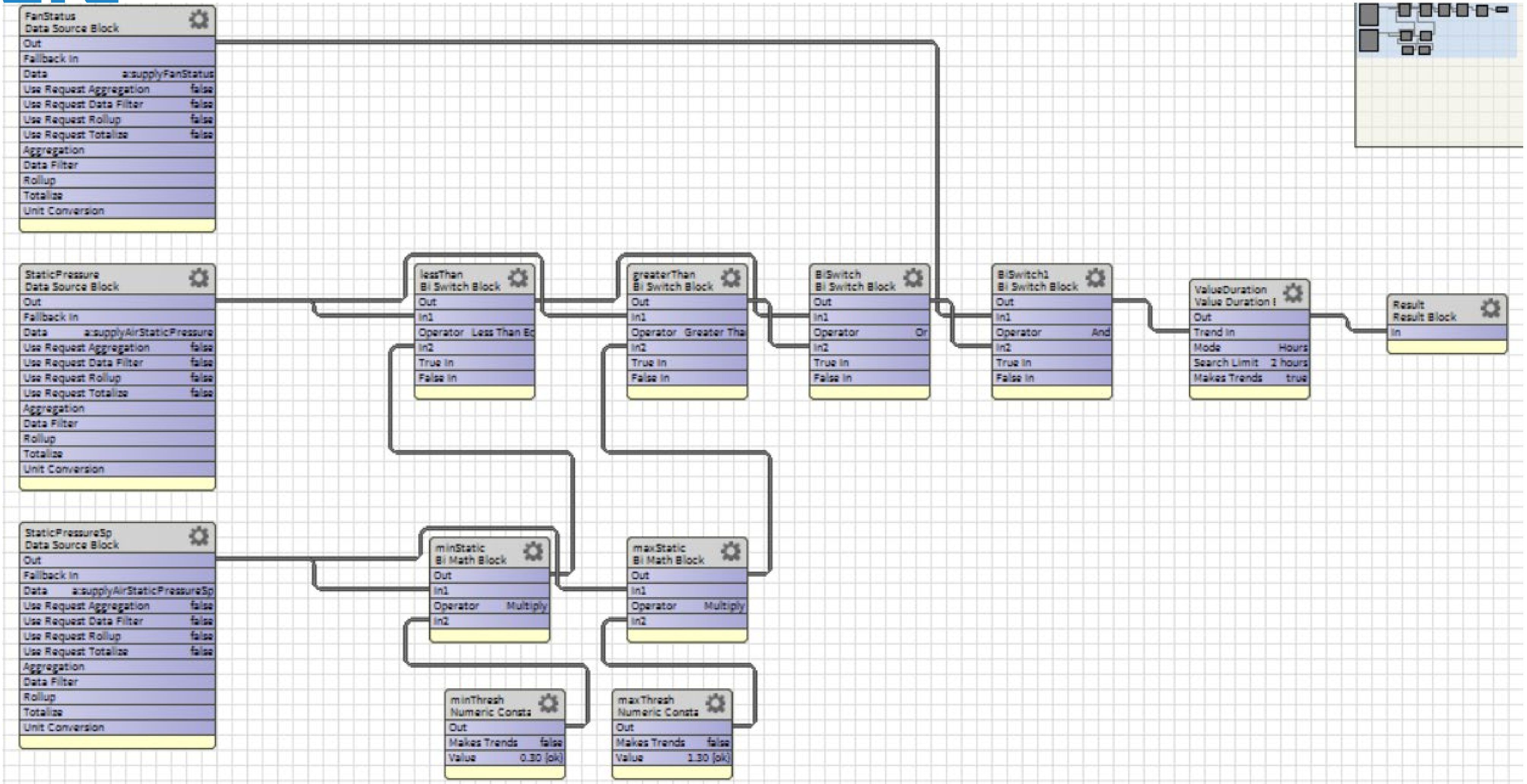
Niagara Analytics- Hot Water Setpoint



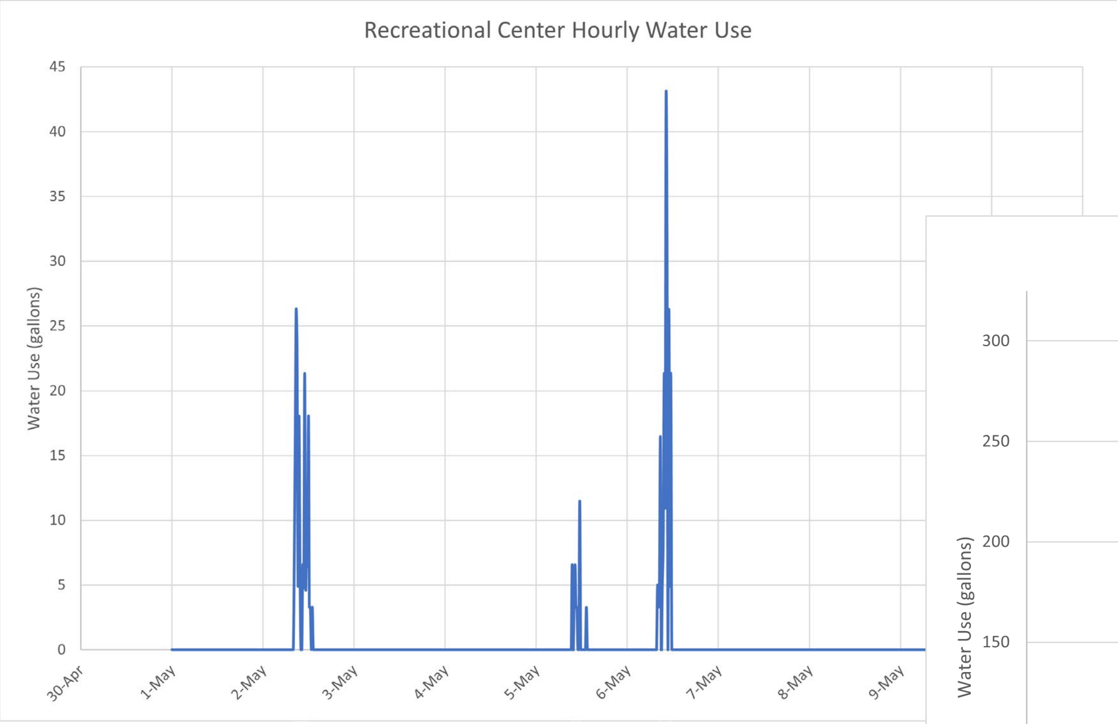
Niagara Analytics- Duct Static Pressure Setpoint

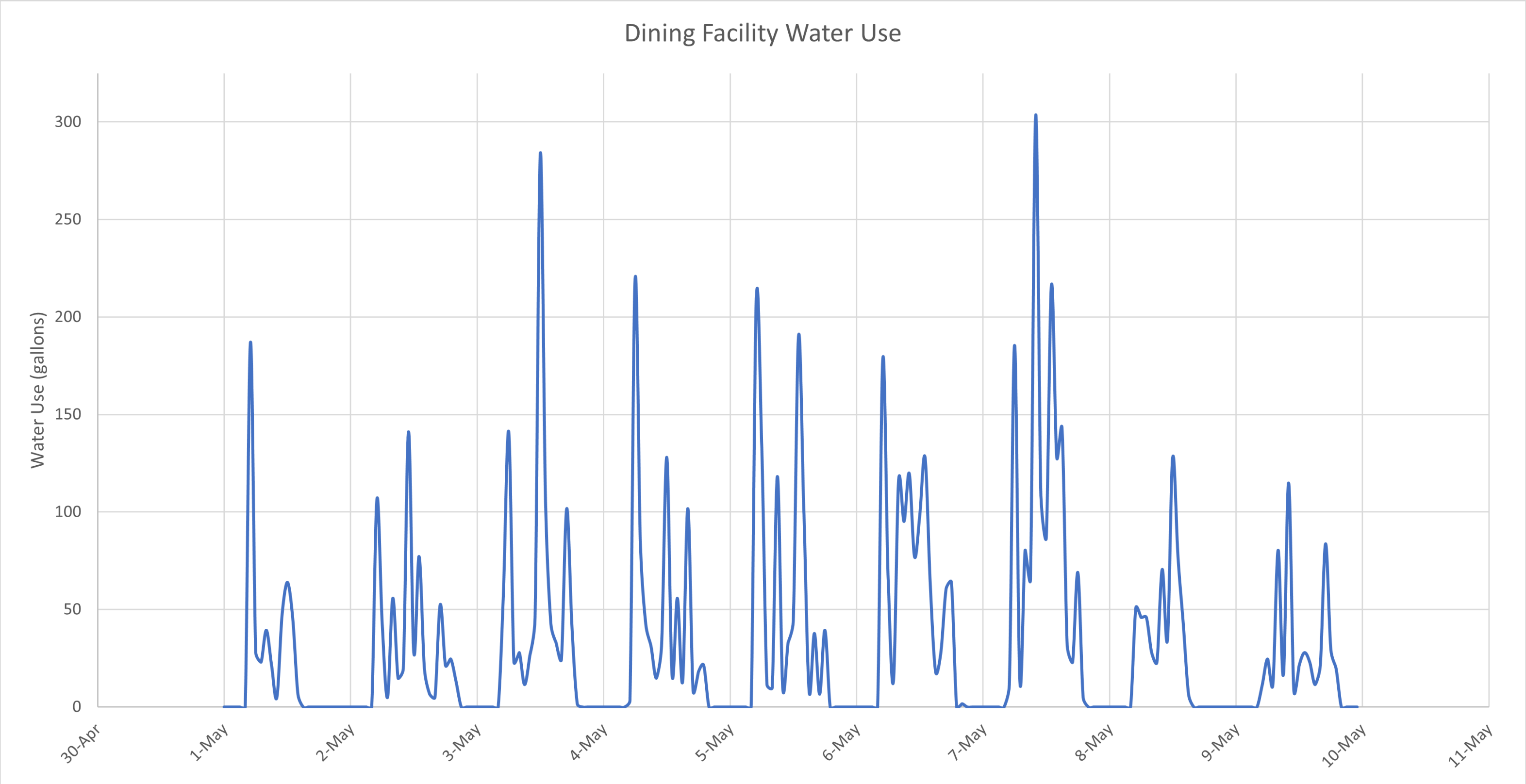


Niagara Analytics-Duct Static Pressure Setpoint vs. Pressure



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).

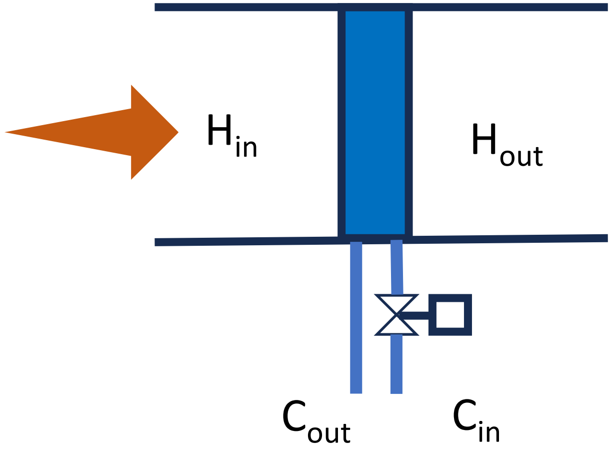
Predictive maintenance:
Continuous performance/health monitoring

Existing BAS may…		Predictive O&M will…
Alert when something is wrong	→	Alert before something is wrong

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.

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

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

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

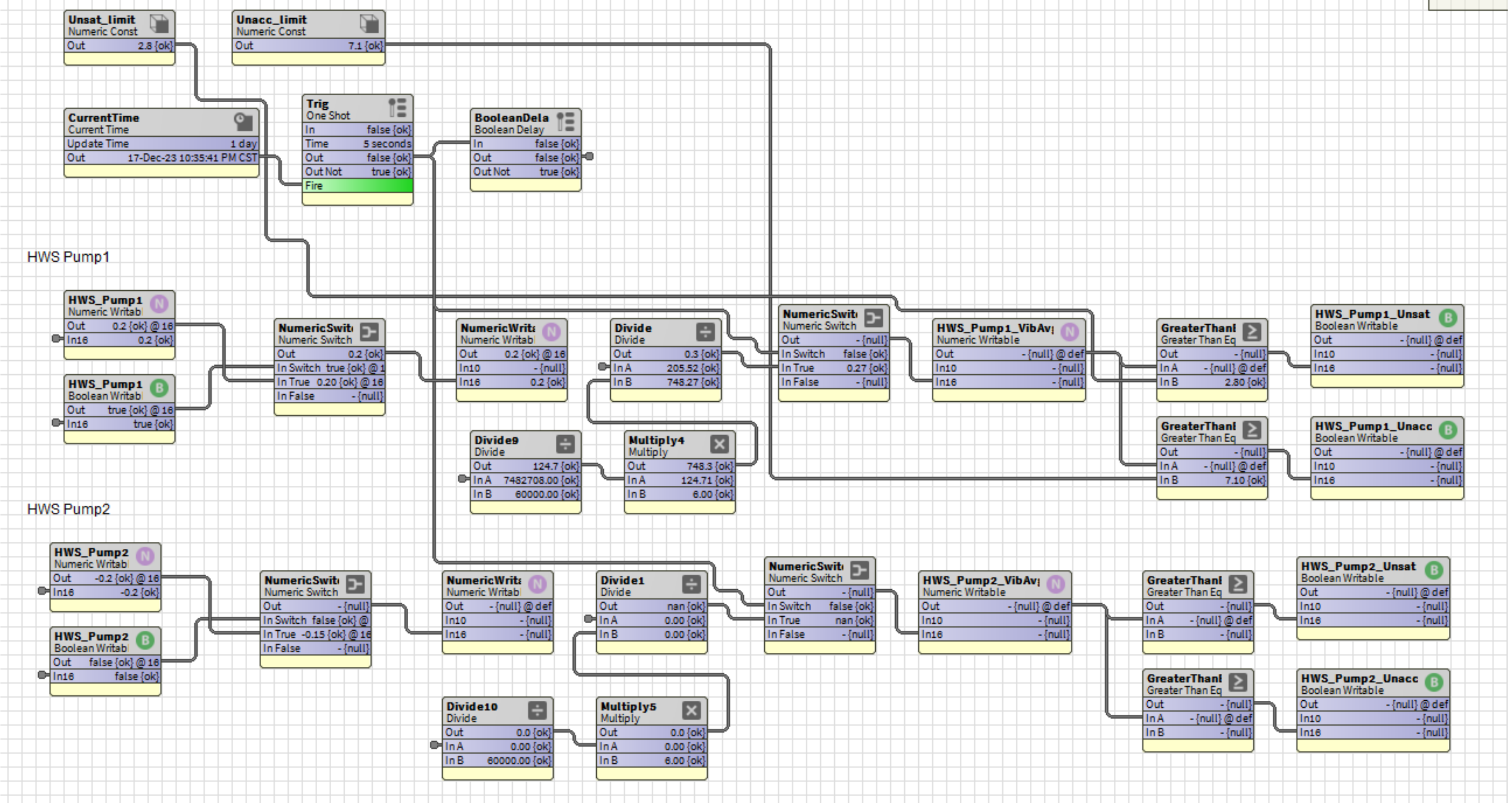
H_{in}, H_{out}, C_{in}, C_{out} are dry bulb temperatures. Enthalpy will improve effectiveness calcs.
Actual coil effectiveness is approximate as it also depends on water flow, airflow, & DAT setpoint.

Predictive O&M: Vibrations Example

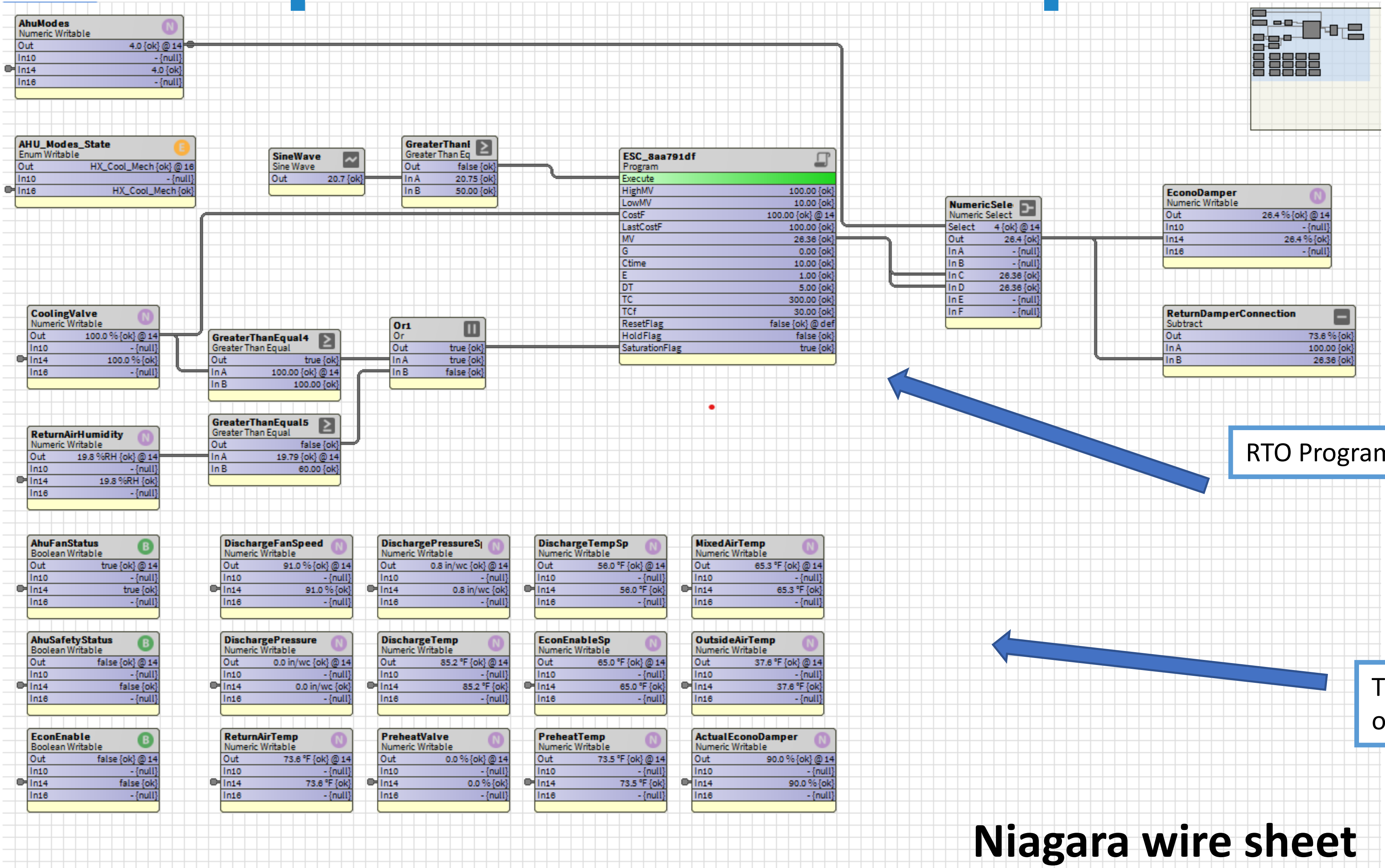
Vibration Analyzer

Unsatisfactory: If the daily viration avg is greater than the lower limit threshold (2.8 mm/s) when the equipment is on.

Unacceptable: If the daily viration avg is greater than the lower limit threshold (7.1 mm/s) when the equipment is on.



RTO Implementation Example



RTO ProgramBlock

Trended datapoints for easy observation

Niagara wire sheet

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