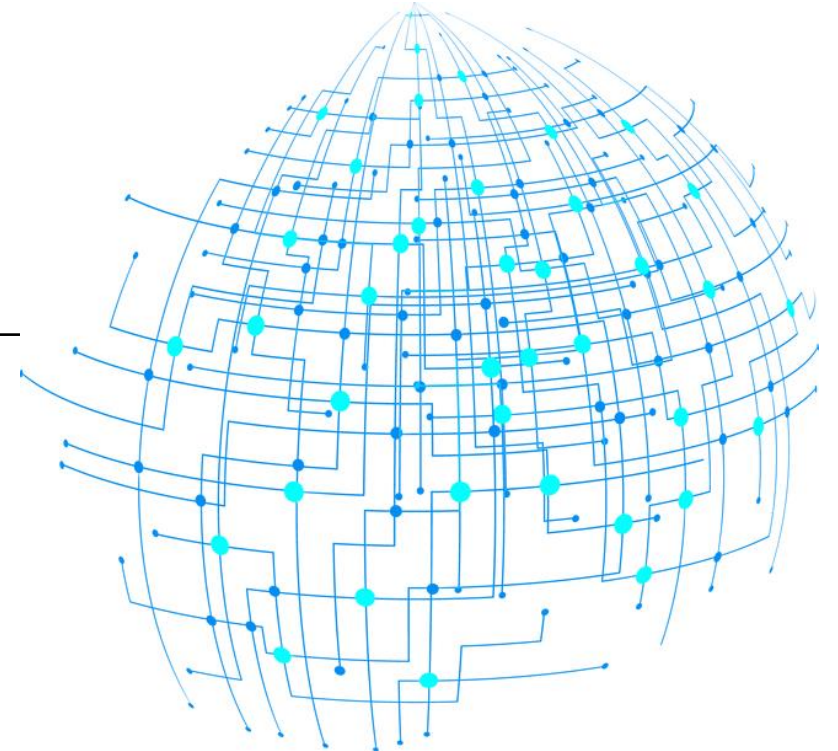# TURN YOUR DATA INTO A CRYSTAL BALL

How Big Data Analytics Can Predict Impending System Failures To Achieve Improved Energy Efficiency, Comfort, & Sustainability

Big Data and IOT

Julianne Rhoads, CEM

Learning Objectives

1. Understand how to evaluate building management system (BMS) data as a tool for fault identification and failure prediction.

2. Understand how predictive analysis can counter reactive maintenance.

3. Identify the economic and environmental benefits of big data analysis and predictive maintenance.

4. Recognize and appreciate high-value data points and reliable data collection.

Maintenance Program Comparison

Reactive/Corrective
- When?   Repair after failure
- Key Driver: Alarms, emergency calls

Preventative
- When?   Scheduled before failure
- Key Driver: Design data, run-hours, CMMS

Predictive
- When?   Eliminate root cause before failure
- Key Driver: AFDD

Shortcomings

- Minimal Performance Improvement
- High Cost & Unplanned Downtime
- Inefficient Resource Deployment
- No Lifetime Asset Performance
- Requires Configuration
- Large Amount of Data

Association of Energy Engineers

Predictive Maintenance (PdM)

- Continuous, automated analysis of equipment performance to **identify faults before becoming critical**
  - Increase Mean Time Between Failure (MTBF)
  - Mitigate risk of product loss & process disruptions

- Predicts when corrective maintenance should be performed

- Promises cost savings over routine PM
  - Resource deployment only when warranted

"The right information at the right time"

The Key Driver: Operational Technology

- Universal connectivity to IOT

- Automatic fault detection & diagnostics (AFDD) and root cause analysis

- Secure big data collection & storage

- Topological system modeling

<u>PdM is driven by AFDD</u>
- ✓ Asset performance over time
- ✓ Scalable to ubiquitous devices

Big Data & PdM

- Modern big data approaches apply algorithms to system models
  - Not limited to high-value assets; detect minor anomalies, failure patterns

- Analyzing & mining system data for value

- **No "Islands of Automation"**
  - Correlate maintenance data to comfort or integrity of process
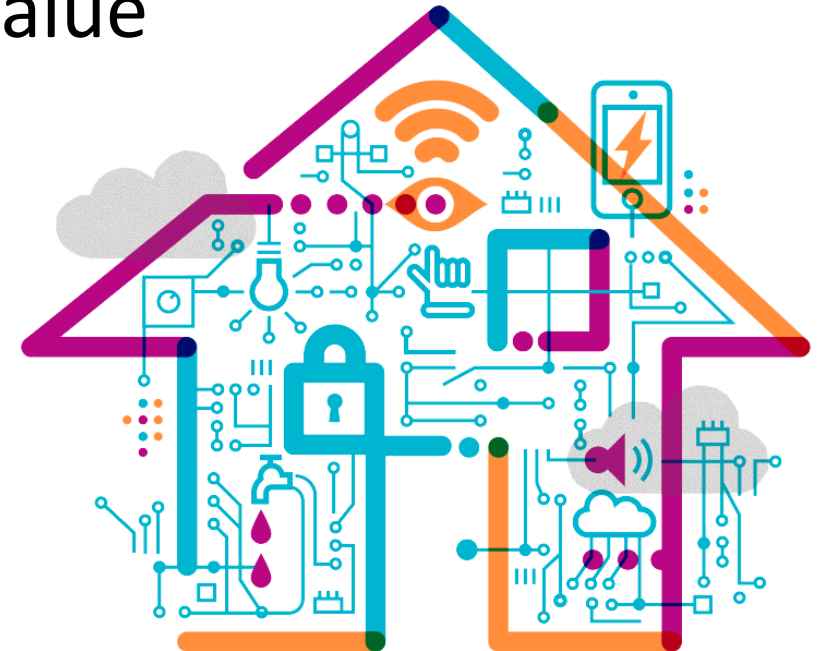
Examples of Predictive Indicators

Controls, Optimization
- Performance Curve Comparison
- Equipment Oscillation
- Failure to Meet Setpoint

Mechanical
- Differential Pressure
- Short-cycling
- Motor Temperature
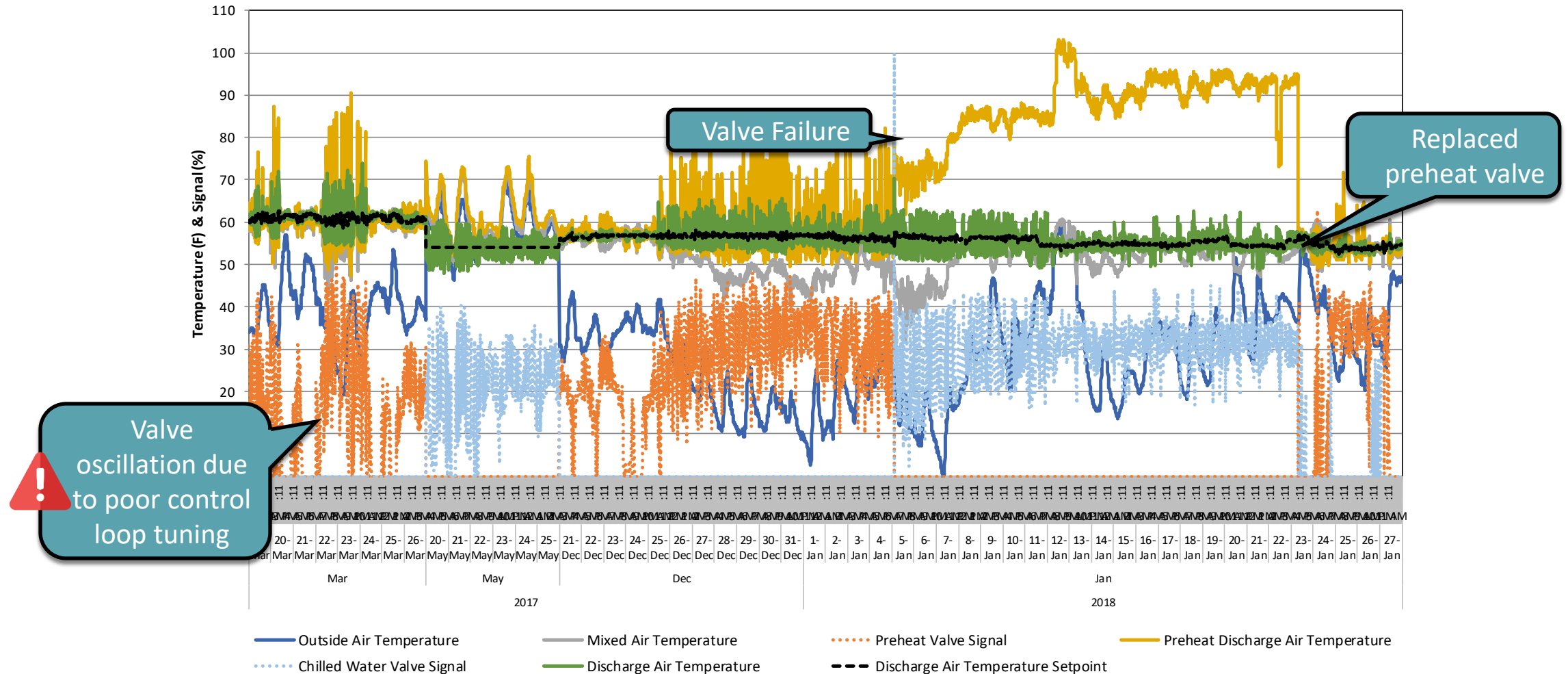- Bearing Temperature

Scheduling
- Equipment Performance Drift

Safety, Comfort
- Severe Weather (Alerts & Performance Analysis)
- Critical Parameter Monitoring

Predicting Valve Failure

Valve Failure Summary

- Symptom: Signal oscillation

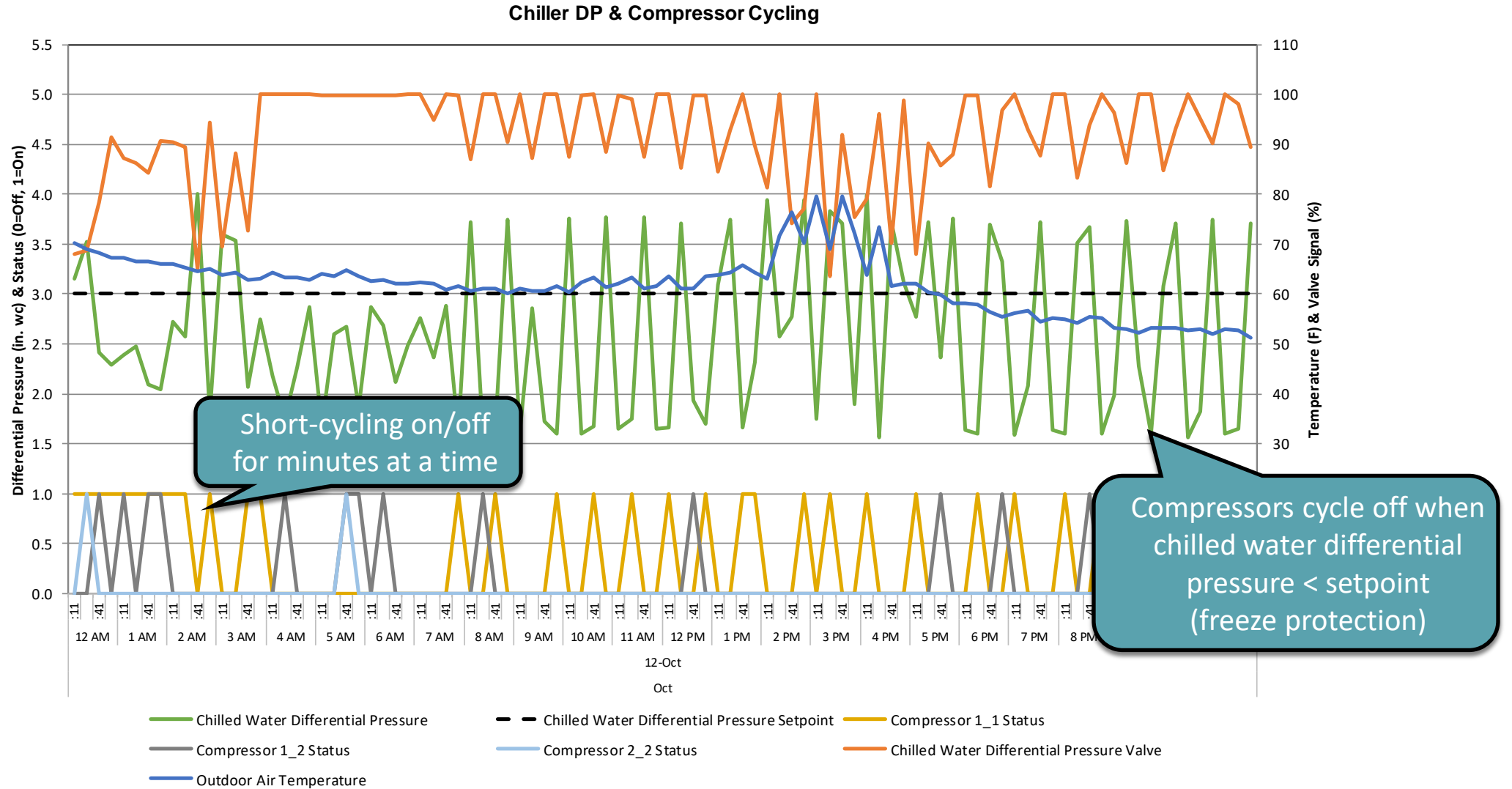- Root Cause: Poorly tuned temperature control loop

- Prediction: Valve failure

- Solution: Tune control loop (eliminate root cause), replace/repair valve

- Savings: $173,000/year

Compressor Cycling

Chiller DP & Compressor Cycling

Compressor Cycling Summary

- Symptom: Short-cycling

- Root Cause: Pressure controller DP set too tight, refrigerant charge, fouled tubes

- Prediction: Reduced equipment lifetime

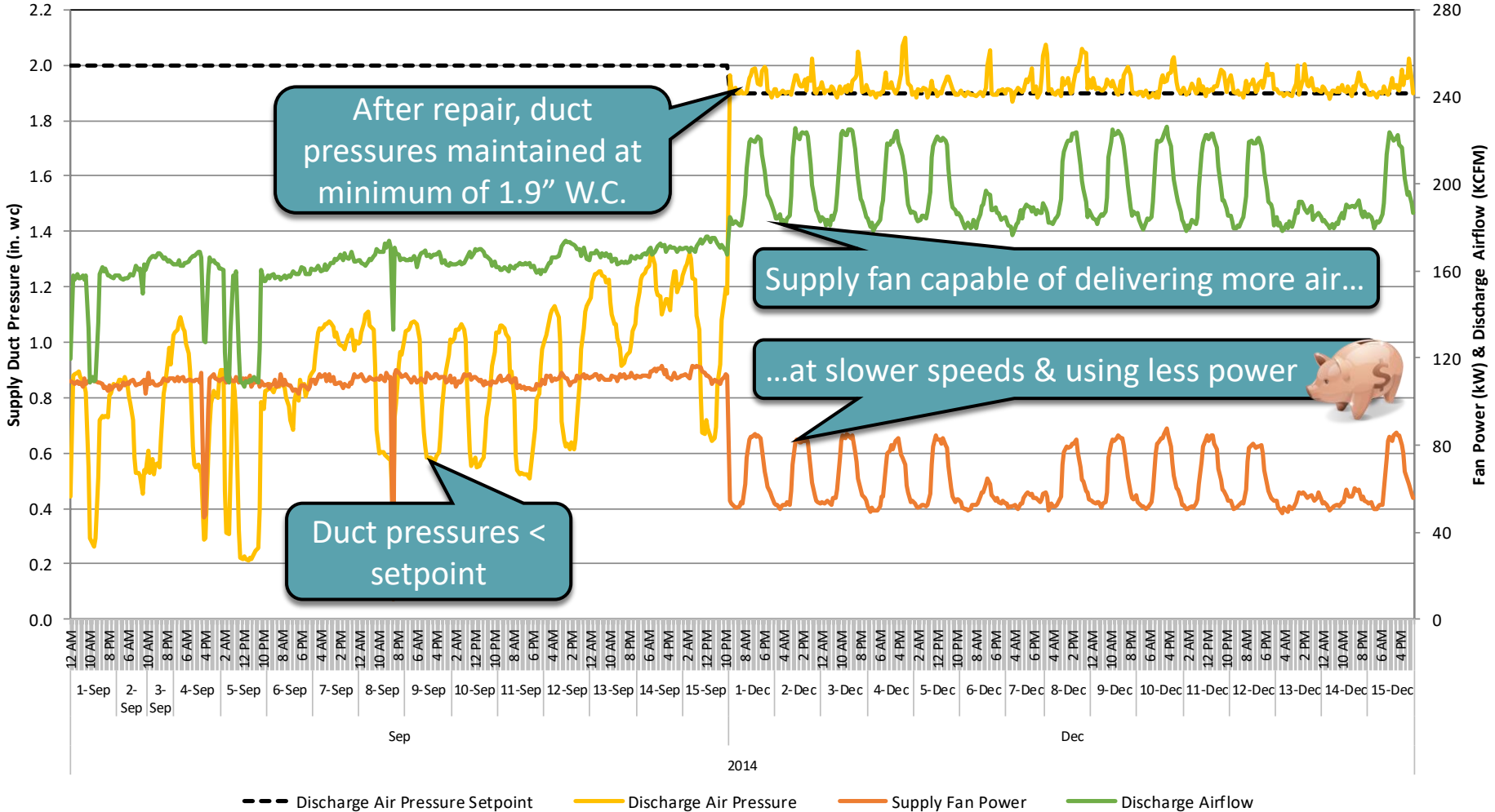- Solution: Increase DP dead-band, turn off chillers in winter (left in-hand)

- Savings: Capital cost avoidance

Fouled Coils

Supply Fan Power and Duct Pressure
Supply Fan = On (Status = 1)

After repair, duct pressures maintained at minimum of 1.9" W.C.

Supply fan capable of delivering more air...

...at slower speeds & using less power

Duct pressures < setpoint

Fouled Coils Summary

- Symptom: Discharge air pressure below setpoint

- Root Cause: Fouled coils

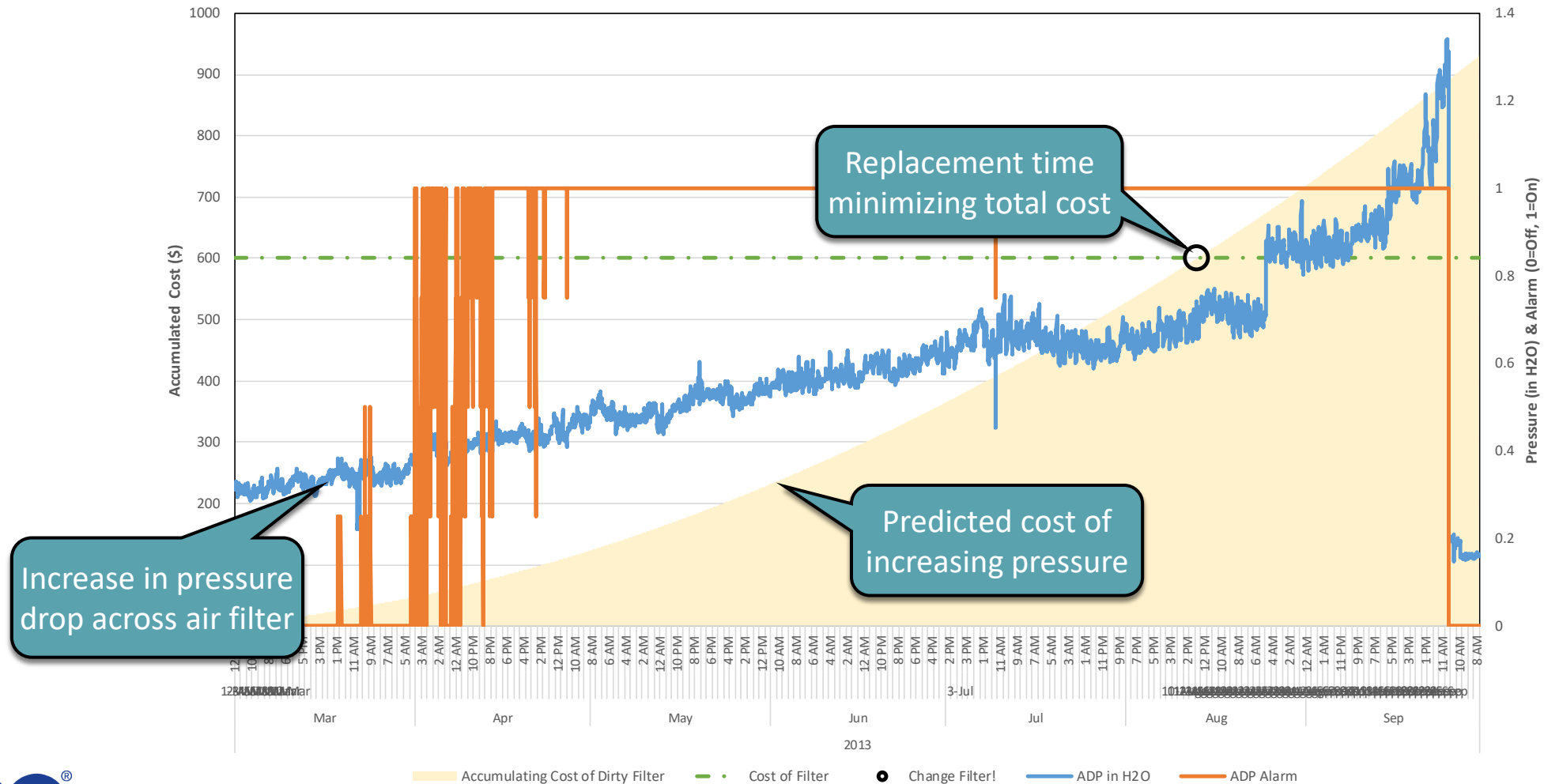- Prediction: Equipment failure, decreased heat transfer, greater energy consumption, poor IAQ

- Solution: Clean coils

- Savings: $113,000/year

Dirty Air Filter Summary

Air Filter Replacement Optimization and Prediction

Dirty Air Filter Summary

- Symptom: Increase in differential pressure

- Root Cause: Dirty air filter

- Prediction: Frozen coils, blower failure, inadequate heating/cooling, lost savings (premature replacement)

- Solution: Data can be used to optimize the time period between air filter replacements
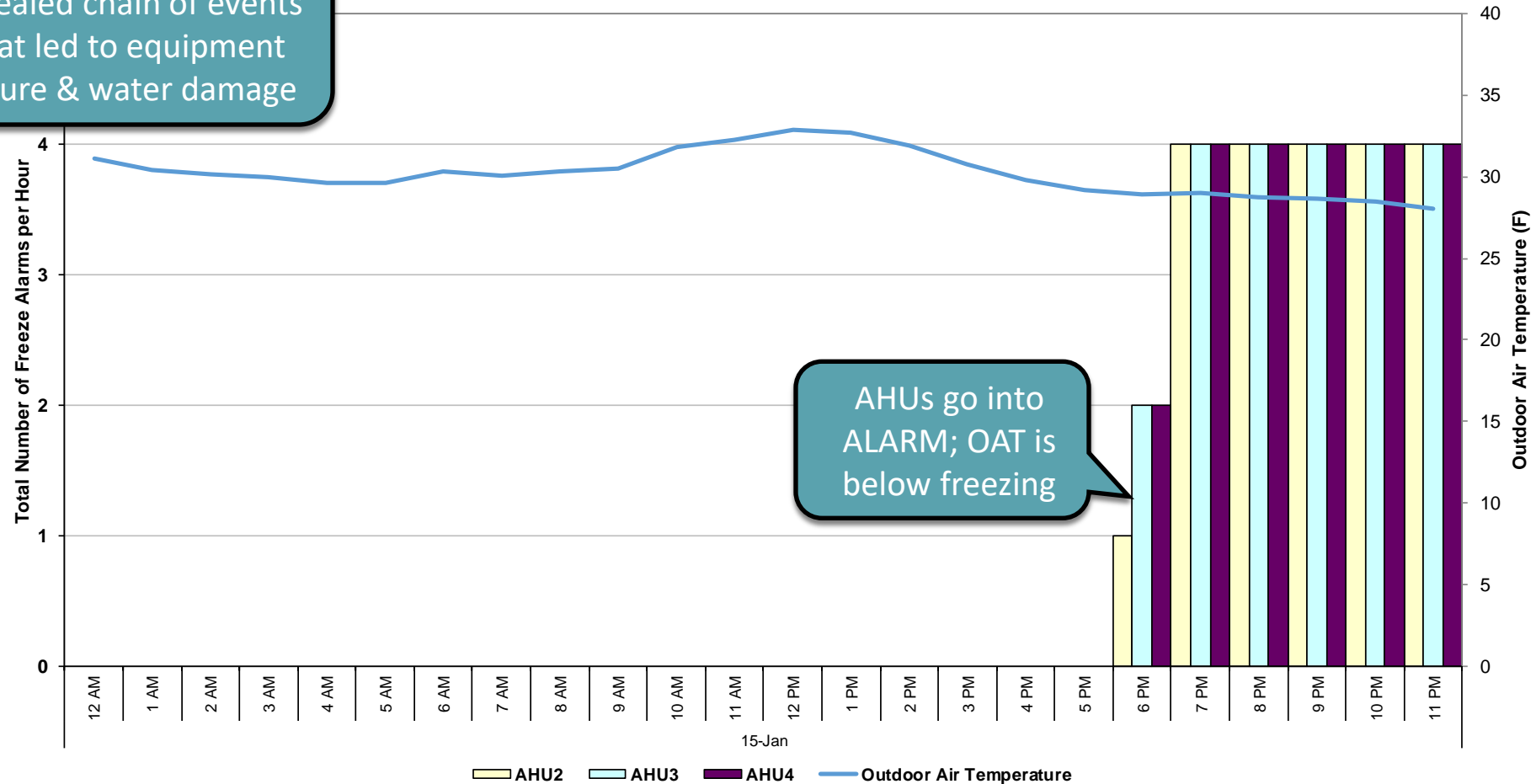
- Savings: $900/year

Frozen Coils Summary

- Symptom: Low stream temperatures in 100% OA units

- Root Cause: Inadequate freeze control logic, Ignored alarms for extended periods

- Prediction: Flagged AHUs susceptible to frozen coils during upcoming cold spell
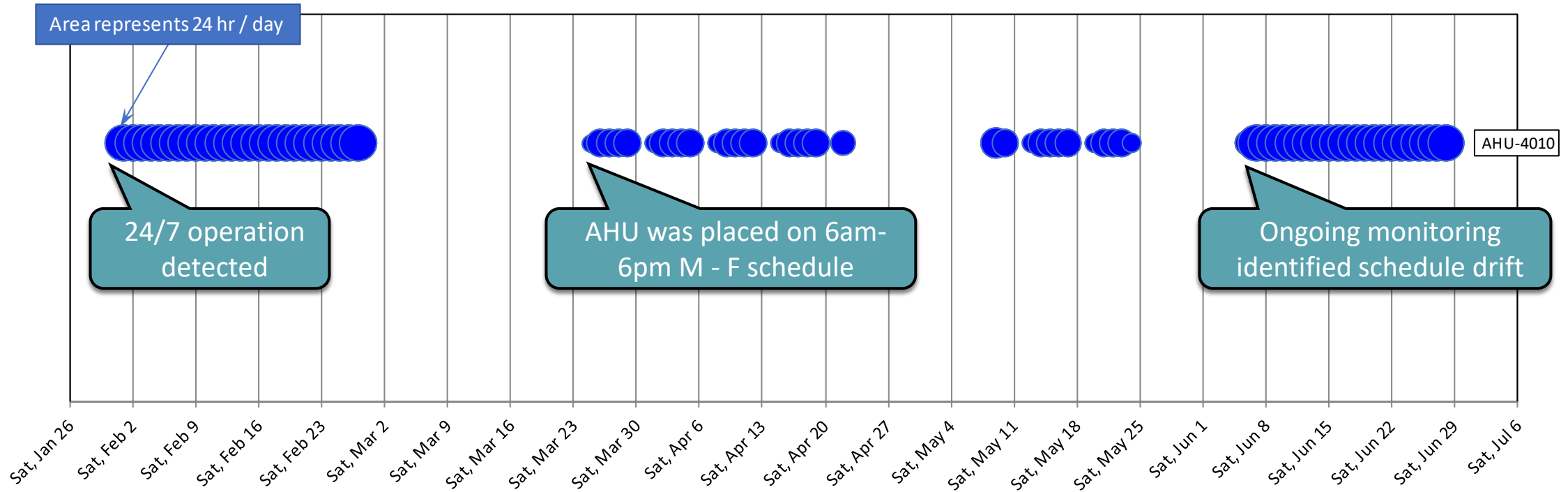
- Solution: Updated valve/damper control sequences for freeze protection mode

- Savings: Contractor admitted negligence and held responsible for damages of $60,000+

Excess Runtime

AHU Schedule Display

- ➢ AHU serves mixed-use area & continuously operates in-hand
- ➢ Generally, equipment is often scheduled 24/7 due to unknown response time
  - ✓ PdM & historical asset knowledge can help!

Excess Runtime Summary

- Symptom: 24/7 operation, continuous drift

- Root Cause: Equipment left in override
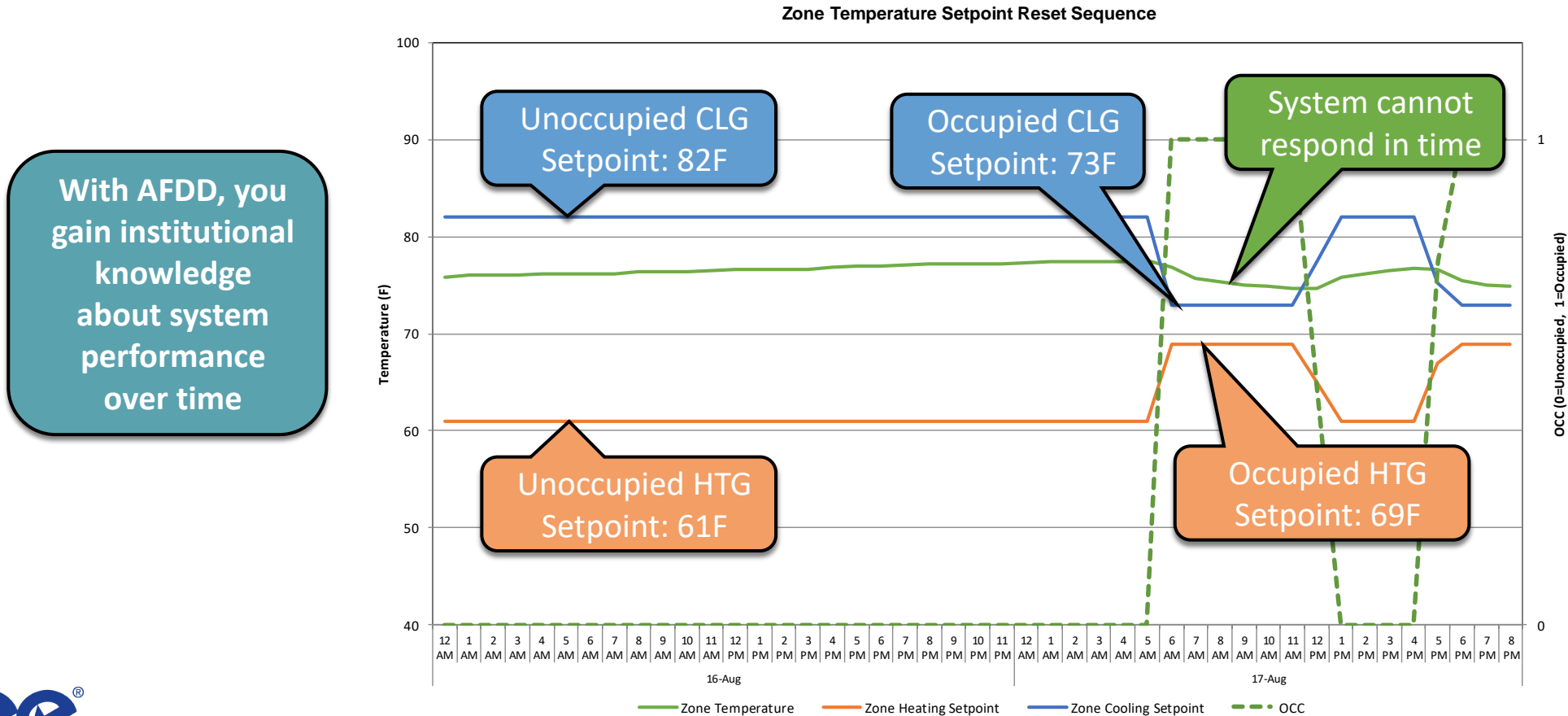
- Prediction: Change in space requirements

- Solution: Install software switch with maximum run-time

- Savings: $53,000/year

Response Time & Temperature Setback

➤ The time for HVAC equipment to bring zone to occupied setpoint

✓ Driven by loop tuning parameters, AHU supply temperature, reheat water temperature, etc.

Response Time Summary

- Symptom: Zone temperature above setpoint

- Root Cause: Occupied/Unoccupied setpoint dead-band is too large

- Prediction: Hot/Cold calls

- Solution: Tighten setpoint dead-band, adjust equipment start-up time

Data Sufficiency

- ASHRAE recognizes the importance of BMS data sufficiency
  - ASHRAE Guideline 36

- How well does your AFDD perform data conditioning?
  - Interpolation
  - Cleansing
  - Sensor errors

- Fault detection and predictions are dependent on data quality
  - Installed sensors and exposed control values necessary for confirming correct system operation

Conclusion

- AFDD & PdM automatically and continuously prioritize big data

- Targeted ongoing Cx ensures year-after-year energy savings

- High value data & the analyst are important for valid root cause interpretation

Questions?

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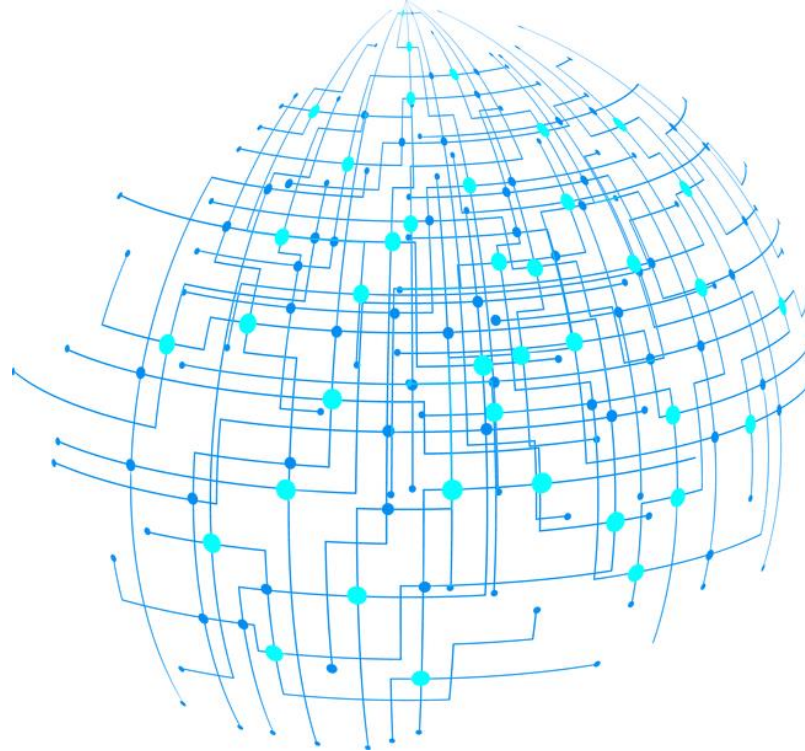
Julianne Rhoads, CEM
Senior Data Analyst
jrhoads@cimetrics.com
(781) 805-5919

Association of Energy Engineers