Leveraging Your BMS to Identify Issues Before they are Issues

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

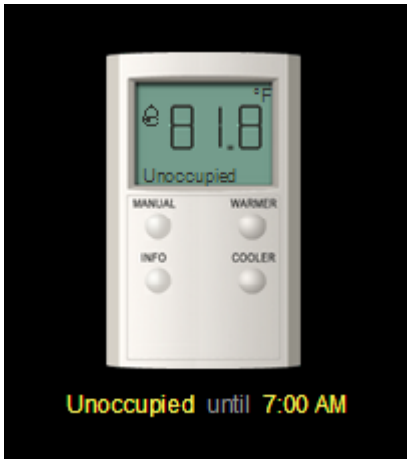
Objectives

- What are Analytics
- Types of Analytics
- What is FDD
- FDD Architecture

Traditional BAS | Two Sides of the Coin

BAS systems traditionally focus on two major objectives:

- Maintain environmental conditions
- Realize cost savings



BAS | Environmental Conditions

Many considerations beyond simple comfort

- Productivity
- Customer experience
- Quality
- Safety
- Health
- Liability

BAS | Cost Savings

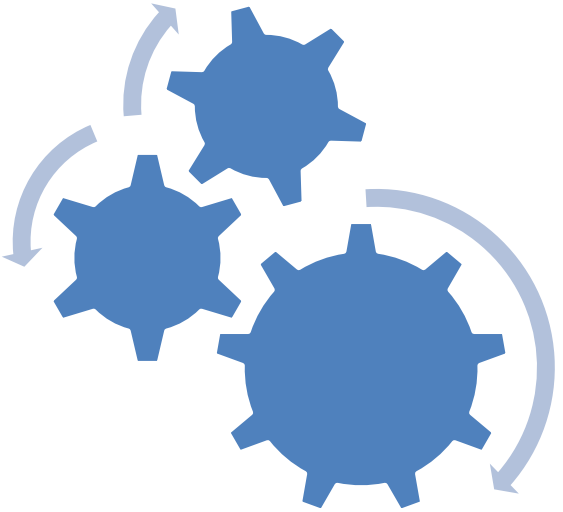
BAS cost savings strategies are numerous

- Demand shifting
- Demand limiting
- Chiller optimization
- Request based control
- Load shedding
- Scheduling
- Trim and respond (reset strategies)
- AFDDR

BAS Provides Data

A variety of factors are driving the development of more robust and sophisticated energy savings strategies, data gathering, data storage, and analytical tools.

- Rising energy costs
- Economic conditions
- Green initiatives
- Legislation
- Rebates and incentives – changing landscape

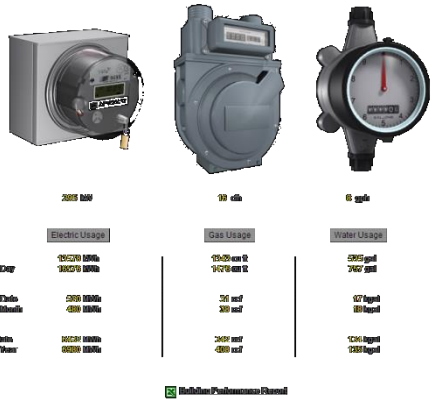


At the core of many of these strategies and tools is the ability to harvest and process data. As a result, data is becoming as valuable, if not more valuable, than other components of the BAS.

Data

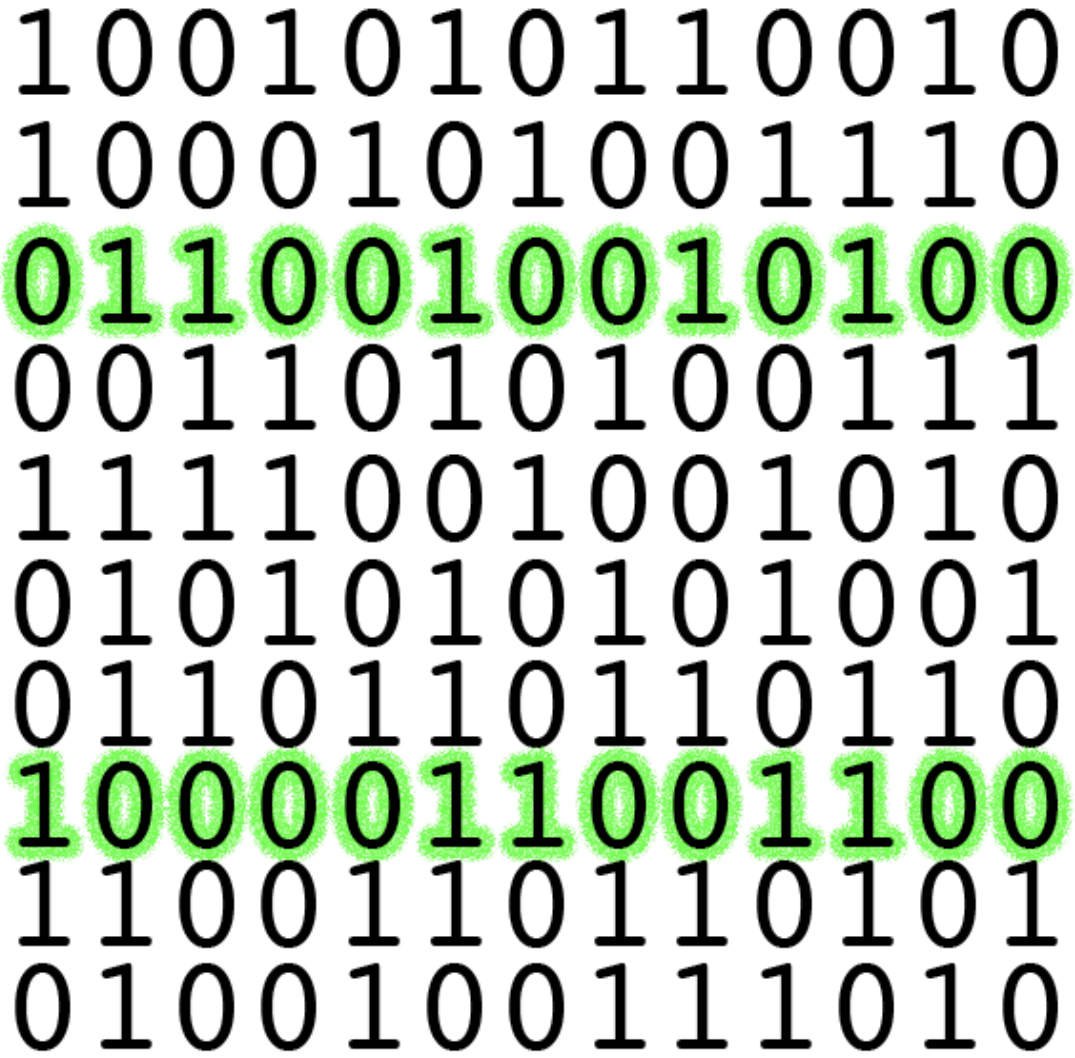
Data is expected to be collected from a variety of sources requiring integration and metering. Long term storage of lots and lots of data is the new norm.

Gathering Data



- Building level
- Sub meters
- Equipment level
- Legacy systems
- Storage capacity
- Common storage
- External database?
- Cloud storage/SAAS
- Enhanced data storage requirements

Data vs Information



What are Analytics?

- Webster
  - The method of logical analysis

- Wikipedia
  - The discovery, interpretation, and communication of meaningful patterns in data; and the process of applying those patterns towards effective decision making

What are Analytics?

- Finding patterns in existing data (temperature, humidity, fan status, damper position, etc)
- Information Contained in the BMS
- Turns Data/Information into Meaningful Insights to
  - Run Building More Efficiently
  - Create Better Environment for Occupants
  - Enhance Occupant Experience
- Often Favors Visualizations

Types of Analytics

- Built into BMS
  - Graphics
  - Trends
  - Alarms

- In The Cloud
  - Typically a Subscription Service
  - Can use Artificial Intelligence
  - Can use Engineers to Evaluate Data

Analytics and the BMS

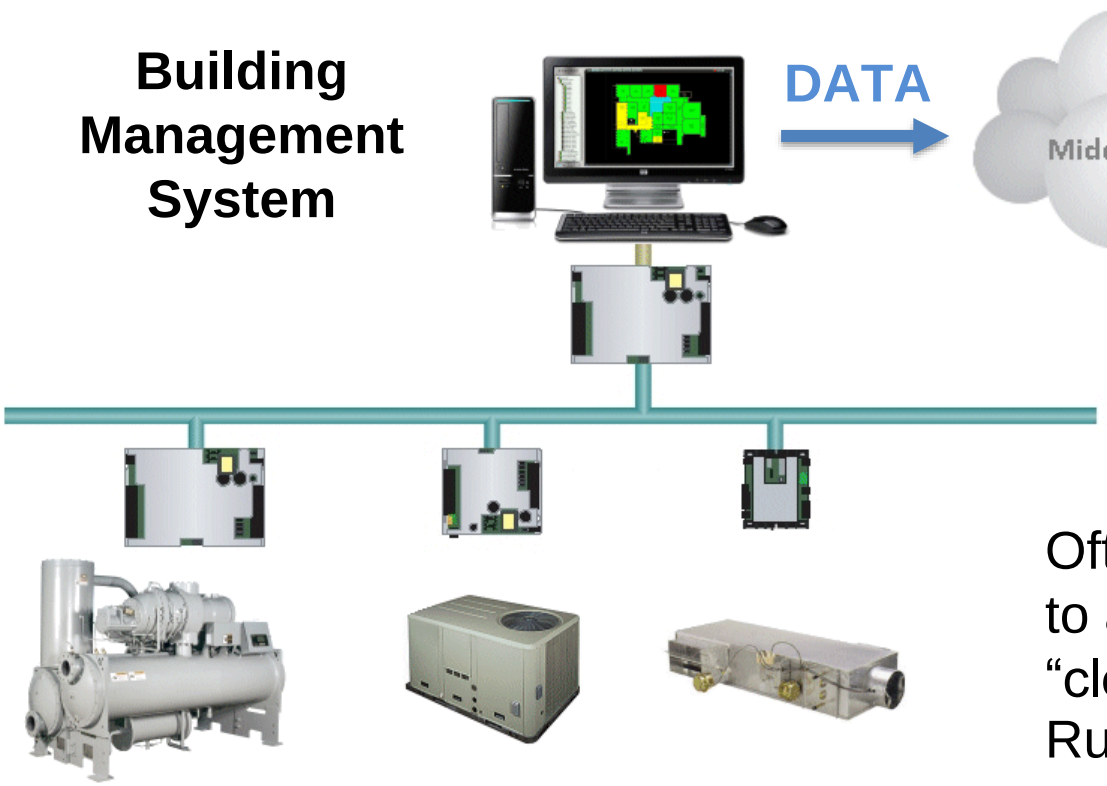
Data is gathered, stored historically, and then ran against a set of rules to hunt down potential operational and efficiency issues.

- Extremely capable
- Can run complex, system-wide rules
- Can mine historical data
- Can be very costly
- Data clean up is cumbersome
- Can be complex and difficult to set up and manage
- Often has subscription based pricing model
- Often looks for low hanging fruit that can be found with FDD

Analytics and the BMS

Trend data is gathered and stored in the BMS database.

Building Management System



DATA

DATA

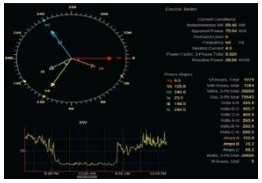
Analytics Software

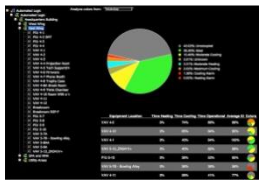
Often the data is migrated to a separate database and “cleaned up”.
Rules are applied to look for equipment issues, energy issues, and other undesirable conditions.

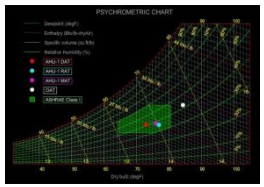
Analytics and Data Visualization

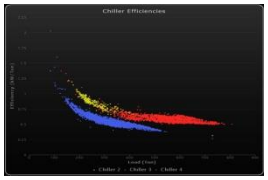
Industry focus evolving to include analytics and data visualization

- “Big Data”
- Analytics
- AFDDR
- Continuous commissioning
- Energy analysis
- Reporting
- New and disparate audiences
- Scalability, database, IT, security issues
- Integration









Data Visualization | Dashboarding

A tool for viewing and understanding real time data. “Eyeball Analytics”

Data Visualization

Data is expected to be processed and turned into information to be consumed by a variety of audiences; many which are not the traditional BAS operator...

Types of Visuals

- Dashboarding
- Energy reporting
- Financial reporting
- Energy analysis and auditing
- Green screening
- Facility management
- Enhanced data visualization requirements

Types of Audiences

- Facility Manager
- CFO/Treasurer
- Energy Auditor
- Technician
- Occupant
- Visitor
- New and disparate audience

Leveraging Analytics - Predictive Capabilities

- Monitors weather forecast
- Calculates future heating/cooling demand
- Uses data to predict opportunities for free-cooling
- Considers current indoor and outdoor conditions to determine whether building should be pre-cooled/pre-heated.

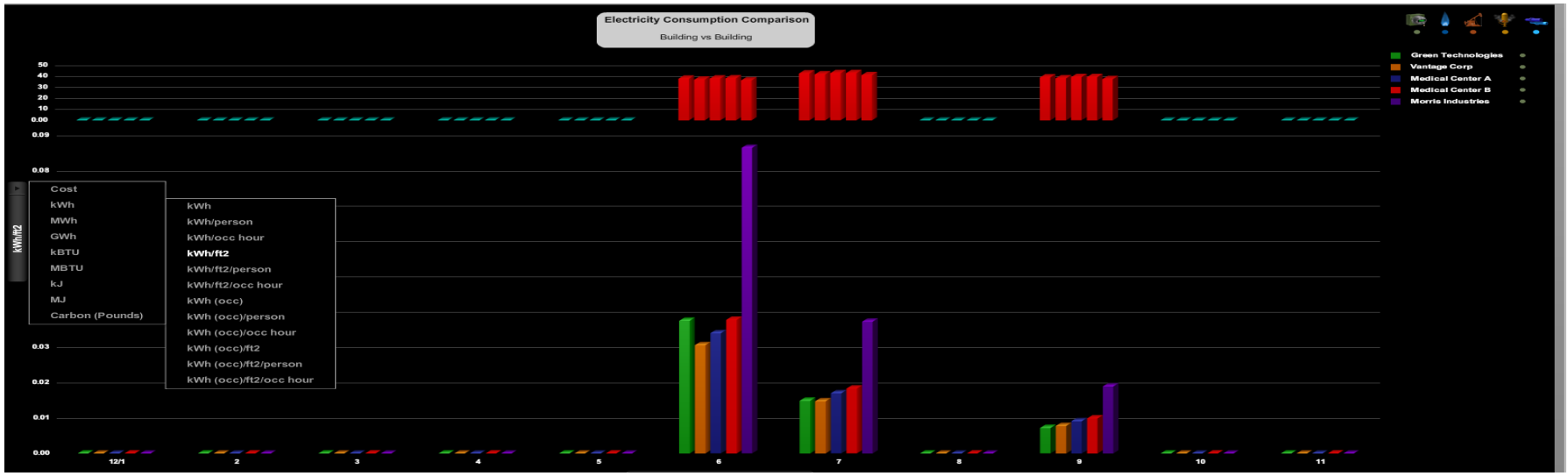
Predictive Capabilities

- Integrates to Weather Data
- Receives future heating/cooling demand
- Considers cost of active vs. passive pre-cool
- Demand Shedding
- Loosens set points to reduce electrical consumption
- Off-peak pre-cooling – Demand Shifting based on predictive Weather

Predictive Capabilities

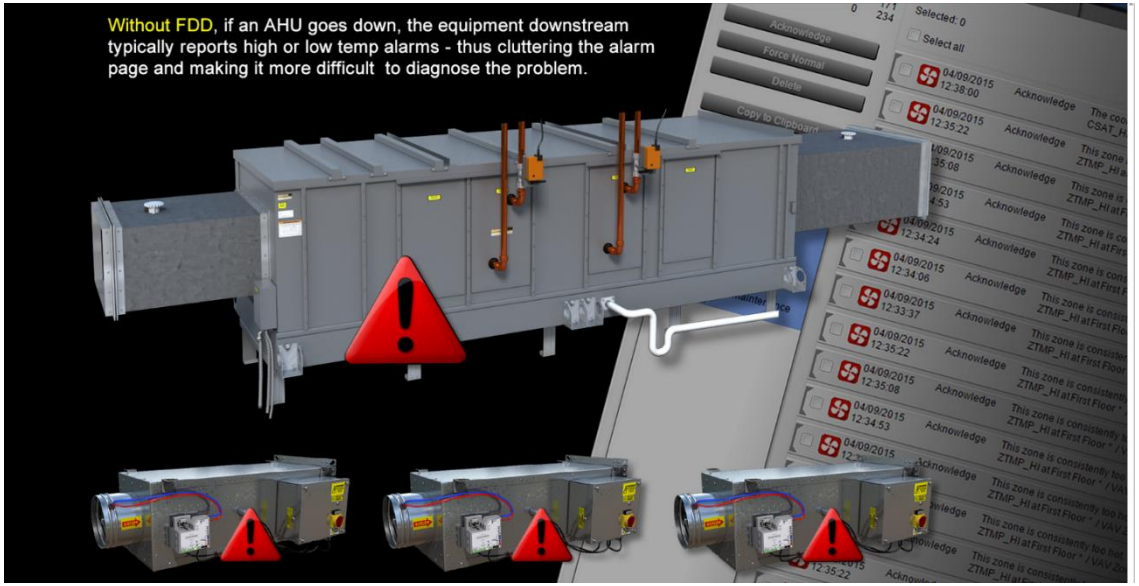
Analytic Takeaways

- Looking for Patterns in Data
- Visualize Data
- Know Audience Examining Data
- Use for Predictive Control

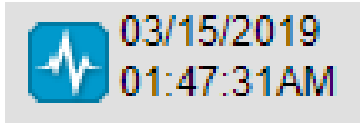


Fault Detection & Diagnostics (FDD)

- What is FDD?
- History and organizations involved to define and establish FDD guidelines
- Standards
- Architecture
- Types
- Platform
- Commissioning



Fault Detection & Diagnostics (FDD)



What is FDD?

FDD is defined as the measurement science that enables automatic detection and diagnosis of equipment faults, sensor failures, and control errors in the heating, ventilating, and air-conditioning (HVAC) systems of buildings.

- Defined as two parts:

Detection and Diagnostics

NIST National Institute of Standards and Technology U.S. Department of Commerce

Fault Detection & Diagnostics

- Detection

  Refers to the identification of a system deviation, or fault.

- Diagnostics

  Refers to the root cause of the detected fault.

FDD = Detection + Diagnostics

Fault Detection & Diagnostics

- **ASHRAE Published RP-1455** -- Advanced Control Sequences for HVAC Systems – Phase 1 Air Distribution and Terminal Systems

  ✓ “Best-in-class” high performance buildings

  ✓ Reduce cost, reduce errors

  ✓ CEC Title 24, ASHRAE 55, ASHRAE 62.1, ASHRAE 90.1

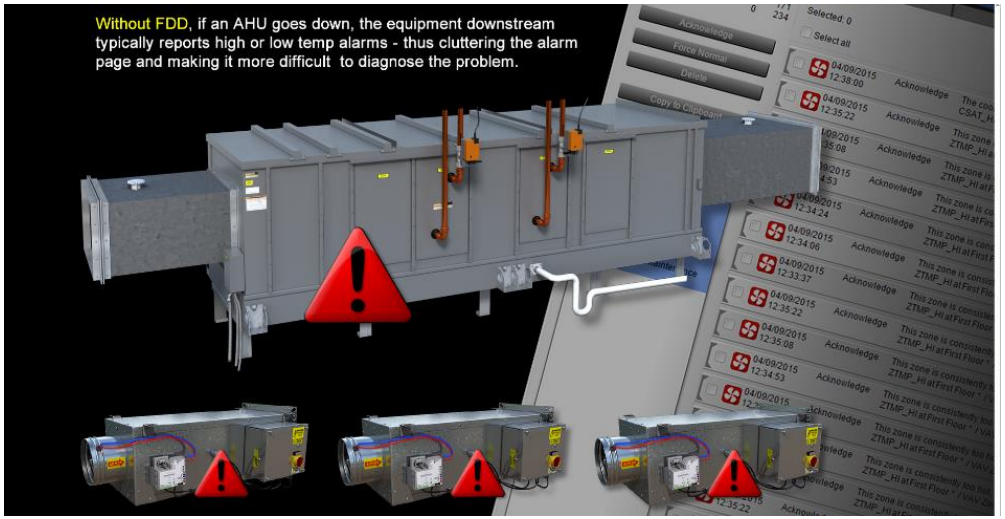
  ✓ Automated Fault Detection and Diagnostics

- **ASHRAE Guideline 36P** – High Performance Sequences of Operation for HVAC Systems

Fault Detection & Diagnostics

Examples of Airside FDD under ASHRAE Guideline 36P

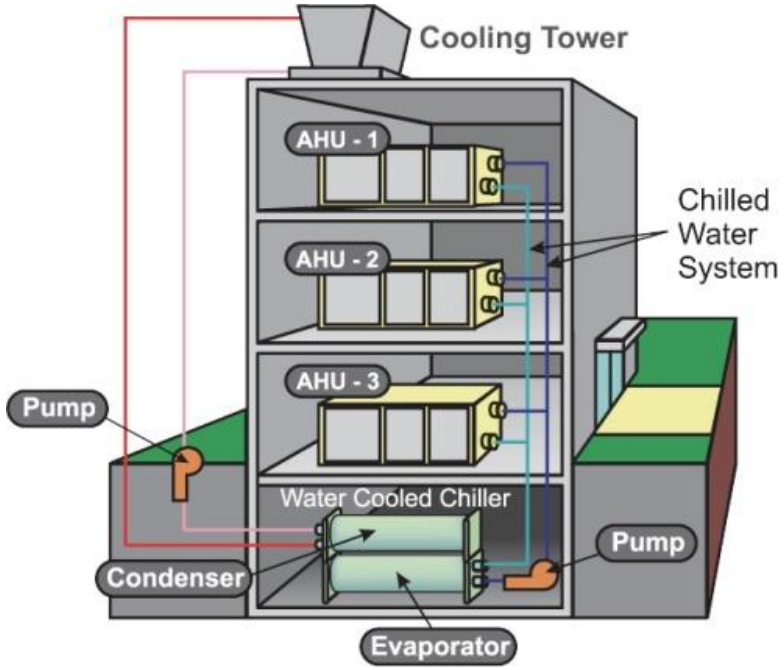
- VAV – Air Handling Unit
- VAV – Terminal Unit
- Single Zone Unit
- Fan Coil Unit
- Unit Ventilator
- Air Source Heat Pump
- Water Source Heat Pump



Fault Detection & Diagnostics

Examples of Waterside (Cold and Hot) FDD: ASHRAE RP-1711

- Differential pressure sensor error
- Water flow is too high
- Flow meter error
- Boiler cycling due to low load conditions
- Staging thresholds need to be adjusted



Fault Detection & Diagnostics

- NIST- Working to measure and improve the operational performance of commercial buildings by leveraging previously untapped capabilities within modern automation and control systems. This requires developing a measurement science that enables automatic detection and diagnosis of equipment faults, sensor failures, and control errors in the heating, ventilating, and air-conditioning (HVAC) systems of buildings. The resulting fault detection and diagnosis (FDD) software ("FDD tools") will utilize existing sensors and controller hardware, and will employ artificial intelligence, deductive modeling, and statistical methods to automatically detect and diagnose deviations between actual and optimal HVAC system performance.

Fault Detection & Diagnostics

National Institute of Standards and Technology
U.S. Department of Commerce

Objective - To improve the operating efficiency of commercial heating, ventilating, and air-conditioning (HVAC) systems by 10% to 30% through development and demonstration of the enabling measurement science for detecting faults and control errors in commercial HVAC equipment and systems, and transferring the measurement science to the private sector.

Spoiler Alert – FDD does not save $

IF…..

Fault Detection & Diagnostics

U.S. DEPARTMENT OF ENERGY

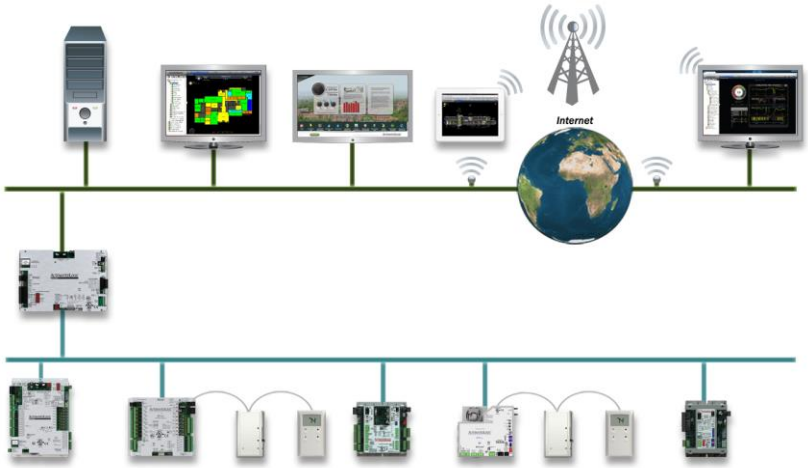
Automated Fault Detection and Diagnostics (AFDD)

National Renewable Energy Laboratory
Pacific Northwest National Laboratory
Oak Ridge National Laboratory
Industry Technical Advisory Group, 17 Orgs

Fault Detection & Diagnostics

FDD Seams like a “No Brainer”

- Why all of a sudden do I hear a lot about FDD?



- The need for standardization
- Semantic Tagging

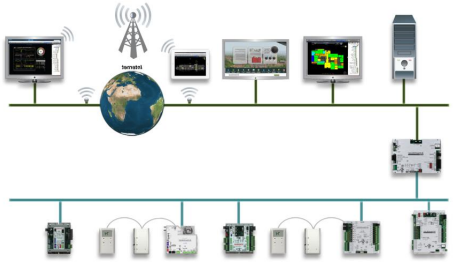
  ASHRAE Standard 223P

Fault Detection & Diagnostics

- Standard 223P - Designation and Classification of Semantic Tags for Building Data
- Open source initiative to streamline working with data from the Internet of Things. Standardizes semantic data models and web services for smart devices
- Open-source, BSD-licensed development effort to create a uniform schema for representing metadata in buildings.

FDD Architecture

BAS:



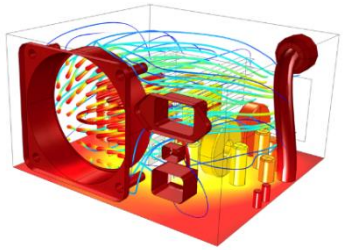
Cloud:

IoT:

Types of FDD (Analytics)

Physics Based Modeling (Cloud):

- Statistical regression analysis approach
- Engineering models, efficiency curves



Trending (Cloud):

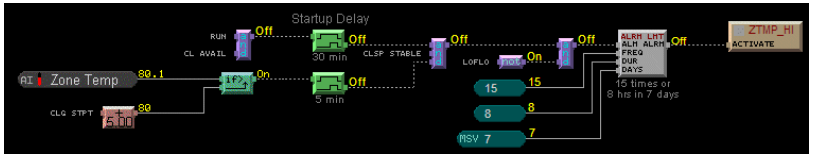
Compare trend signatures to known fault signatures

Rule Based (Local):

Built right into your BAS

Hybrids (Cloud):

Combination of the above



Important Aspects of an FDD Platform

Analytics:

Rule based, trending, modeling, hybrids

Reporting

- Daily, weekly reports, summary reports
- Shows faults

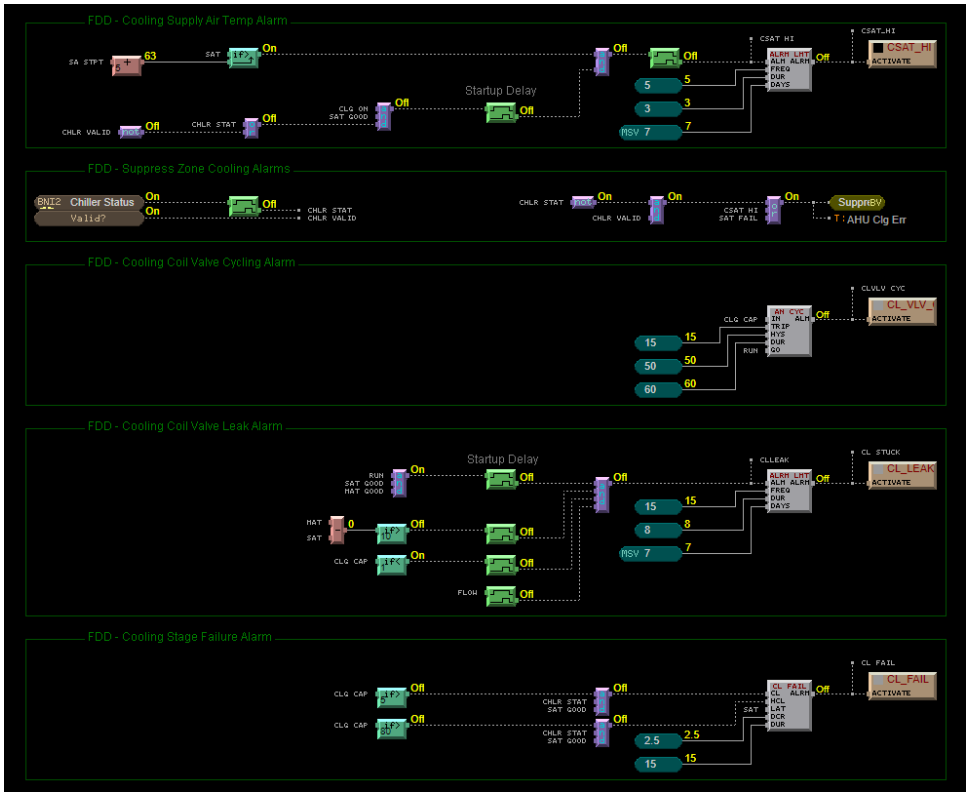
Alarms:

Directs the workflow to the root cause or fault

Visualizations:

Dashboards, a quick way to see what is going on at any moment

FDD Example


FDD - Cooling Supply Air Temp Alarm
SA STPT
63
SAT
On
Off
Startup Delay
CHLR VALID
CHLR STAT
CLG ON
SAT GOOD
CSAT HI
ALM LMT
ALM ALRM
FREQ
DUR
DAYS
ACTIVATE
5
3
MSV 7
FDD - Suppress Zone Cooling Alarms
Chiller Status
Valid?
SupprBV
AHU Clg Err
SAT FAIL
FDD - Cooling Coil Valve Cycling Alarm
CLVLV CYC
CLG CAP
RUN
15
50
60
FDD - Cooling Coil Valve Leak Alarm
CLLEAK
CL STUCK
CL_LEAK
RUN
SAT GOOD
MAT GOOD
MAT
SAT
FLOW
8
FDD - Cooling Stage Failure Alarm
CL FAIL
CL_FAIL
CL ALRM
HCL
LAT
DCR
2.5

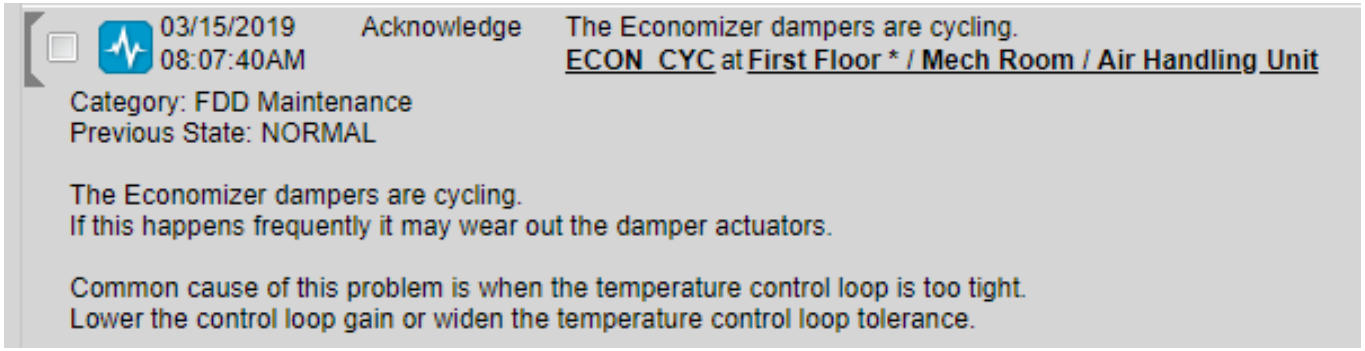
FDD Reporting Example

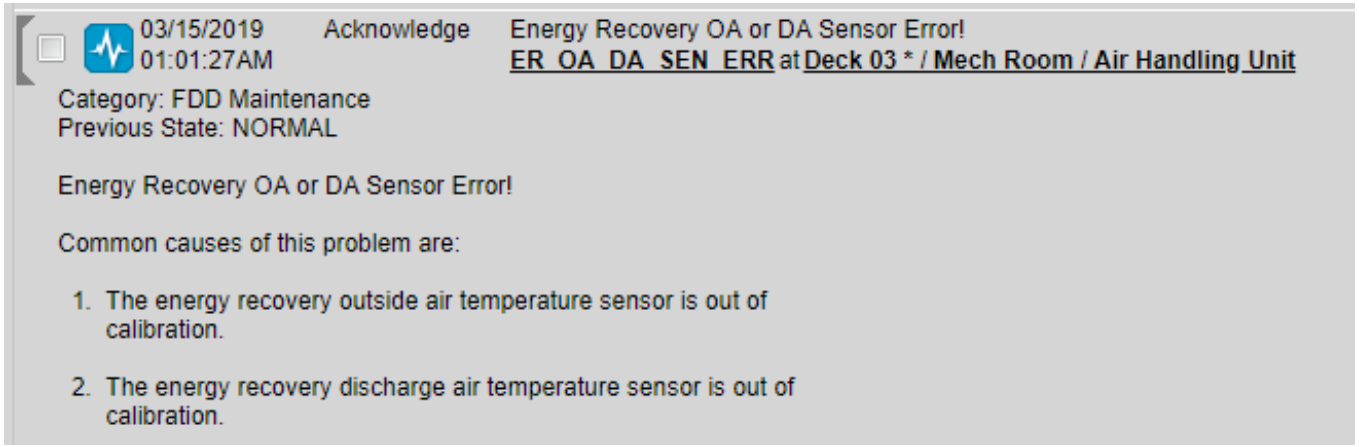
Categories Applied:

FDD Critical, FDD General, FDD Maintenance

	Location	Equipment	Issue	Mon 01/22/18	Tue 01/23/18	Wed 01/24/18	Thu 01/25/18	Fri 01/26/18	Sat 01/27/18	Sun 01/28/18	Description	Category
1	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 1	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
2	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 2	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
3	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 3	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
4	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 4	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
5	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 5	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
6	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 6	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
7	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 7	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
8	Highlight Projects / UTC CIB / 1st Level / HVAC	VAV 8	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
9	Highlight Projects / UTC CIB / 1st Level / HVAC	Chillbeam	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
10	MultiSite / Communications / State / City / Station	Split System 2	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical
11	Green Hospital / Basement / HVAC	Maintenance Room	ZTMP_FAIL	0	0	0	1	1	0	0	The Zone Air Temp sensor has failed.	FDD Critical

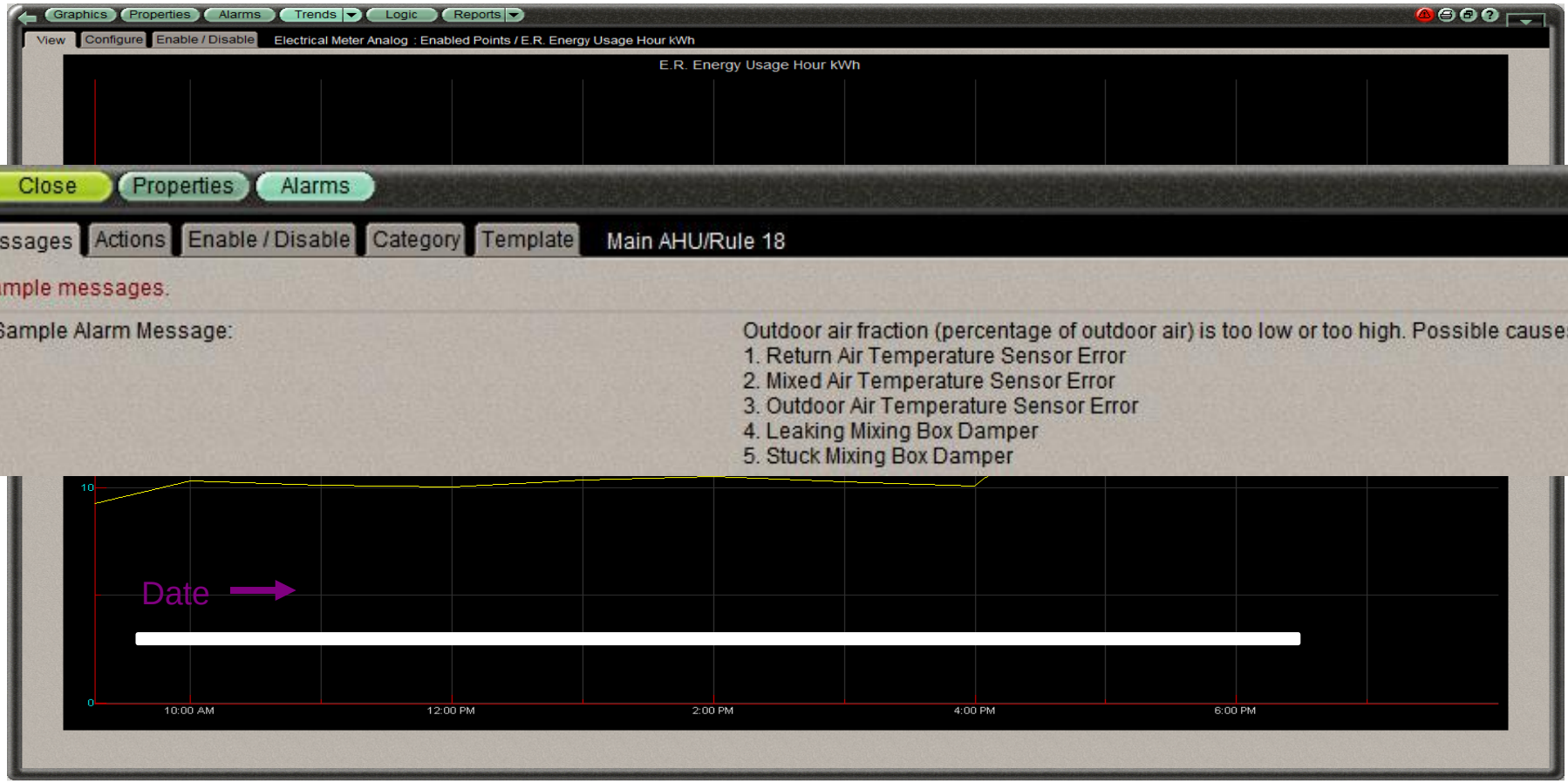
FDD Alarming Example





Fault Detection

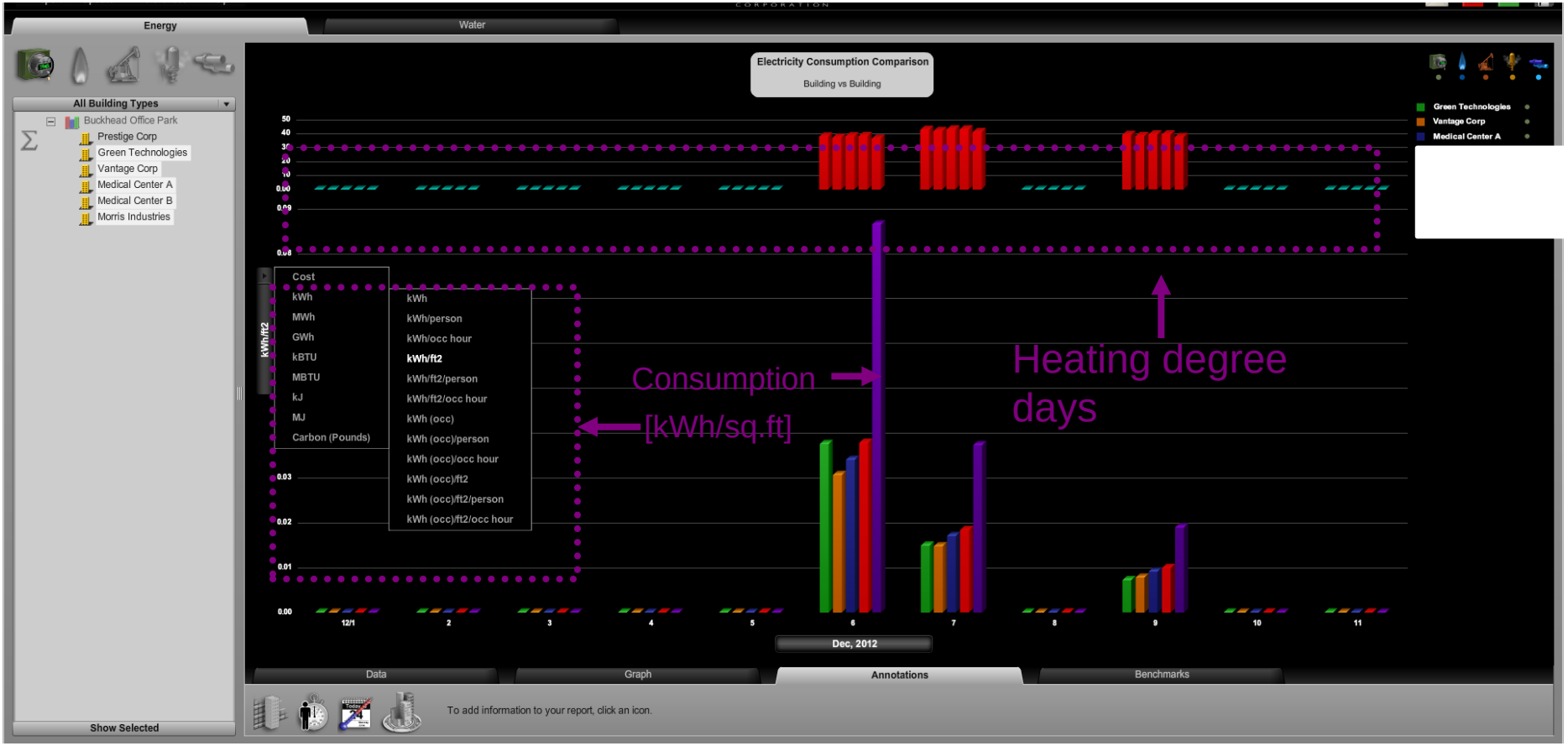
Proactively notify and suggested Diagnosis



FDD Visualization

Fault Detection

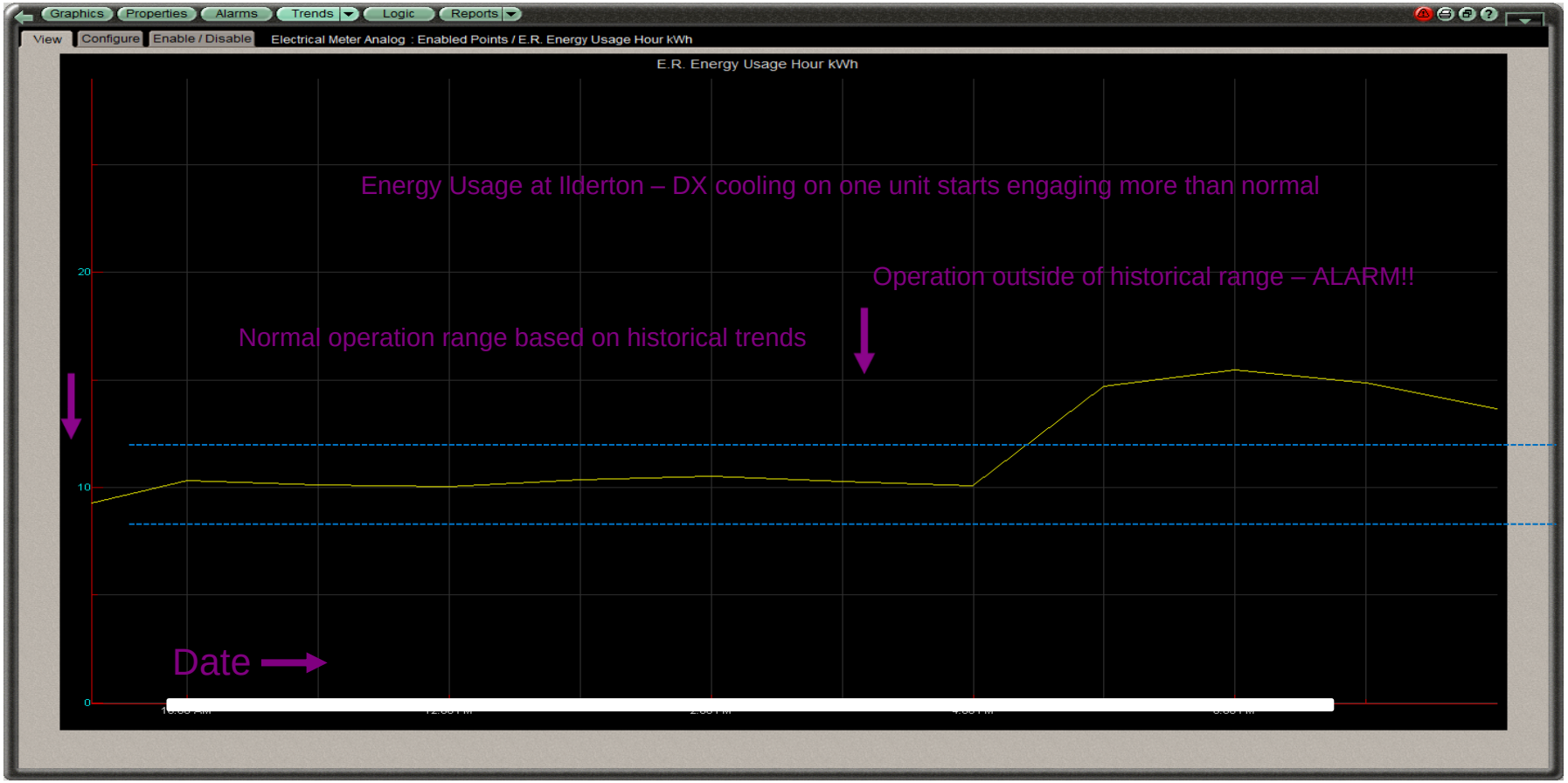
Eliminate Energy Hogs



ENERGYREPORTS

Fault Detection

Identify out of Performance Assessment Rule Equipment



Ongoing Commissioning

Works similarly to FDD but is not FDD:

- A software based commissioning tool that uses rule sets or models to commission or re-commission (retro-commission) a building.
- Runs the building equipment through its paces at a set time usually during unoccupied states. Can be run daily, weekly, monthly, yearly, etc.
- Usually more thorough than a commissioning agent.
- Can save time and money.

Works well in conjunction with FDD:

- Once a commissioning baseline is established, FDD is always running to maintain the baseline. If FDD alarms are growing, it may be time to run an ongoing commissioning software tool.

FDD Takeaways

Standardize:

- Use semantic tagging when designing a building automation system.

Reporting and Visualizations:

- Need the ability to easily identify, categorize, and document faults.

Workflow:

- Establish a routine to regularly check reports. This can be a building engineer, controls or mechanical service provider that can identify and fix issues.

Commissioning/ Ongoing Commissioning:

- A good time to implement FDD is after commissioning or part of an ongoing commissioning plan.

Key Takeaways

- We often see customers not realizing full potential of a BMS
- Lots of opportunity in existing capability
- Data is critical
- Use Data to Drive Insights
- Analytics and FDD are Critical for Insights

Wrap Up

Questions?
Feedback?