AABC Commissioning Group

AIA Provider Number 50111116

FDD Software to Support Monitoring-based Commissioning & Building Optimization

Course Number: CXENERGY1929

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CopperTree Analytics

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CONTINUING EDUCATION AIA

Course Description

This session explores how advanced energy and building analytics software unlocks the power of BAS data to enable monitoring-based commissioning, giving owners and energy managers the insights to improve energy efficiency, occupant comfort, and equipment longevity. An overview of Fault Detection & Diagnostics (FDD) tools will be presented. These advanced tools allow users to leverage BAS data to automatically and continuously identify energy saving measures.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand how Fault Detection & Diagnostics (FDD) can leverage building data to identify deficiencies and specific energy efficiency measures.
2. Apply key performance indicators (KPIs) to assess performance of building systems and indoor air quality
3. Utilize virtual metering to identify deficiencies and perform M&V to measure achieved savings in building systems.
4. Integrate FDD into an ongoing commissioning program

Fault Detection and Diagnostics (FDD)

What is it?

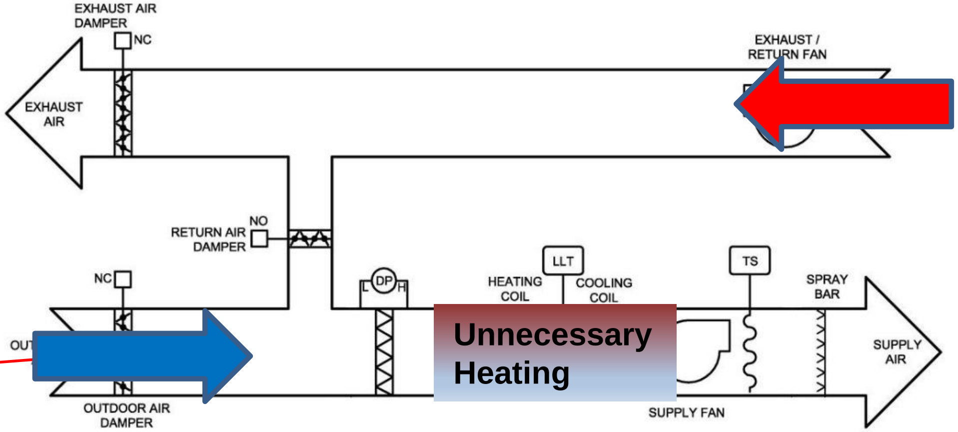
- Logic “Rules” that execute against trended building data or sets of trended building data:
  - To find patterns
  - To find anomalies
- Allow the user to answer to any user defined question
- Community Library of Rules
- Automated

AHU Fault – Leaking Damper

Fault:

Outside Air Damper is Leaking
(mechanical system fault)

- Should be re-circulating pre-conditioned air
- No BAS alarms are triggering
- Occupants do not complain: Zones at setpoint
- Operator believes everything is working great
- Energy Waste Built Into Energy Baseline



Leaking
Damper!

~$7,000+/year!

AHU Fault – Leaking Damper Rule

Insight Notification Triggers Only When All Parameters TRUE:

- Outside Air Damper says it is **closed (0%)**
- Mixed Air & Return Air Temperature Sensor **Delta T > 2 degrees**
- These conditions have all been true for **> 6 total occupied hours in a week.**

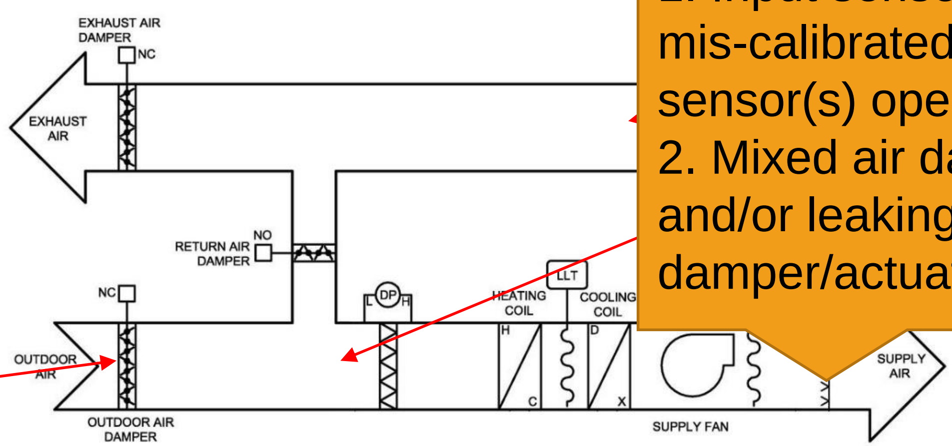
Once per week this data is analyzed and fault results (if any) sent to interested parties.

elta T >

egrees?

1. Input sensor(s) faulty or mis-calibrated. Verify input sensor(s) operation.
2. Mixed air damper stuck and/or leaking. Verify damper/actuator operation.

Damper Closed?



Common Types of Faults

- Systems running outside intended schedule
- Manual overrides
- Incorrect sequencing – not per spec
- Inefficient Sequencing
- Heating/Cooling simultaneously
- Valves & dampers leaking, hunting & PID tuning issues
- Temperature/Comfort issues in zones (temp/airflow/CO2)

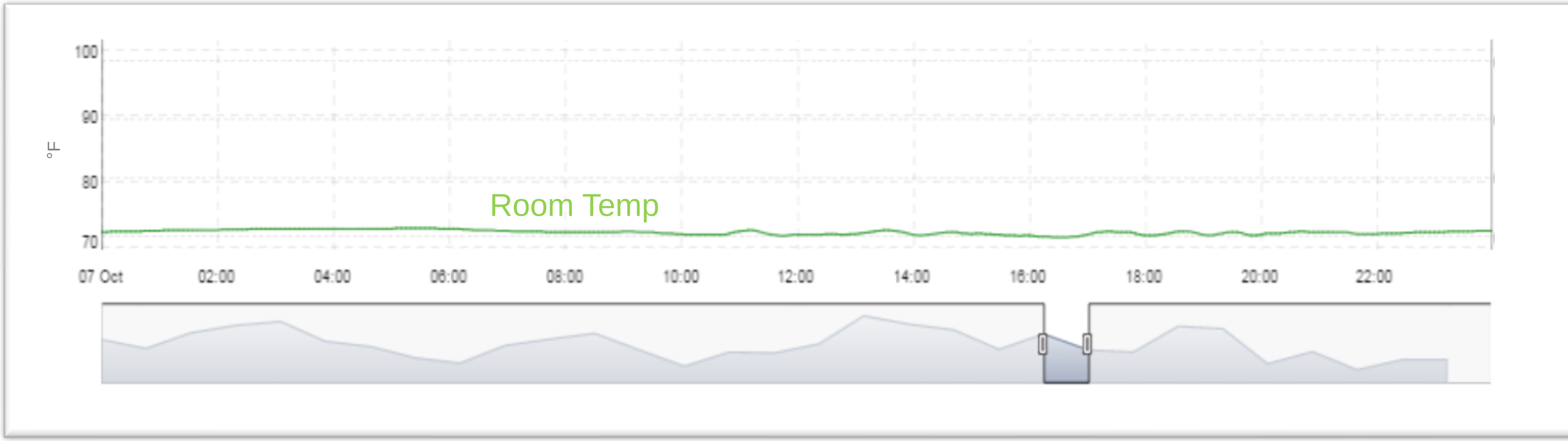
Case Study #1

University Medical Education Building

- Year Built: 2001
- Boiler & Plant Upgrades 2 Years Ago
- 72,000 Square Feet of:
  - Medical Classrooms
  - Meeting rooms
  - Administrative offices
  - Medical library

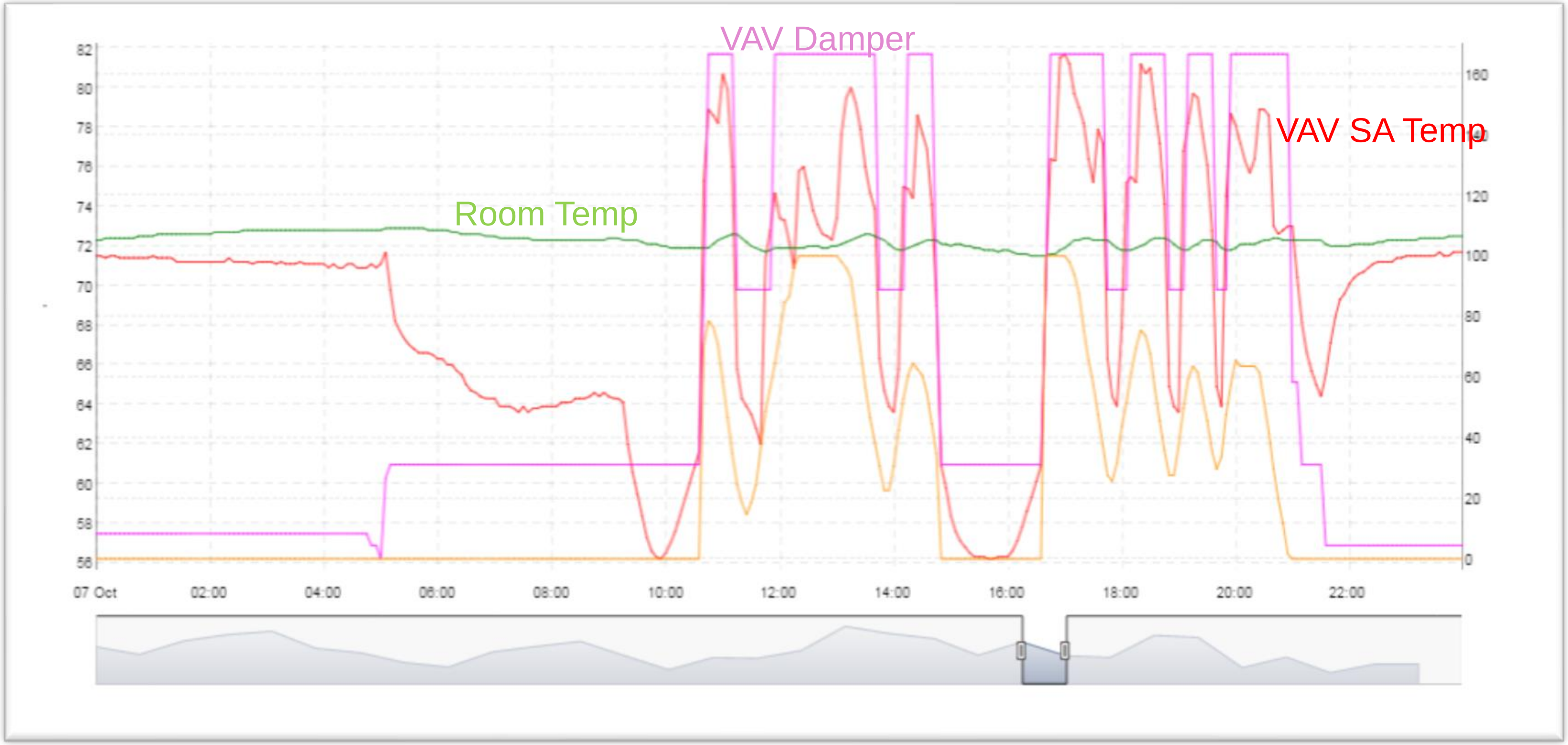
The Building Operator's Perspective

Room Temperature Avg. 15 Minute Trend



- BAS is not generating alarms - Avg. temps are within range
- Many occupant temperature complaints despite trend above
- No evidence there's anything wrong with the room temperatures or underlying mechanical equipment

Zone System Mechanical Analysis



- VAV dampers are actuating and hunting wildly
- VAV hot water valves are hunting wildly
- Tremendous wear and tear on these systems!

Root Cause: Boiler Sequence Analysis

- Boilers designed to be “lead/lag” sequenced
- Boiler control sequence analysis shows that is not the case: both are turning on and off together, overshooting HWS setpoints, then shutting off

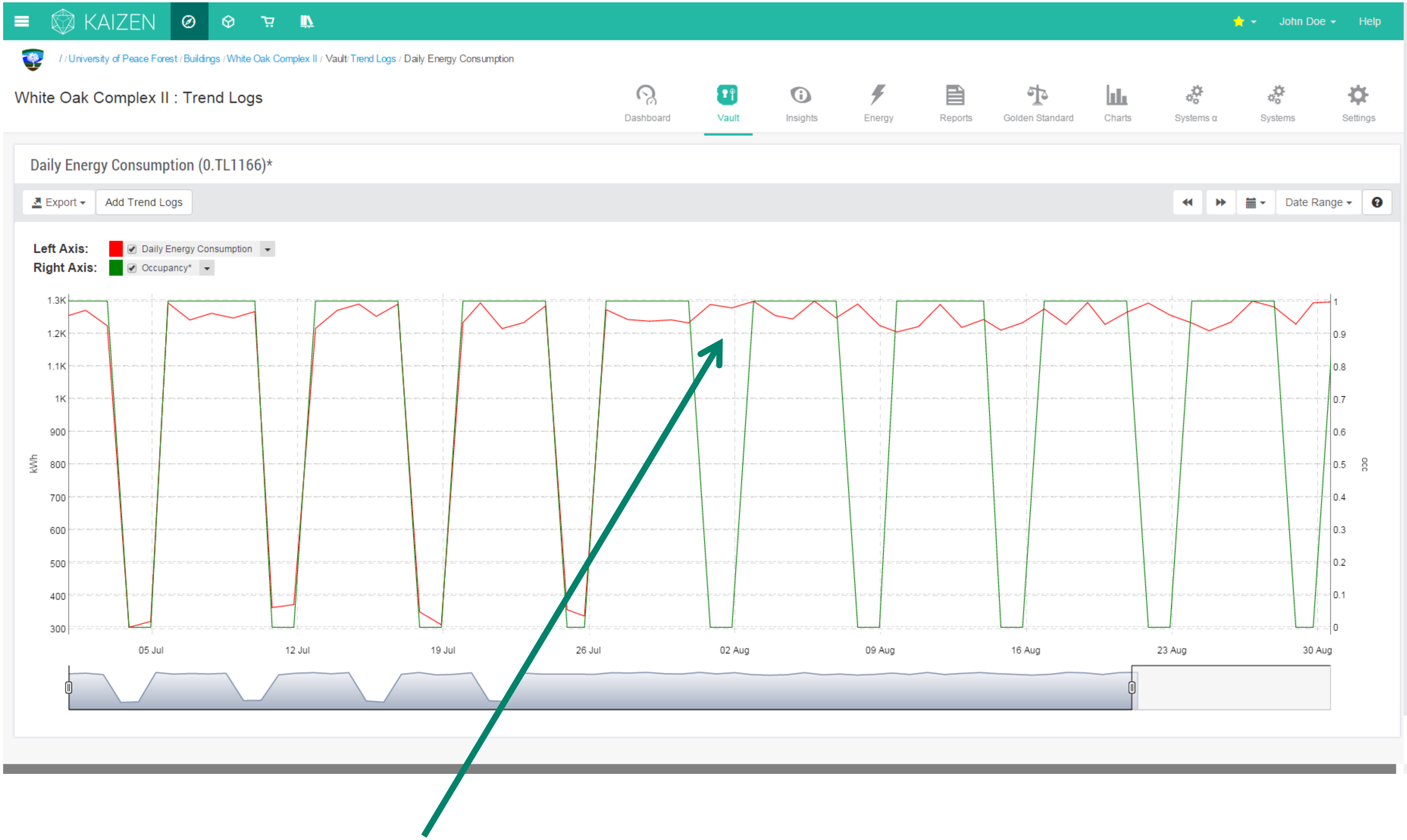
Analytics Results: This Building

- Not having to replace the boilers prematurely
  - **$40,000 estimated**
  - + reduced maintenance on the boiler system
  - + reduced wear and maintenance on 86 VAV boxes
- Stopping wasted heat in VAVs
  - **$12,000/year**
- Improved boiler plant efficiency
- Increased occupant comfort – Hard to quantify but very important!

Ongoing Commissioning Using Kaizen Golden Standard

- Baseline of BAS configuration
- Daily ‘snapshots’ of BACnet objects and all properties
- Differences are flagged as “insights” and logged
- High priority insights can be emailed immediately
- “Good changes” / intended changes can be promoted
- Daily or weekly Golden Standard “digests” – report showing all changes

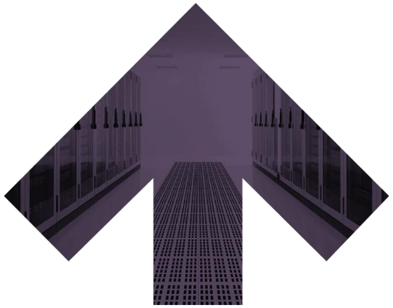
What can ongoing commissioning prevent?



Case Study #2

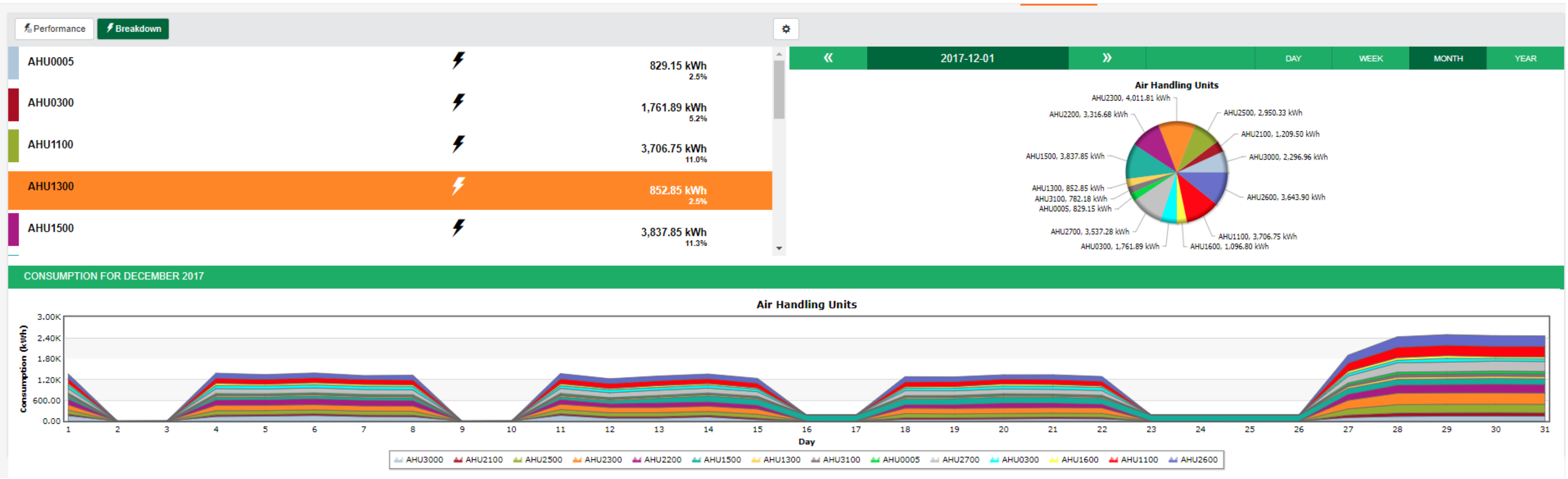
Ongoing Commissioning ROI:

- Helicopter pad snow melting system was switched to manual and left on during the summer
- Time left on: 2 months = 1440 hours
- Demand: $3,917
- Consumption: $13,778



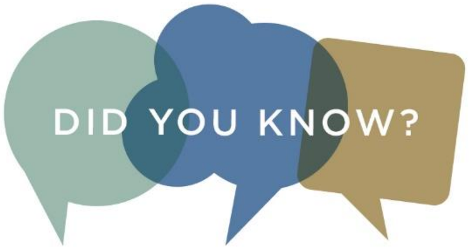
- **Cost that Should Have Been Avoided: $17,695**

Virtual Metering



Virtual Metering

- Energy meters created from existing sensor data
- Pinpoint energy issues
- Meter every single piece of equipment or zone!
- Baseline everything!



Example Formulas:

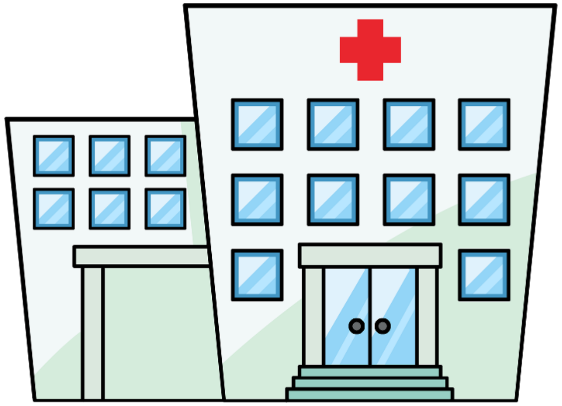
Virtual BTU Meter for Airside System:
BTU/hr = Fan Volume *1.08 * (SAT-(MAT+ Fan Temp Gain))

Pump Affinity Energy Calculations
kWh = Motor Size [kW=hp/1.34102] /pf * (Speed/100)^3 * Runtime

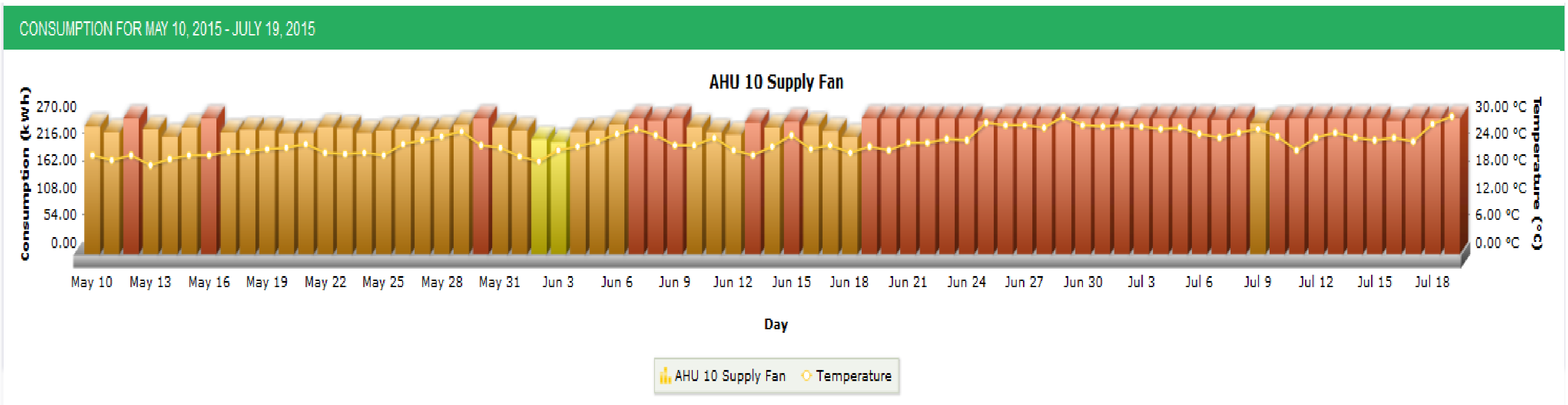
Case Study #3

Publicly Funded Hospital

- Location: British Columbia, Canada
- Year Built: 1980
- Boiler & BAS Upgrades 2 Years Ago



The Energy Manager's Perspective



- The energy has increased after Jun 18th
- No occupant complaints. Operators unaware
- Discovered using Virtual Energy Meters and FDD Insights

Automated Zone System FDD Analysis

Fault Detection and Diagnostics (FDD)

Insight messages crated by the rule:

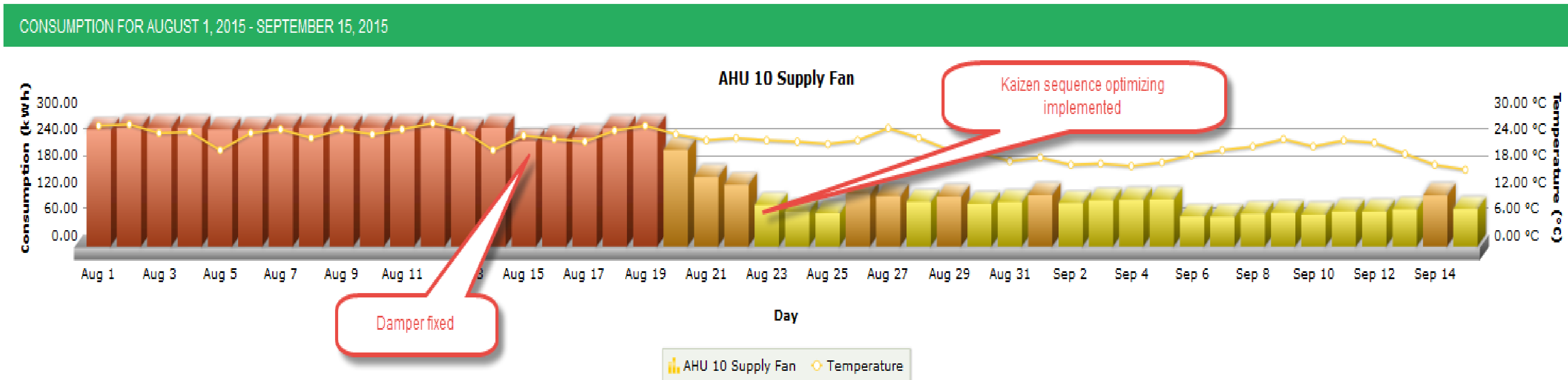
Description	Weekday	Occurred
VAV_10_1 Damper is fully open for more than 12 hours per week.	Mon	Jun 29, 2015 12:00 am
VAV_10_1 Damper is fully open for more than 12 hours per week.	Mon	Jun 22, 2015 12:00 am

- Analytics reported insights related to AHU subsystems
- VAV dampers are open for atypical amounts of time
- FDD rules for this were reporting the condition

Automated Main System FDD Analysis

- AHU Damper command trend log capture indicates transition change
- Also coincides with energy increase and VAV damper saturation (started same day)

Results Driven by FDD Analysis



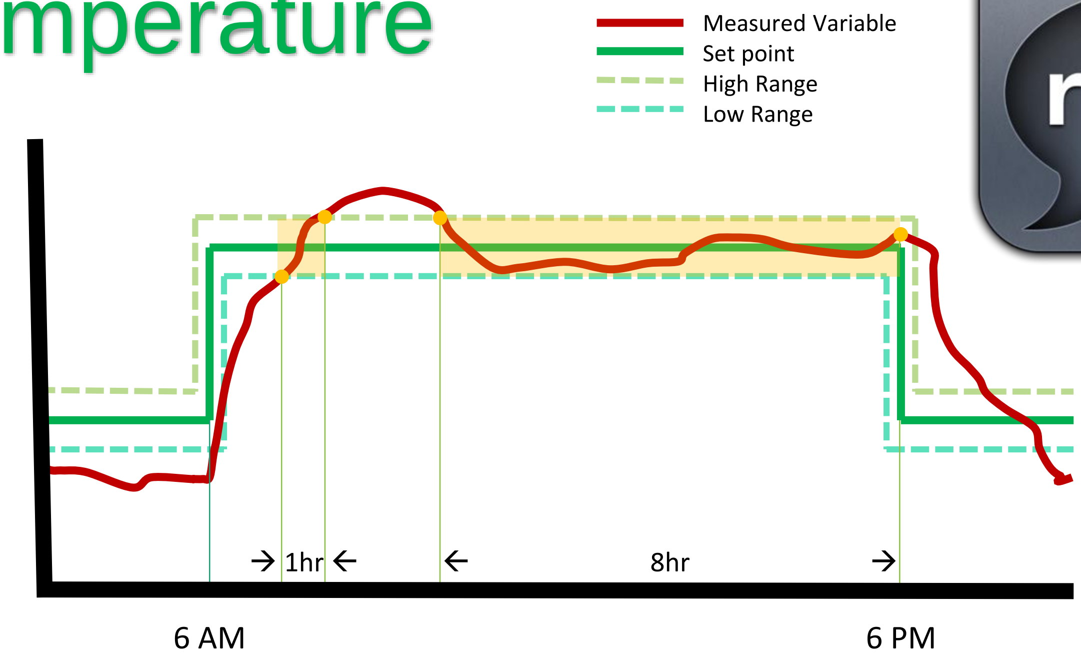
- Identified issues used to direct action at the site
- Dampers fixed (electrical power issue)
- Analytics recommended sequence changes implemented
- Estimated savings $20,500 yearly for this problem alone
- Savings measured (M&V) for ongoing reporting & ROI calculation

Analytics Key Performance Indicators (KPIs)

- Analytics which provide KPIs to measure performance
- Compare multiple systems or buildings to each other and find best and worst performers
- Prioritize Maintenance & Repair

A KPI “Rule” Explained for 1 Zone/System

75% Temperature KPI



Target: KPI of 100 - *A KPI of 100 means that the measured variable has been within normal operating range during the occupied period.*

This Example - Total time within range: 9 hours (1 hour + 8 hours)
KPI = 9 hours / 12 hours = 0.75 = **75%**

Case Study #1 Continued

University Medical Education Building

- Location: Southwestern USA
- Year Built: 2001
- Boiler & Plant Upgrades 2 Years Ago
- 72,000 Square Feet of:
  - Medical classrooms
  - Meeting rooms
  - Administrative offices
  - Medical library

KPIs in This Building: Temperature

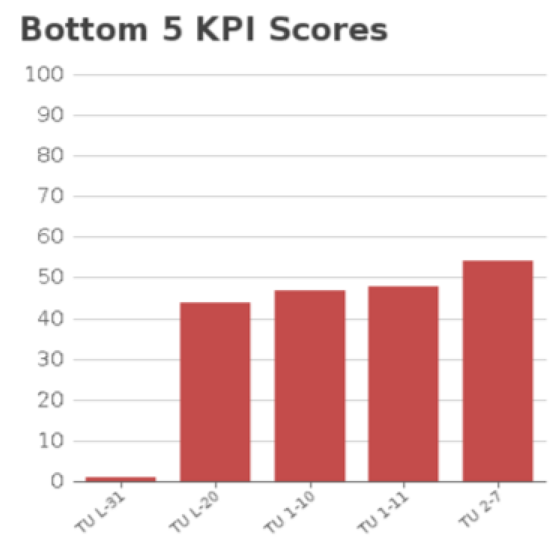
Zone Temperature Performance

770,000

Data points

KPI: 85%

Analysis showed 85% of zones maintained zone temperature within desired deadband (setpoint +/- 1.5 degrees F) during occupied hours



System	KPI
TU L-31	1
TU L-20	44
TU 1-10	47
TU 1-11	48
TU 2-7	54

KPIs in This Building: Airflow

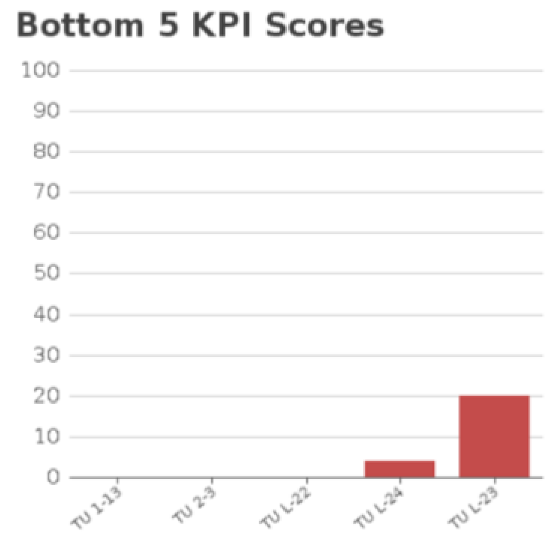
Zone Airflow Performance

770,000

Data points

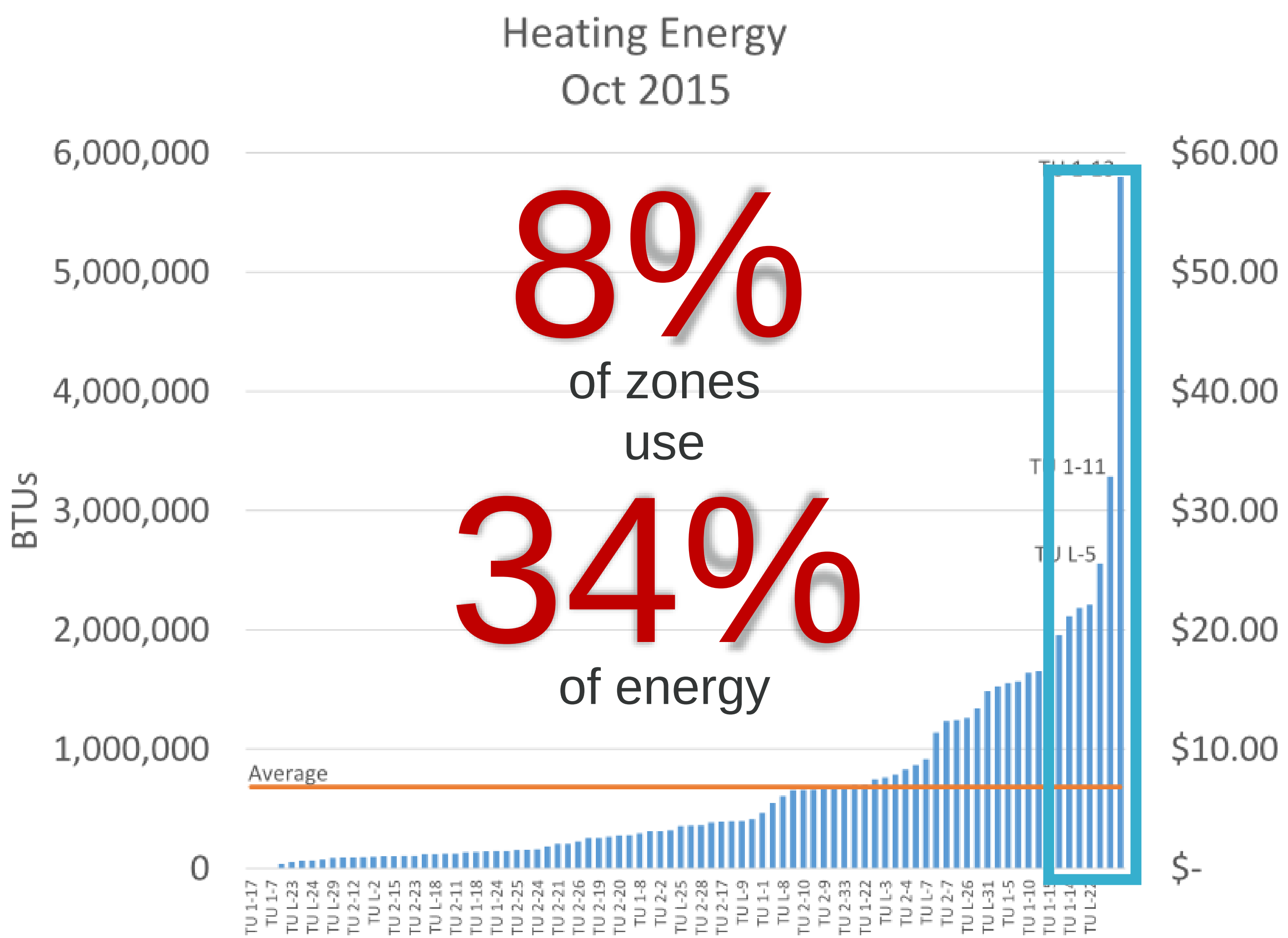
KPI: 45%

Analysis showed 45% of zones maintained airflow within desired deadband (setpoint +/- 8%) during occupied hours



System	KPI
TU 1-13	0
TU 2-3	0
TU L-22	0
TU L-24	4
TU L-23	20

VAV Reheat Energy KPI



8%

of zones use

34%

of energy

Findings Worst Performers Quickly & Easily

Temperature KPI	
TU L-31	1
TU L-20	44
TU 1-10	47
TU 1-11	48
TU 2-7	54
TU 1-3	56
TU 1-2	70
TU L-7	71
TU 1-4	74
TU 1-5	77
TU 1-6	78
TU 2-29	79
TU 2-32	80
TU L-8	80
TU L-25	82
TU 1-16	84
TU 1-9	84
TU 2-27	86
TU 2-21	88
TU 1-12	89
TU L-28	90
TU L-26	95
TU L-27	95
TU 2-24	96
TU 2-30	96
TU 1-13	97

Reheat Energy	
TU 1-13	2,988,971
TU L-5	1,823,936
TU L-6	1,615,534
TU 1-15	1,140,873
TU 1-14	1,127,586
TU 1-11	977,038
TU 2-27	790,242
TU 1-10	688,504
TU L-31	687,599
TU L-28	618,168
TU L-13	593,248
TU 1-12	585,086
TU 2-30	580,148
TU 2-29	541,903
TU L-22	538,241
TU L-26	537,037
TU 1-2	528,713
TU 1-5	504,830
TU L-7	472,769
TU 2-32	464,877
TU 1-22	450,989
TU 2-7	428,750
TU 1-4	422,306
TU 1-1	388,135
TU 2-33	387,041
TU L-20	334,175

Airflow KPI	
TU 1-13	0
TU 2-3	0
TU L-22	0
TU L-24	4
TU L-23	20
TU L-18	36
TU 2-34	42
TU L-29	50
TU 2-7	52
TU 1-21	53
TU 1-5	54
TU L-6	64
TU 2-33	68
TU L-21	68
TU 2-24	70
TU 2-31	70
TU L-31	70
TU 2-22	71
TU 2-23	71
TU 2-27	71
TU 2-28	71
TU 2-29	71
TU 2-30	71
TU 2-32	71
TU 1-23	72
TU 1-8	72

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Zones (of 86) score poorly on multiple lists

Ongoing Workflow

Model Building,
Find Issues

Meter Everything,
Apply **FDD**

Sample of a Good Process

1. Identify & Plan Which Data to Collect
2. Set Up Infrastructure/Resources for Action
3. Collect & Aggregate/Store Data
4. Analyze Data Based on Goals/Needs
5. Prioritize Actions – Based on Goals/Needs
6. Take Action to Address
7. Track & Report Results – Comparative Analysis
8. Praise Successes & Identify/Address Shortcomings
9. Re-Invest Savings
10. Repeat!

This concludes The American Institute of Architects Continuing Education Systems Course

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