Your Buildings are Trying to Talk to You...
But how can you hear through all the noise?

Service Leadership Through Building Analytics: Converting data into useful information & sustainable infrastructure

RM APPA – Denver September 26, 2018

University of Saskatchewan

CopperTree Analytics

MC Energy & Environment

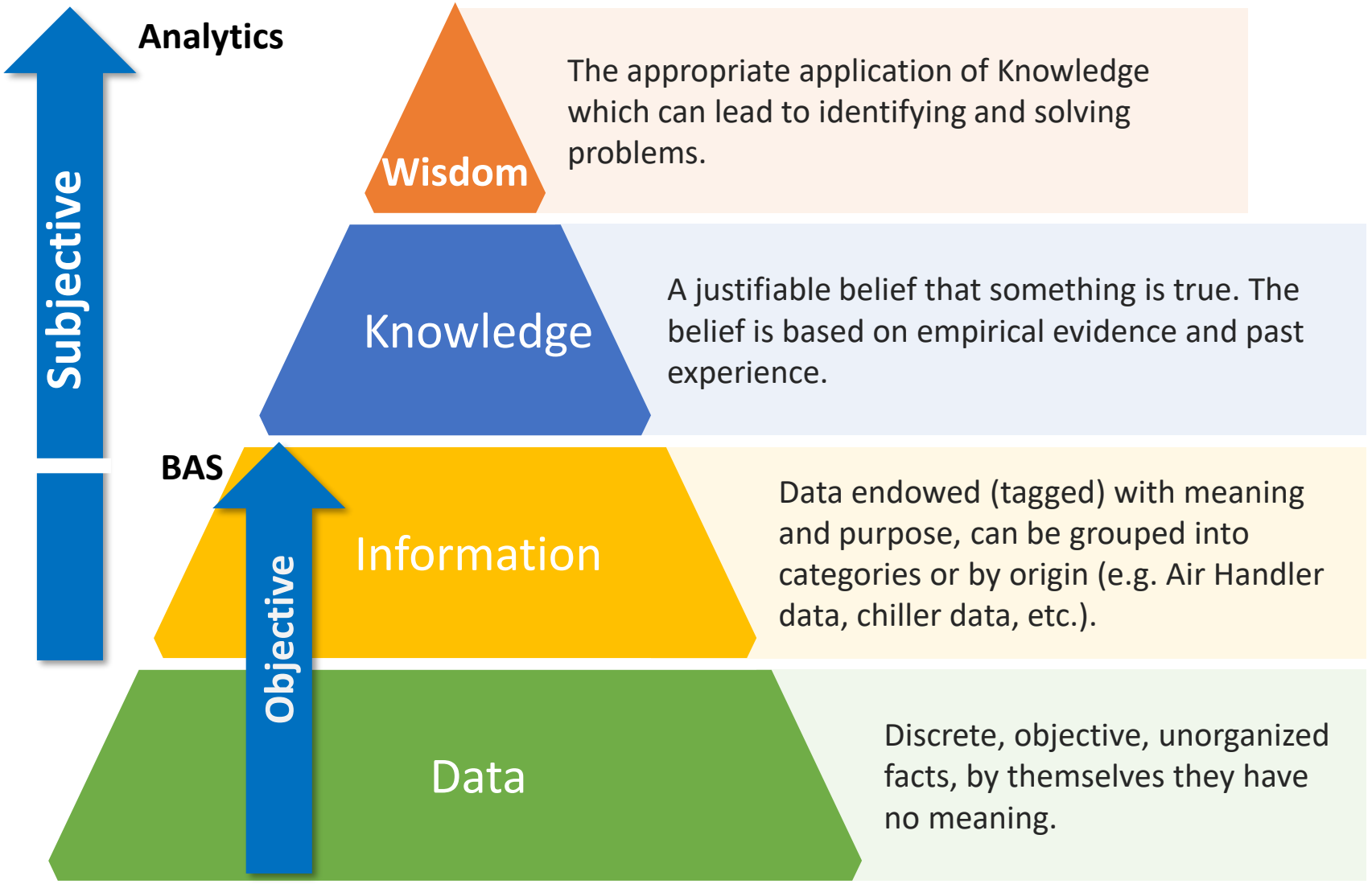
Introduction & Agenda

- **Understanding Building Analytics – Converting Data to Useful Information:** Sunny Sandhu, CopperTree Analytics

- **Servant Leadership Through Advanced Analytics & Fault Detection:** Chris Davies, University of Saskatchewan

- **Building Analytics: Sustainable Infrastructure & Keys to Success:** David Naccarato, UMC Energy & Environment

Understanding Analytics



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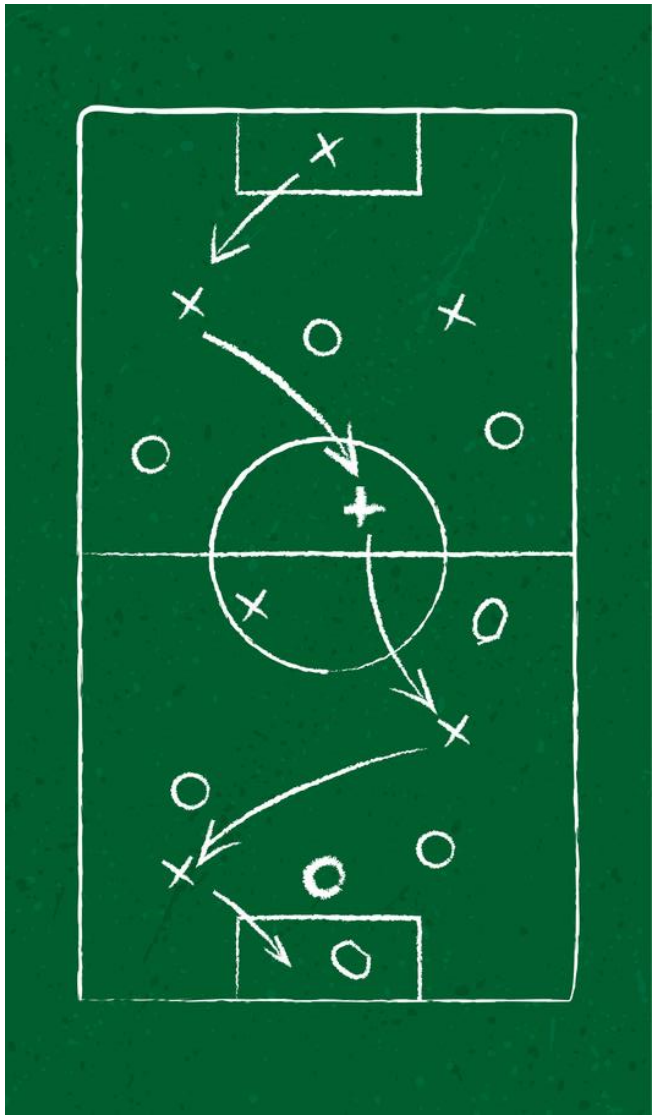
Building & Energy Analytics Goals

- ✓ Increase energy efficiency, reporting, occupant comfort & safety
- ✓ Reduce maintenance costs & prolong equipment & plan capital upgrades
- ✓ Tracking results and accountability
- ✓ Eliminate data drowning
- ✓ Supports staff retention teamwork and job satisfaction
- ✓ Allows Servant Leadership practices



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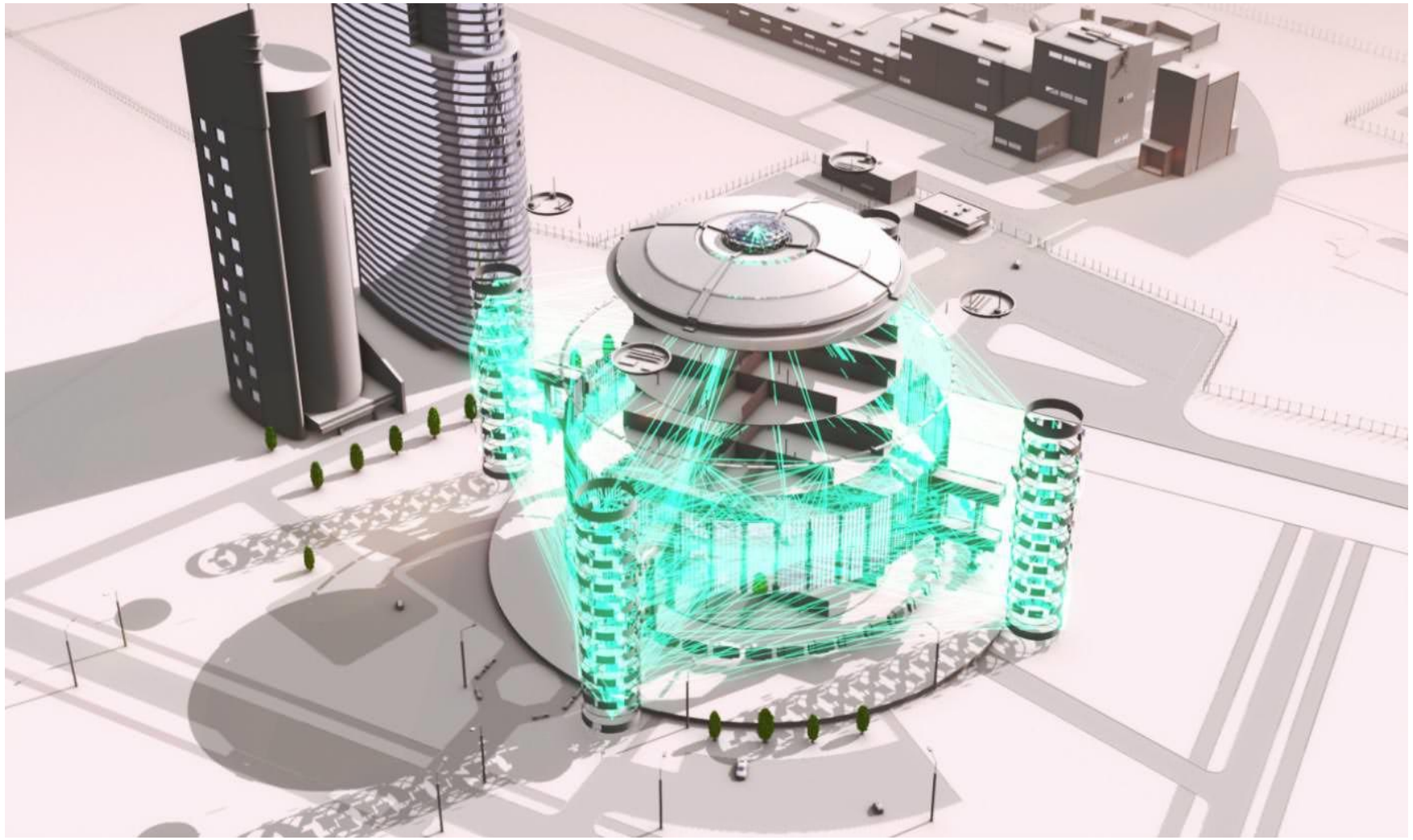
What Data is Already There?



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Let's Unpack This…

- 30 data points in 1 Air Handling Unit (AHU)
- Each data point has data in 5 minute sample intervals
- Daily, that's 288 samples per point (12 samples per hour*24)
- On 30 data points (1 AHU) that's 8,640 samples per day (288*30 points)
- In a month that's 259,200 samples (8,640*30 days)
- For 1 year, we're talking about **3,153,600** samples (8,640 * 365)
- And remember, this is for only ONE AHU!
- Then consider you could have 10 of these AHUs in a building.
- Add in 200 zone systems, each with 10 points…(210,240,000 samples)

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Let's Unpack This…

241,776,000 Samples!

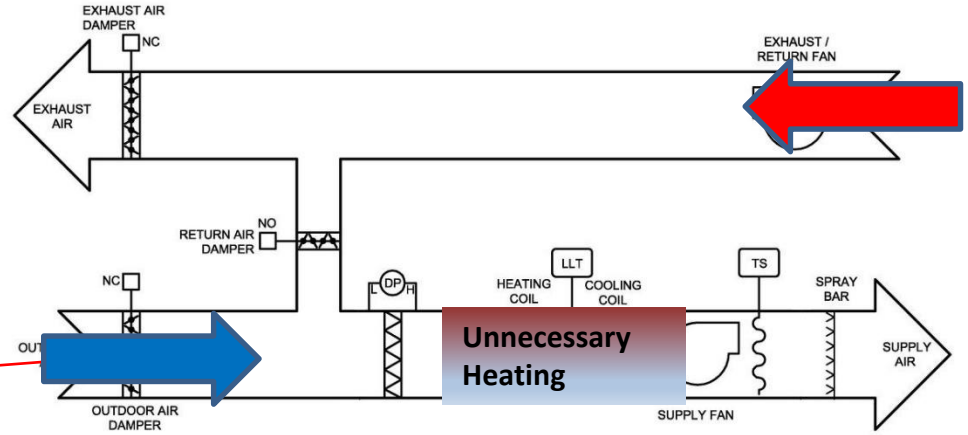
AHU Fault – Leaking Damper

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!



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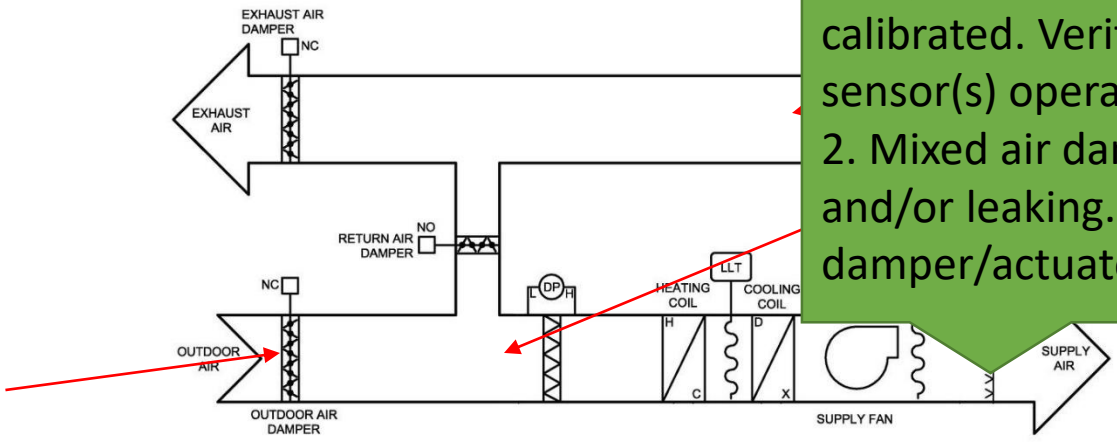
AHU Fault – Leaking Damper Rule

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.

Damper Closed?



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.

lta T > 2 grees?

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Typical Results Achieved

From hundreds of projects:

- ✓ **~18% total building energy reduction average**
- ✓ **~60% HVAC maintenance labor savings**
- ✓ **We have never had a project that did not show positive ROI in less than 2 years – <u>most are in weeks</u>**

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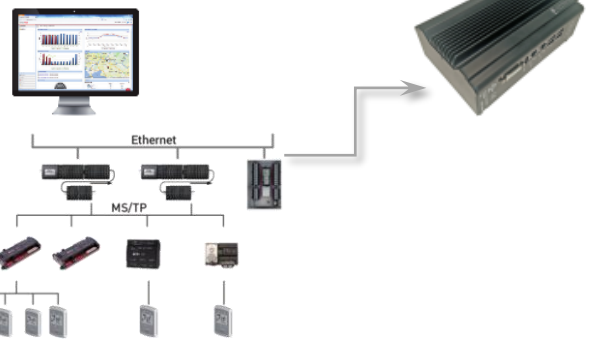
How Does It Work?

Weather Data

Existing Metering & HVAC Control System



HVAC Zone, Plant & Auxiliary Equip.

Analytics Server

Alerts & Reports

Mobile & PC

Onsite device acquires and prepares data for delivery

Cloud server analyzes the data & gives access to analytics, charts and reports.

Notifications are delivered via the web and mobile

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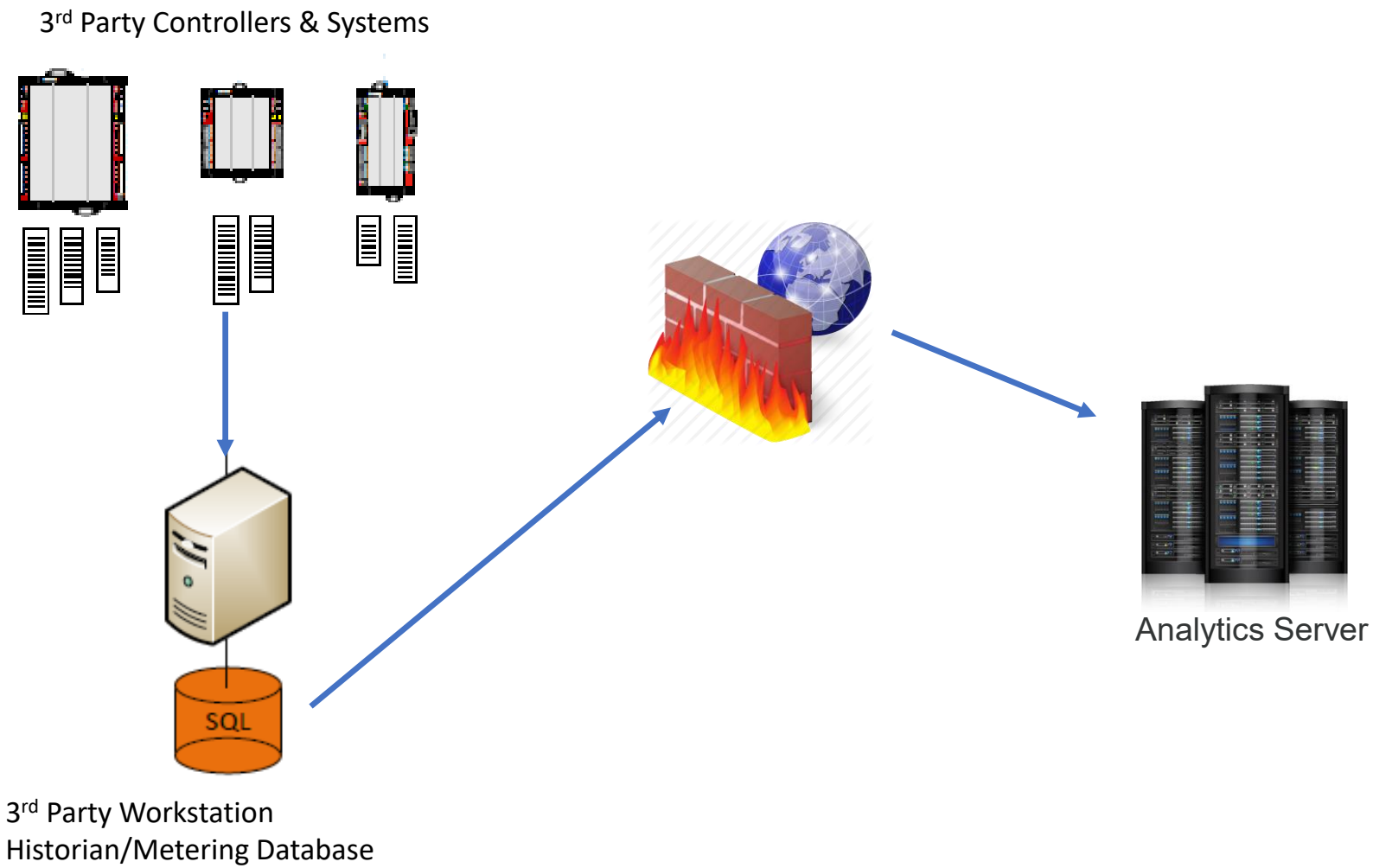
Alternative – Direct Integration to 3rd Party Databases



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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)

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How Do We Prevent This?

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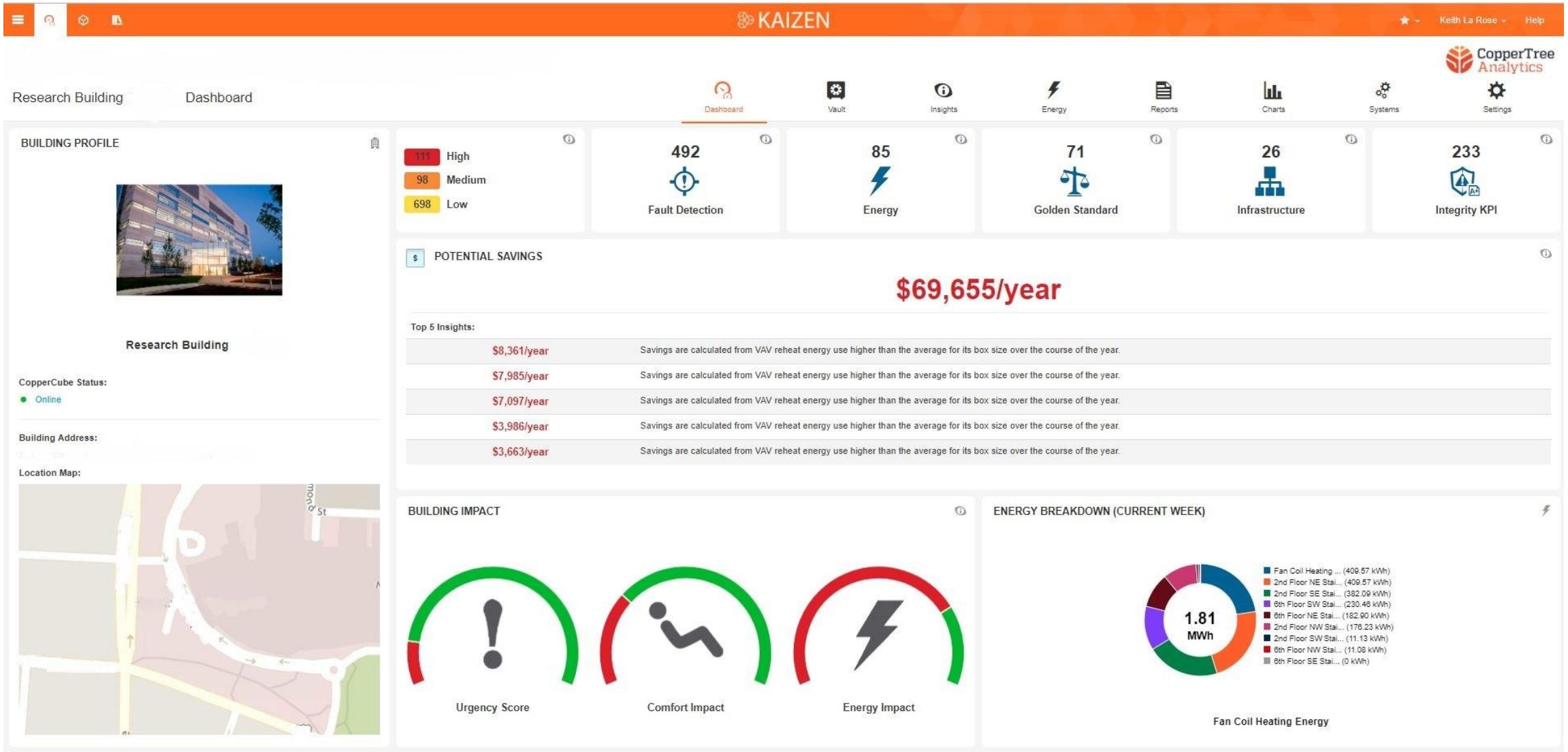
…by Turning Faults Into £ and Occupant Impact (User-Friendly Dashboards)



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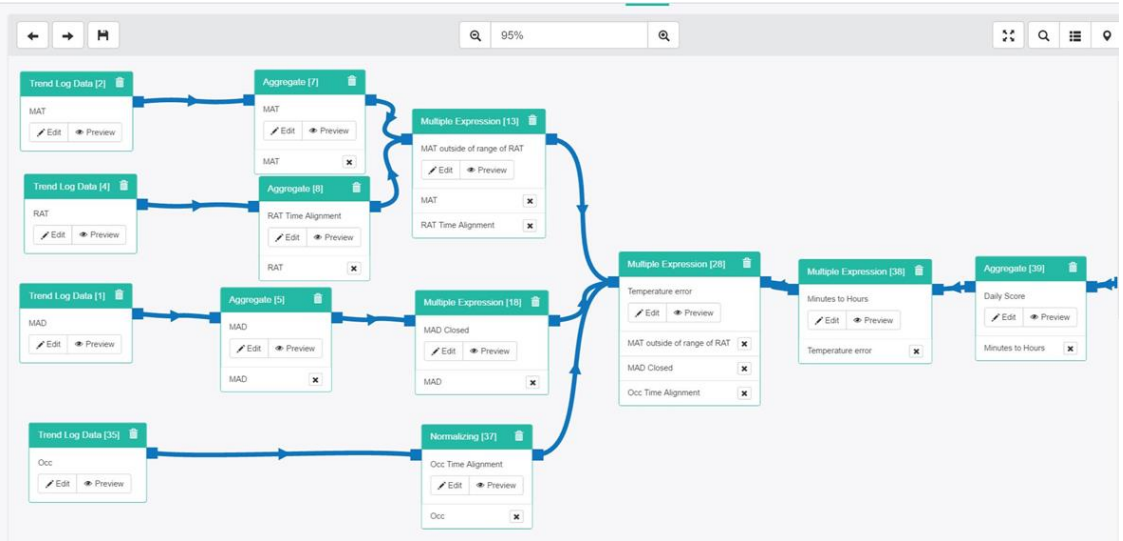
Customizable Rules & Baseline Development



- Leverage large existing library of rules which are customizable
- Write your own rules for your particular scenario/building

Baseline Development for Energy Analytics

- Regression Analysis (Initial and ongoing Automated)
- Baseline and Target Calculations
- Analyze Energy Usage vs. Predicted Usage

Model:	Ordinary Least Squares	**R-squared:**	0.863
Method:	Least Squares	**Adj. R-squared:**	0.862
No. Observations:	356		
Df Residuals:	353		
Df Model:	2		

	Coefficients	Std Error	t Stat	P-values	[0.025	0.975]
constant	0.2004	0.550	0.364	0.716	-0.881	1.282
Weather-CYVR-Heating Degree Hours (2116.71892.TL5)	0.4215	0.040	10.411	0.000	0.342	0.501
Weather-CYVR-Temperature (2116.71892.TL1)	-0.0063	0.033	-0.192	0.848	-0.070	0.058

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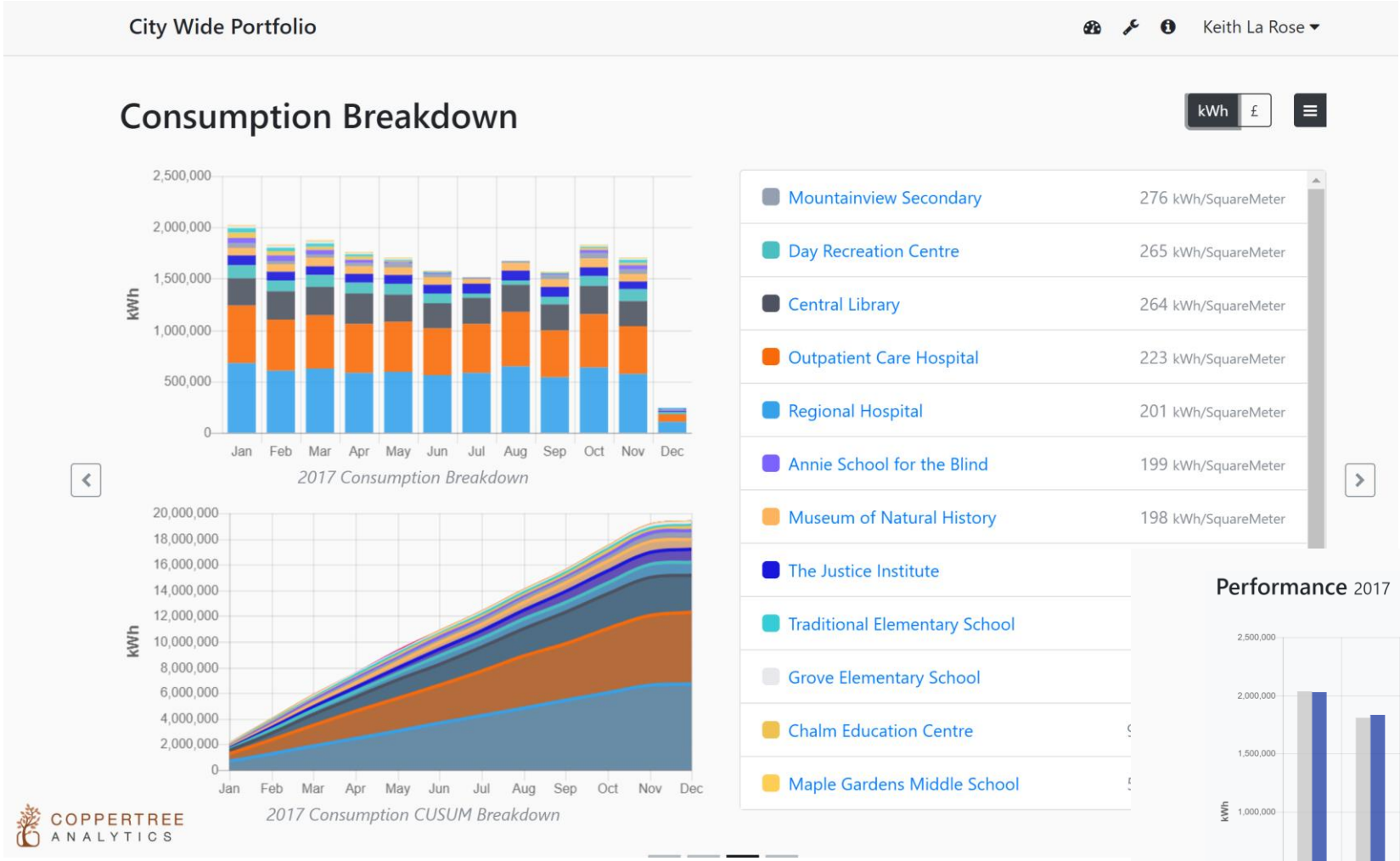
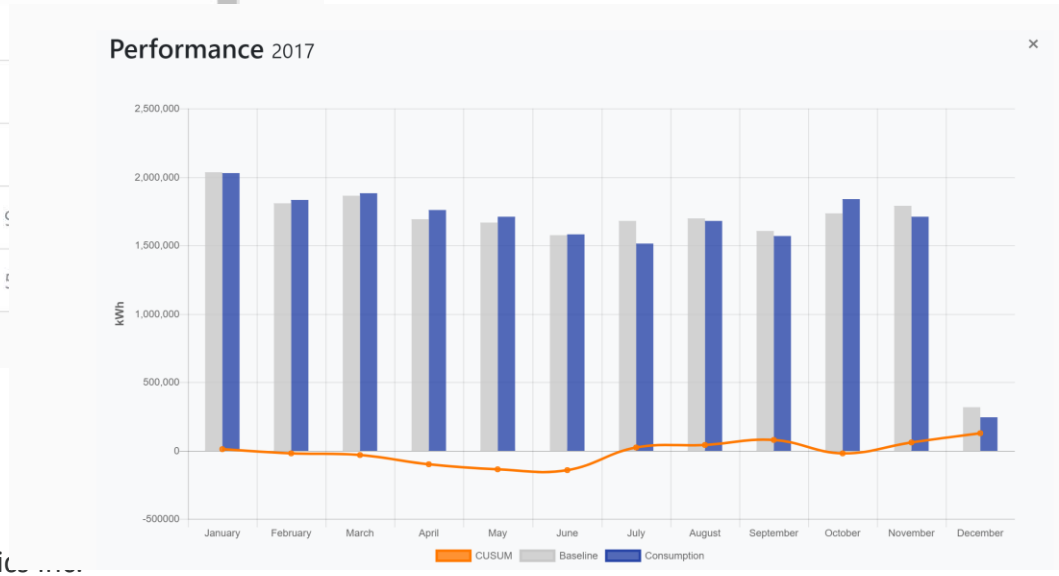
Building Energy Analytics – Benchmark – Calculate - Communicate



VIRTUAL METERING

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



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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

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Summary – CopperTree Analytics

- ✓ Start at the portfolio level: identify best and worst performers to prioritize actions
- ✓ “Zoom in” to automatically identify areas for immediate action to save energy and improve indoor conditions
- ✓ Change the way maintenance is performed across the whole portfolio, drastically improving efficiency
- ✓ Use energy Monitoring, Verification and Targeting (MV&T) to quantify results, celebrate improvements and calculate savings
- ✓ Quantify, measure and verify qualitative, operational and financial benefits & results

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Servant Leadership

Through Advanced Analytics and
Fault Detection

Creativity, Sustainability, Connection, Diversity, Reconciliation

UNIVERSITY OF SASKATCHEWAN

About the University of Saskatchewan

"At the heart of Saskatoon, on Treaty 6 territory and the homeland of the Métis, is the University of Saskatchewan, one of Canada's top research universities. Driven by prairie spirit, we make life better for the people of Saskatchewan and the world."

http://www.usask.ca/

University of Saskatchewan – Drone Video (3 min)

University – Drone Video (3 min) to be inserted

Health Sciences Building

- The first Health Sciences Building at the University of Saskatchewan completed in 1950
- Health Science “A-Wing” is a heritage building
- The Health Sciences Building underwent a number of expansions starting in 2010
- The “E-Wing” Expansion was primarily designed to house
  - A multi-story library
  - 2 Large lecture theatres
  - And Clinical Learning Resource Centre (CLRC)

Health Sciences Building E-Wing Post completion

- Substantial Completion awarded in 2013
- Almost immediately the owner found the following:
  - A higher than expected number of occupant complaints
  - A higher than expected number of O&M Call-outs
  - A high number of “Band-Aid” changes required to keep systems running
  - The systems inability to maintain setpoints
  - A higher than estimated energy load

Health Sciences Building E-Wing
EMIS, FDD Corrective Measures Project

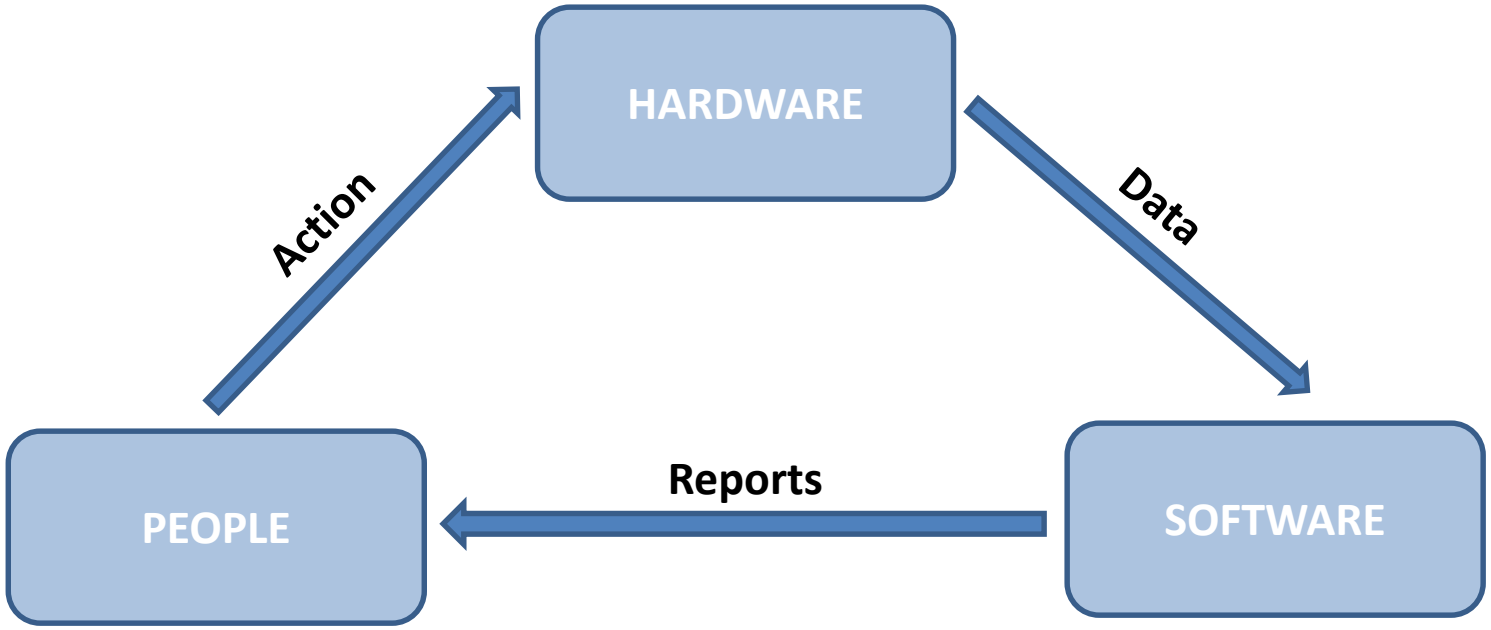
- CopperTree Analytics Awarded a Pilot Project 2016

  To implement Kaizen Analytical Software

  - Energy Management Information System (EMIS)
  - Fault Detection and Diagnostics (FDD)
  - Create a system for Continuous Commissioning

- Kaizen, a natural fit for the University of Saskatchewan's BAS infrastructure
  - Delta Controls BAS architecture already in E-Wing
  - U of S in the process of replacing the Historian Application with CopperCube Archiving

EMIS & Fault Detection & Diagnosis



Hardware (utility meters, building management system) to measure consumption on a frequent basis and generate data

Software to analyze the data collected and provide meaningful reports

People to respond to the reports to drive action

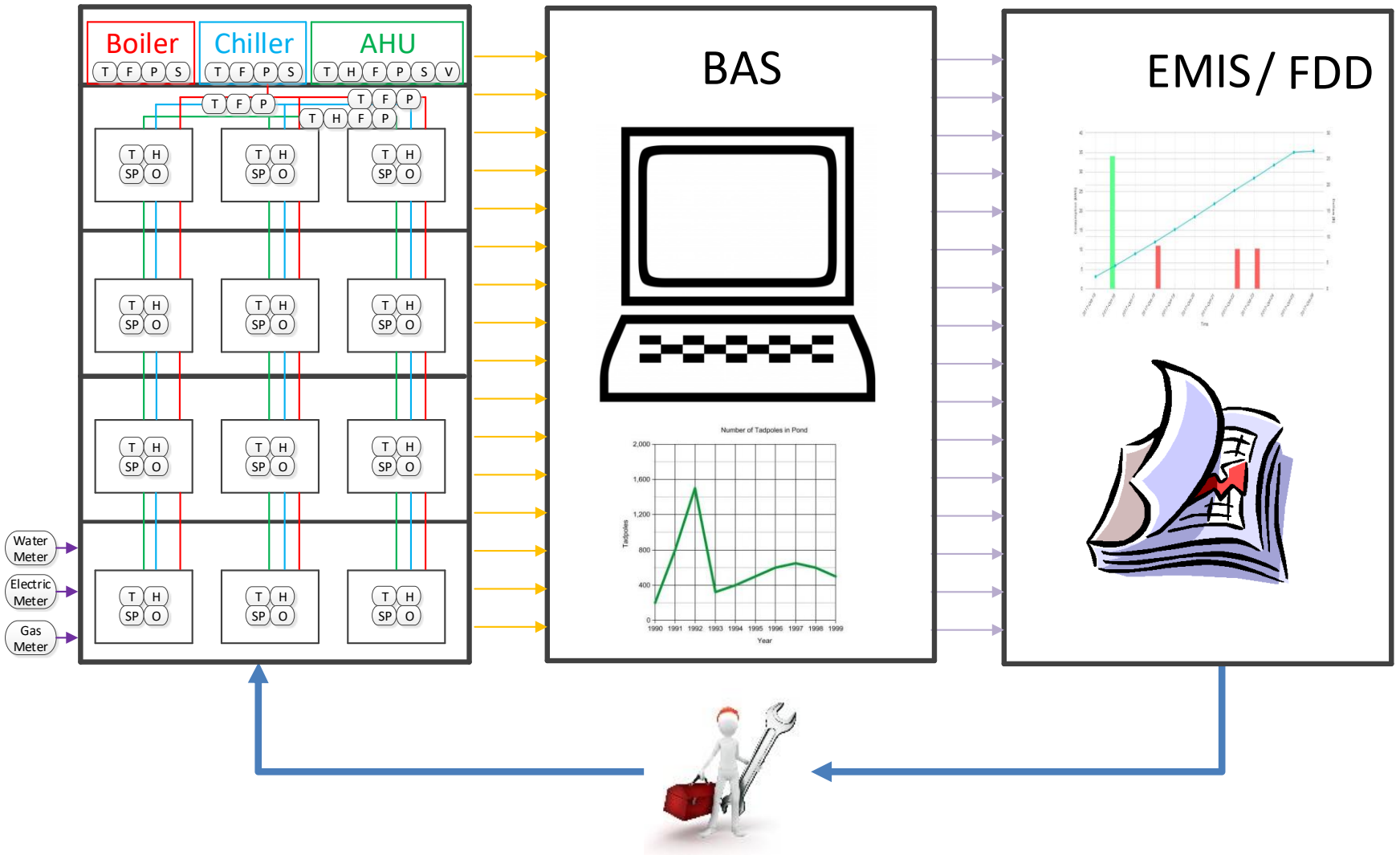
Typical FDD Insights

- Input (Output) Out-Of-Service
- Program In-Fault
- Output Commanded to Manual
- Schedule Out-Of-Service
- Control Loop Out-Of-Service
- Trend Log In-Fault
- Air Valve air flow control requires tuning
- Measured value is significantly away from setpoint
- Chilled beam and radiant panel control valves are open simultaneously
- Lead/Lag pumps operating simultaneously

Building (Hardware)

Controls Software (Runs on Building Hardware)

EMIS & FDD Software (Runs on External Database)



Why Use Analytics Software

- Building Automation System (BAS) software is capable of much of the same functionality for which EMIS software is used; trending, creating variables, logical comparison.
- From a practical perspective, EMIS software can be much more detailed than BAS software.
- Analytics databases are much quicker when querying large amounts of data.
- BAS controllers should be used strictly for controlling live processes.
- Insight reporting can be distributed to departments and individuals responsible for a particular type of insight
- Virtual metering can be easily set up on all types of equipment

Meters

- Anyone can read a meter, make some comparisons and determine if something is wrong.
- That assumes someone is available to read meters and make comparisons.
- Analytics application software can get data from many meters and only needs to notify someone if something is wrong.
- Prior to our analytics, the Health Science E-Wing Building had fans put on manual but it took several weeks for someone to notice that the building electrical consumption had increased.

Steam Consumption Insight

Uses linear regression equation from steam consumption-HDD relationship to predict consumption. When the current consumption exceeds the (predicted forecast + 5% * predicted forecast), the rule triggers an insight.

Priority
High

Insight Type
Energy

Systems

Insight ID
20258.447217

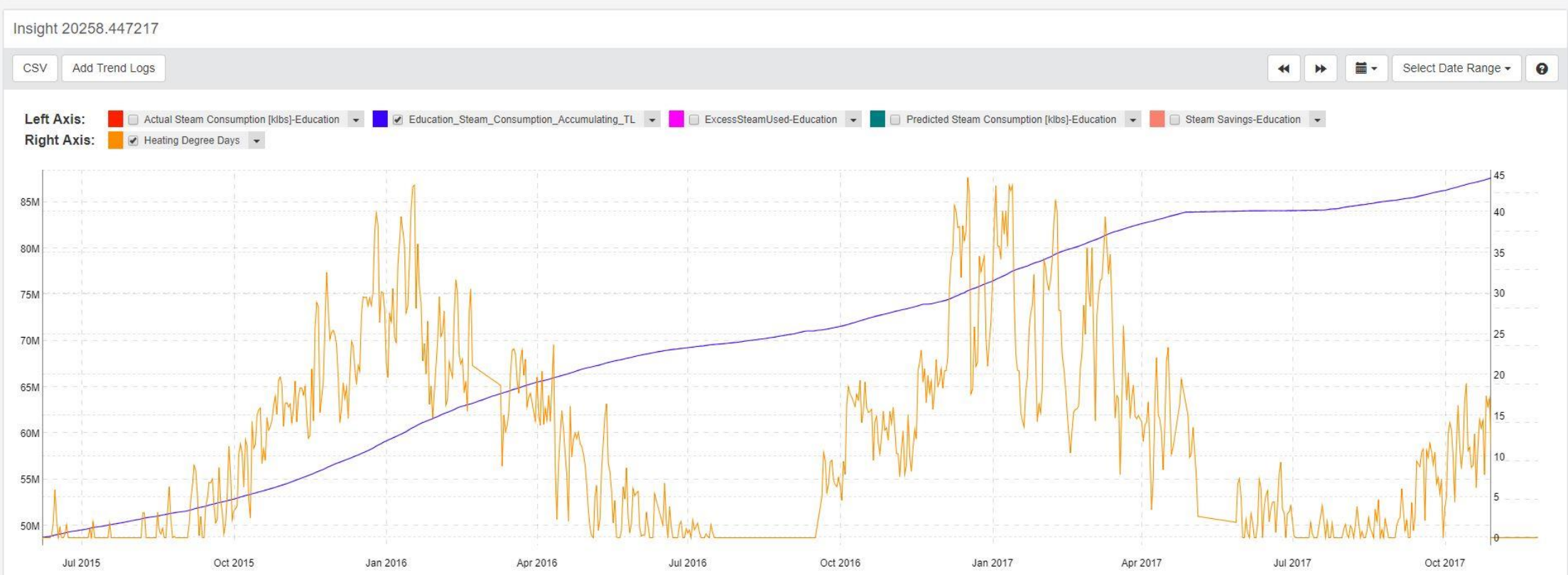
Working Rule
Education

Description / Method
Uses linear regression equation from steam consumption-HDD relationship to predict consumption. When the current consumption exceeds the (predicted forecast + 5% * predicted forecast), the rule triggers an insight.

Message
Steam consumption for the week has exceeded predicted consumption based on degree day relationship.

Diagnosis / Recommended Action
Please review steam consumption for respective meters.

Insight 20258.447217



E-Wing Steam Consumption

- A analysis by Kaizen of the steam meter at E-Wing indicated excessive consumption during the summer, this generated an insight.
- Steam at E-Wing is used in four places:
  - Steam Unit Heaters/Force Flows (UH/FF),
  - Domestic Hot Water (Supplemental Solar Thermal),
  - Perimeter Heating System,
  - Glycol Heating Coils.
- Subsequent analysis showed that the isolation valve to the Steam Unit Heaters/Force Flows was not being shut off seasonally.
- During that investigation it was noted that the solar thermal system was not as effective as it could be, which led to a proposed modification.

Ongoing Steam Analysis

- Steam is also used for perimeter heating, which utilizes zone valves. Experience suggests that these zone control valves are failing at a high rate. Failed heating valves will waste heating energy.
- As we uncover additional steam savings, the steam consumption per Heating Degree Day will decrease.
- This decrease will result in a change to the linear regression equation, which can be used to determine cumulative steam consumption savings.
- These savings can be used to justify expenditures on additional energy savings investigations.

Virtual Sub-Meters

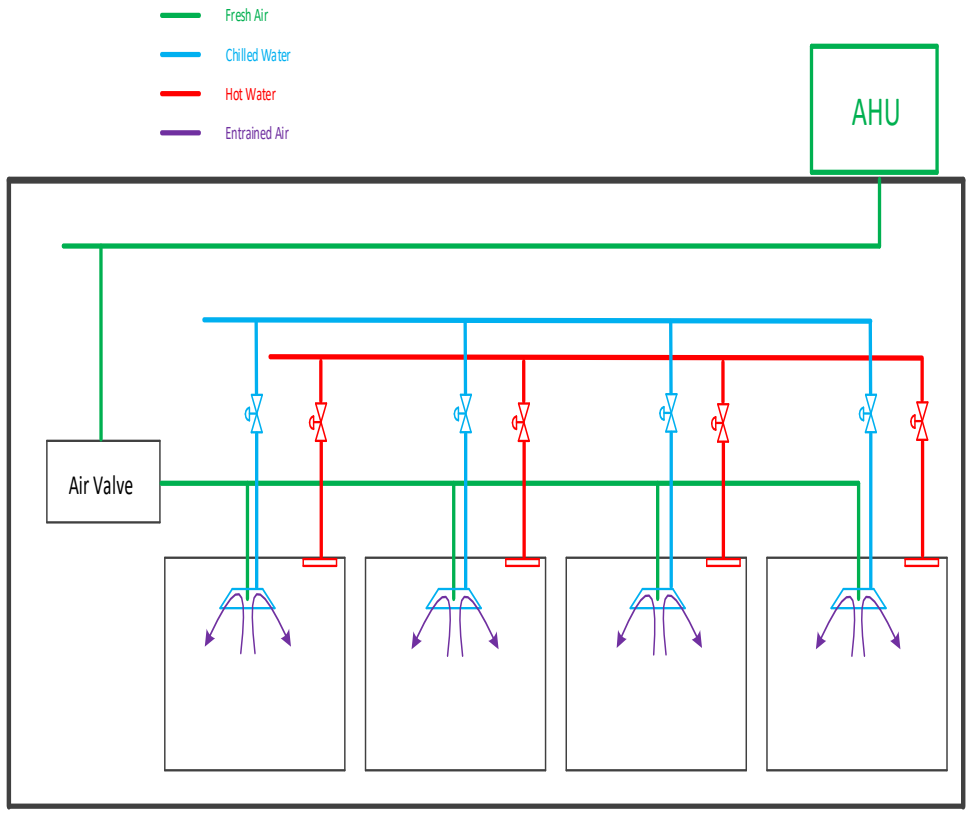
- As noted in the previous examples, it is possible to determine excess energy consumption from building meter data.
- However, due to the large number of variables that can affect building energy consumption it takes a relatively large change over a long period of time to be noticeable.
- Smaller changes can be noticed more quickly if sub-metering is used, however physical sub-metering is expensive.
- Utilizing BAS data and equipment data sheets, an EMIS can create virtual sub-meters.
- For example virtual meters for natural gas consumed for UH/FF, domestic hot water, perimeter heating and heating coils can be created.
- Virtual sub-meters can be set up for Air Handling Units or an individual coil in an Air Handling Unit .

More Sophisticated Insights

- Chilled beam control valve is open when room temperature is below setpoint
- Airflow increases when damper is closing or decreases when damper is opening
- Air valve dampers open to more than 10% when airflow is set to less than 1% of maximum flow
- Equipment is changing state more frequently than specified

Finding Failed Valves

- If a cooling valve fails open, the heating valve will compensate to maintain set-point.
- The opposite will happen if the heating valve fails open.
- Even if the occupant complains of comfort issues, the thermostat will indicate the room is OK.
- Very time consuming to continually physically check each room on a continuous basis.
- Ask the FDD system to calculate "*Open*" time for each valve and write a report listing these times from highest to lowest.
- View a trend report of the rooms with the highest "*Open*" times.

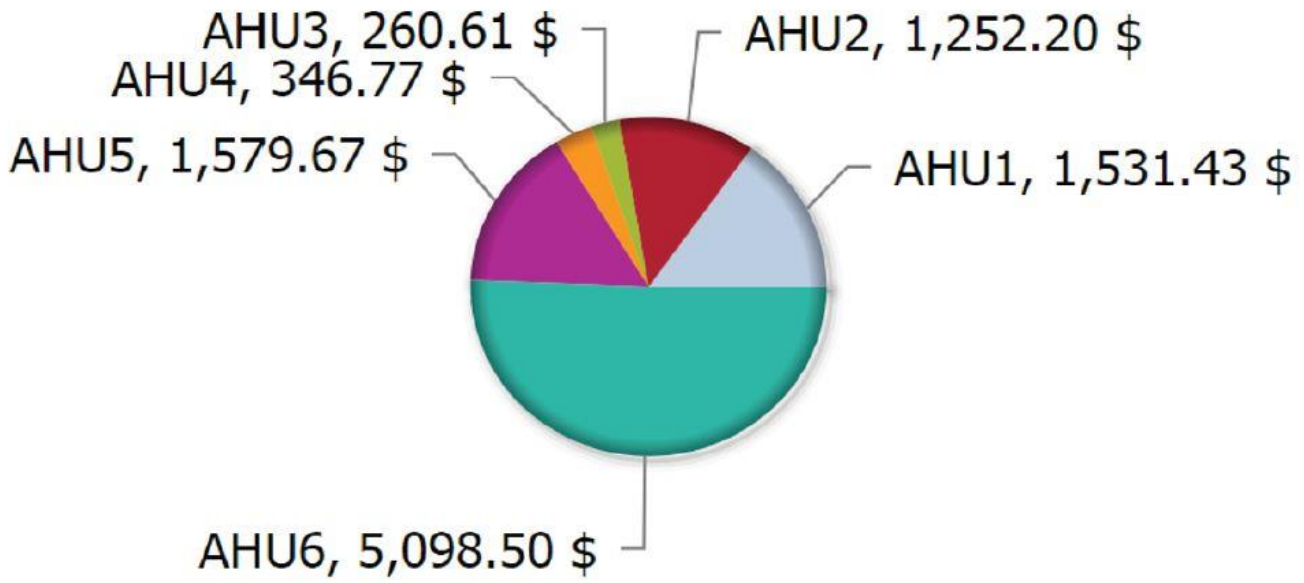


Realized Savings

- **$50,000 in estimated annual savings on utility costs**
- A substantial reduction in:

  maintenance call-outs

  Engineering review and correction post substantial
- **Roughly $10,000 in savings on AHUs alone**



Setting the Golden Standard

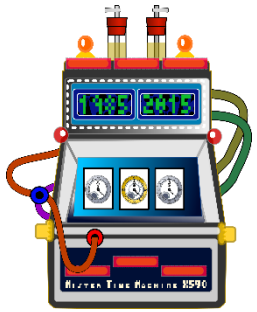
The Golden Standard is set by the implementation team to set a benchmark for the building to be compared to by the Analytics Software moving forward into the future.

The Golden Standard is a tool used for continuous commissioning. Insights will be automatically generated when systems move away from the benchmark.

The Golden Standard and an active Continuous Commissioning plan will allow the University to move from Reactive Maintenance or Preventative Maintenance to Proactive Maintenance.

Reactive

Preventative



Proactive

Key Take Home

1. EMIS, FDD and CC can provide substantial benefits.
2. Energy costs can be greatly reduced.
3. Maintenance costs can be lowered.
4. Occupant comfort and satisfaction can be increased.
5. Building reliability can be increased.
6. The software will not do it all, you need to commit people to take the action that will make the improvements.

Thank You

Chris Davies, A.Sc.T., CMVP, QCxP
Building Automation Specialist
University of Saskatchewan

Building Analytics: Service Leadership, Sustainable Infrastructure & Keys to Success

David Naccarato

UMC Energy & Environment

MC | ENERGY & ENVIRONMENT

WHY ARE WE HERE? KEYS TO SUCCESS

- **Data analytics can become the neural network that integrates humans with the infrastructure and buildings they inhabit.**
- Converts data into useful information that is real-time and real-condition
- Setting goals is the easy – the challenge of “unfunded mandates”
- **Solutions must be technically, financially, operationally, environmentally & politically viable!**
- Transition to sustainable operations – transferring generational expertise

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THE GREATEST LEADERS SERVE

- As **Provider's** are we prepared to tell Owner's what they need to hear – not what they want to hear?
- As **Owner's,** are you prepared and welcome to be challenged?
- Do we take the path of least resistance?
- Are we asking hard questions? Do we listen? Do we seek those with the lowest titles for their experience, insights & recommendations?
- "Doing good" is better (and more difficult) than "feeling good"

Key to Success

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TRANSITION TO SUSTAINABLE OPERATIONS

- Successful transfer of knowledge and experience from one generation to another
- Effective training and operations for new equipment & technologies (737 vs. Dreamliner)
- Ask questions – listen – learn.
- **Truth is the combination of conflicting opinions** – WELCOME DISSENTING VIEWS!

Thank You

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