AABC Commissioning Group

AIA Provider Number 50111116

Using Data Analytics to Automate and Enhance the Commissioning Process

Course Number: CXENERGY1917

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SkyFoundry

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SkyFoundry

https://skyfoundry.com/

Course Description

Consultants involved in commissioning, energy analysis, energy management and Monitoring and Verification have found data analytics software to be a powerful tool that enables them to transform the services to their clients.

Today's Data Analytics software allows them to automate the analysis that has traditionally required continuous manual effort, and provide clients with new, ongoing consultation-based service offerings to help continuously improve facility performance and eliminate the backwards-drift seen in many energy conservation projects.

This presentation will provide case study examples demonstrating how analytics software was applied to the commissioning process and its role in delivering significant financial results and help owners and operators make energy and operational efficiency improvements permanent.

Learning Objectives

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

1. Examples of common and useful analytic rules that can be applied to HVAC systems and KPI’s to track building energy performance.

2. The difference between alarms, analytics and analysis tools.

3. The role of data tagging to prepare equipment data for analytics.

4. How including utility tariff rates brings deeper understanding of performance, and equipment operating patterns.

The Role of Data in Commissioning, M&V, Energy Analysis and Reporting

Data is the fundamental element for commissioning, energy analysis, energy management and Monitoring & Verification

More and more data sources are available today: BAS, Metering, Utility APIs for consumption and rate data, weather

There is more data available than humans can deal with manually

We need tools

Analytics software is that tool

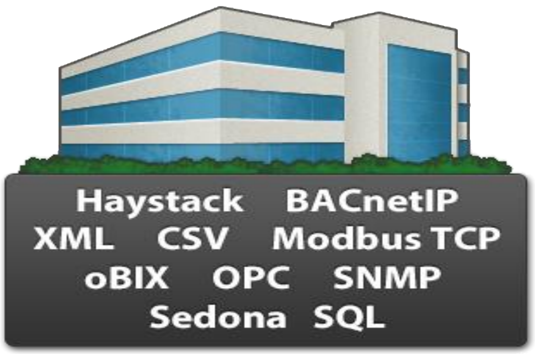
The Role of Analytics

Analytics software tools enable us to automate and streamline the tasks involved in acquiring, processing, analyzing, and reporting data for commissioning, energy analysis and M&V

Traditional Approaches

- Manually interpret and process csv files
- View graphics of equipment systems
- Review reports or history logs
- Import data into Excel for manual analysis
- Manually assemble reports
- No single tool that works across all kinds of data
- ***How do you do this today?***

Applying analytics to our data



Easy to get started – what data do you have?

BAS data

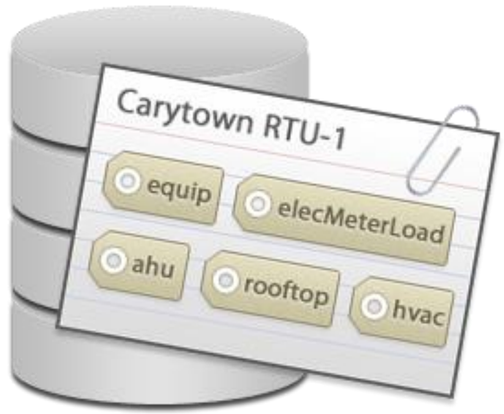
Facility data

Utility data

Weather data

Production data

Connect to available data sources



Aggregate and normalize available data

Results: KPI's, Calculations, Identify faults, anomalies, deviations, correlations

Step 1: Acquiring Data

Communication connectors enable direct access to data…

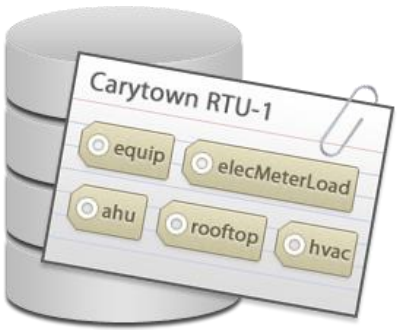
- Streaming data from control/BAS systems via Protocols such as: BACnet, Modbus, Haystack, OPC UA, Obix (supports polling, watches, trend log synchs)
- Batch import of data (CVS, XML, JSON, formats)
- Existing Data from databases: SQL and similar
- *Software automates data acquisition and storage in a* ***normalized format***

Step 1: Normalizing Diverse Data

Data from different sources comes in different formats with different time stamps and different semantic information (descriptive information)

In order to do analysis across diverse data that data needs to be normalized

Data normalization is a key part of the process with analytics software is the



Normalizing Diverse Data – Semantic Tagging

- Give the data meaning via “tags”
- No need to maintain rigid schemas – add tags whenever you want to capture information

- Tags represent
- Dimensions, units
- Relationships, associations
- Location
- Other meaning and descriptors

dis	elecMeter	equip	hvac	lighting	plug	siteMeter
Headquarters ElecMeter-Main	✓	✓				✓
Bon Air ElecMeter-Main	✓	✓				✓
Va Beach ElecMeter-Lighting	✓	✓		✓		
Woodley Park ElecMeter-Main	✓	✓				✓
Inner Harbor ElecMeter-Main	✓	✓				✓
Bon Air ElecMeter-Hvac	✓	✓	✓			
Inner Harbor ElecMeter-Lighting	✓	✓		✓		

Project Haystack

Project Haystack Is…

- **A community** of people working to address one of the key challenges in using smart device data…
- **THE CHALLENGE**: Device data has poor “semantic modeling” (information describing the meaning of the data)
- A manual, labor intensive process is required to "map" the data before it can be used in different applications
- This adds cost and slows the use of this valuable data

Project Haystack

- Project Haystack Solution: A standardized methodology for describing data that makes it easier and more cost effective to analyze, visualize, and derive value from our operational data. *Open-source, no cost.*
- Think of it as a “MARKUP LANGUAGE” for data
  - *Why can I point my browser at your website and read what you have published?*
  - *We didn’t pre-arrange for me to be able to interpret your website code*
  - *It works because industry agreed on a mark up language (HTML)*
  - *If you use HTML I can read the “data” (text) on your website*
  - *Haystack does the same thing for device data*

Project Haystack

- Analyze this: **zn3-wwfl4 = 76.2**
- Hmmmm… What does the number represent? Deg C, F, KW, kPa???
- Need to know units. Lets say it is Deg C
- Hmmmm… Is 76.2 Deg F OK?
- What is it? Zone temp, Return air temp, chilled water temp? Lets say it's a Zone
- What is the schedule for the space? Schedule #1 = 7:30 AM - 6:30 PM
- What AHU is it served by? AHU-1
- What VAV box serves it? VAV-27
- How can I convey these answers in a standard way that other software can interpret?

Project Haystack

Example of Haystack tags to describe a point in a system:

AHU1-SAT = sensor, discharge, air, temp, deg F, ahuRef -> AHU-1

Point Name | **descriptive tags** | **association tag**

Learn more about Project-Haystack.org here: https://project-haystack.org/

Project Haystack

BACNET COLLABORATION WITH HAYSTACK

RICHMOND, VA. (PRWEB) MARCH 02, 2018

RSS

ASHRAE's BACnet Committee, Project Haystack and Brick Schema Collaborating to Provide Unified Data Semantic Modeling Solution

- Formal collaboration to integrate Haystack tagging and Brick data modeling concepts into the proposed ASHRAE Standard 223P for semantic tagging of building data.

  ASHRAE Standard 223P: "Designation and Classification of Semantic Tags for Building Data" provides a dictionary of semantic tags for descriptive tagging of building data including building automation and control data along with associated systems.

  By integrating Haystack tagging and Brick data modeling concepts with the upcoming ASHRAE Standard 223P, the result is intended to enable interoperability on semantic information across the building industry, particularly in building automation.

- http://www.prweb.com/releases/2018/03/prweb15264563.htm

Project Haystack

Step 1: Normalizing Data – the Time factor

Different time stamps and different semantic information (descriptive information)

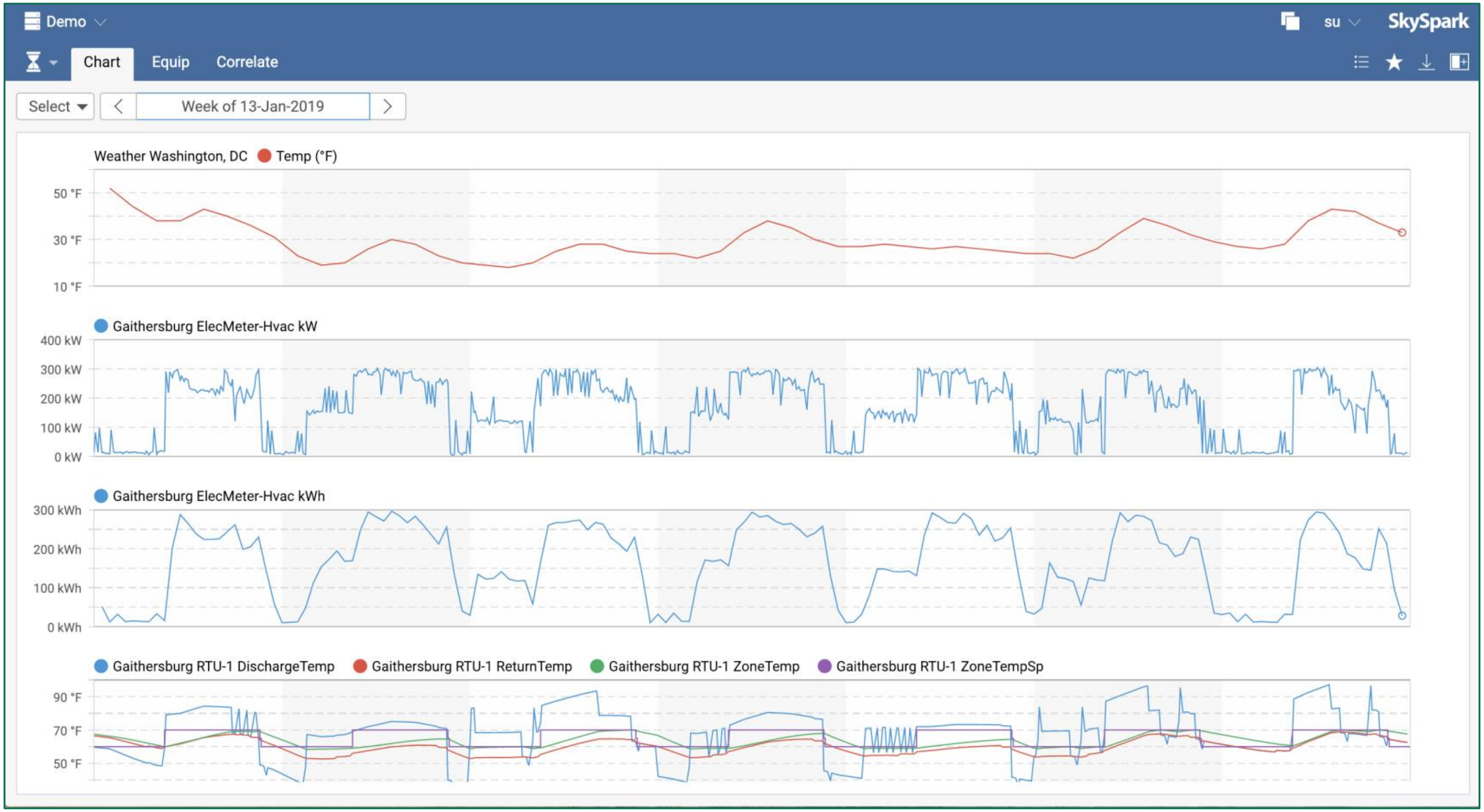
Historian functions address differing timestamps to enable users to see meaningful trends

Sample csv file showing different time stamps for differing data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Timestamp	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Washington,	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	Gaithersburg	RTU-1 ZoneTempSp	
2	2019-01-22T00:00:00-05:00 New_York	FALSE															
3	2019-01-22T11:15:00-05:00 New_York						FALSE										
4	2019-01-22T12:00:00-05:00 New_York			FALSE													
5	2019-01-22T13:00:00-05:00 New_York											FALSE					
6	2019-01-22T21:15:00-05:00 New_York													FALSE			
7	2019-01-22T23:00:00-05:00 New_York					49¬∞F											
8	2019-01-22T23:45:00-05:00 New_York		67.06527709960938¬∞F		0.0500000074505806inH‚ÇÇO			67.06527709	10kW	69.10281372	0%				60¬∞F		
9	2019-01-23T00:00:00-05:00 New_York	FALSE	66.99794769	FALSE	0.07999999821186066inH		FALSE	58.08896255	6kW	69.01850891	0%	FALSE		FALSE	60¬∞F		
10	2019-01-23T00:15:00-05:00 New_York		66.78258514404297¬∞F		0.0500000074505806inH‚ÇÇO			57.98020553	10kW	68.78629302	0%				60¬∞F		
11	2019-01-23T00:30:00-05:00 New_York		66.59963989257812¬∞F		0.07999999821186066inH‚ÇÇO			57.88782119	15kW	68.55690002	0%				60¬∞F		
12	2019-01-23T00:45:00-05:00 New_York		66.41918182373047¬∞F		0.0700000029802322inH‚ÇÇO			57.79668426	15kW	68.33055877	0%				60¬∞F		
13	2019-01-23T01:00:00-05:00 New_York		66.2411117553711¬∞F		0.05999999865889549inH‚ÇÇO			57.70676422	11kW	68.10723114	0%		11.5kWh		60¬∞F		
14	2019-01-23T01:15:00-05:00 New_York		66.06541442871094¬∞F		0.0700000029802322inH‚ÇÇO			57.61803436	13kW	67.88686370	0%				60¬∞F		
15	2019-01-23T01:30:00-05:00 New_York		65.89205169677734¬∞F		0.05999999865889549inH‚ÇÇO			57.53048706	17kW	67.66942596	0%				60¬∞F		
16	2019-01-23T01:45:00-05:00 New_York		65.72099304199219¬∞F		0.05999999865889549inH‚ÇÇO			57.44410324	10kW	67.45487976	0%				60¬∞F		
17	2019-01-23T02:00:00-05:00 New_York		65.55220794677734¬∞F		0.050000000	49¬∞F		57.35886383	9kW	67.24317932	0%		12.75kWh		60¬∞F		
18	2019-01-23T02:15:00-05:00 New_York		65.4365005493164¬∞F		0.0500000074505806inH‚ÇÇO			57.42417907	89kW	67.03513336	0%				60¬∞F		
19	2019-01-23T02:30:00-05:00 New_York		65.32614135742188¬∞F		0.0500000074505806inH‚ÇÇO			57.49220275	13kW	66.83316802	0%				60¬∞F		
20	2019-01-23T02:45:00-05:00 New_York		65.22057342529297¬∞F		0.05999999865889549inH‚ÇÇO			57.56264114	9kW	66.63720703	0%				60¬∞F		
21	2019-01-23T03:00:00-05:00 New_York		65.11973571777344¬∞F		0.07999999821186066inH‚ÇÇO			57.63546371	16kW	66.44717407	0%		30kWh		60¬∞F		
22	2019-01-23T03:15:00-05:00 New_York		65.02355194091797¬∞F		0.07999999821186066inH‚ÇÇO			57.71064376	11kW	66.26298522	0%				60¬∞F		
23	2019-01-23T03:30:00-05:00 New_York		64.93197631835938¬∞F		0.0500000074505806inH‚ÇÇO			57.78814697	7kW	66.08457183	0%				60¬∞F		
24	2019-01-23T03:45:00-05:00 New_York		64.84493255615234¬∞F		0.05999999865889549inH‚ÇÇO			57.86794281	82kW	65.91184997	0%				60¬∞F		

Step 1: Normalizing Data – the Time factor

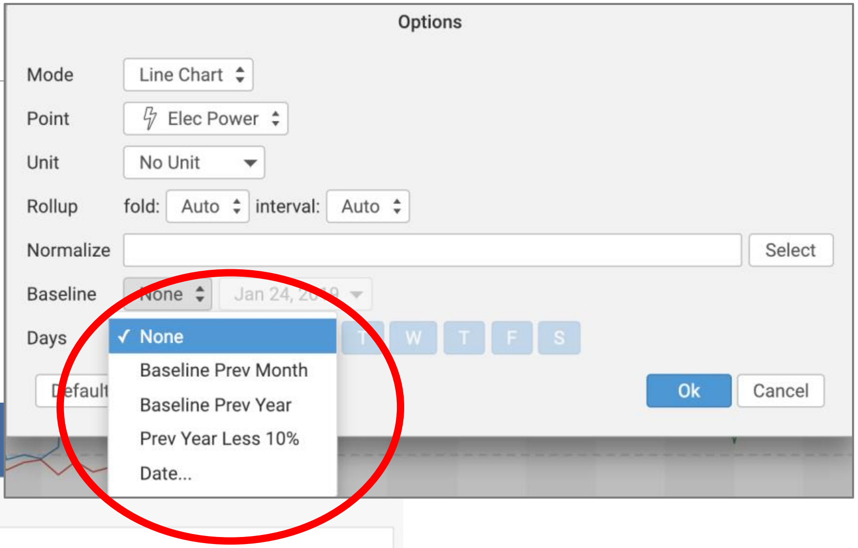
Historian functions correlate the data and show operators seamless trends across data with varying sampling frequency



Use Case: Analyzing and Visualizing Energy Data

Baselines

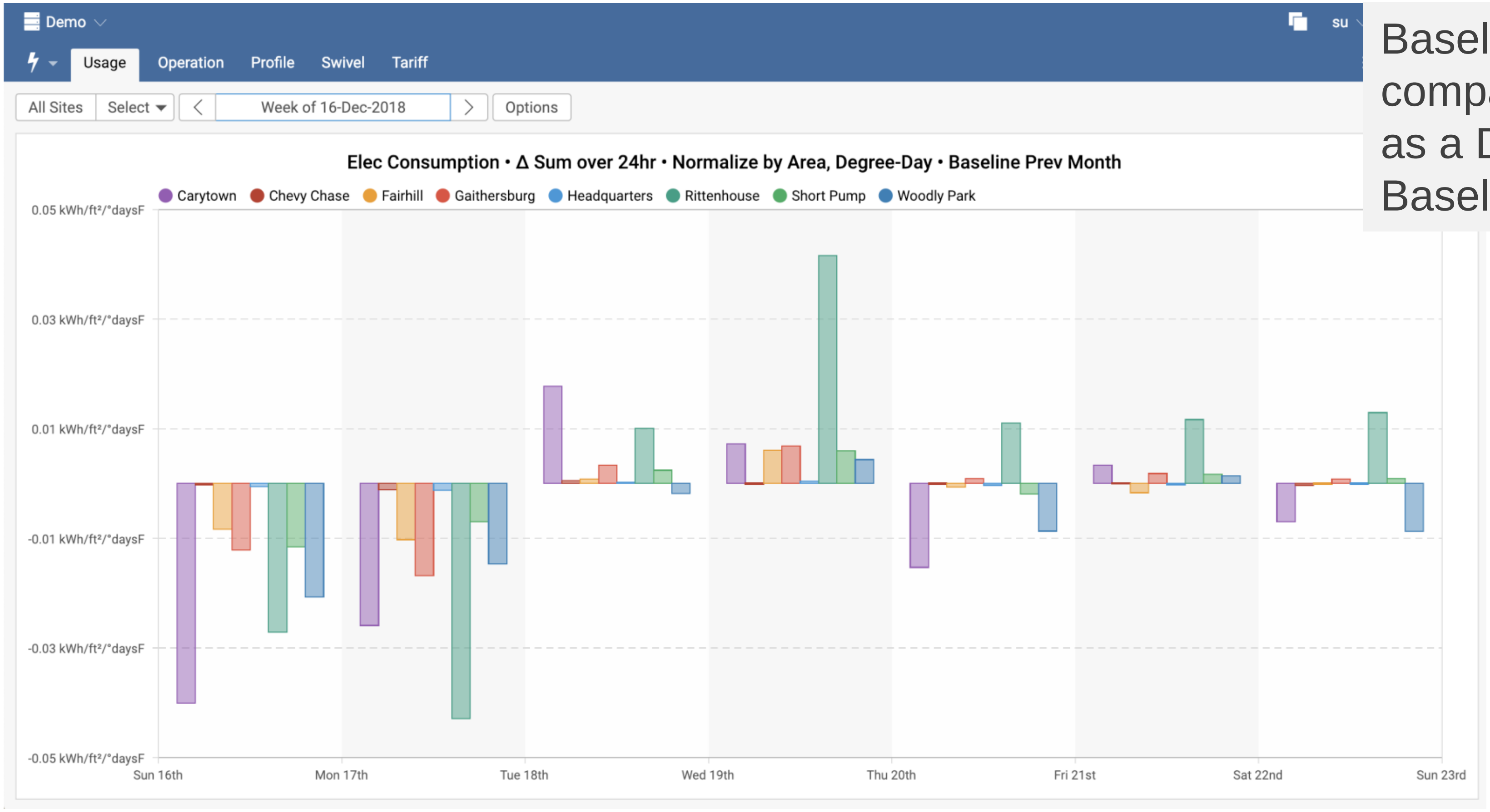
View and analyze energy against baseline using past data, calculated baselines, model based baseline data



Baseline comparison as a line graph

Use Case: Analyzing and Visualizing Energy Data
Baselines

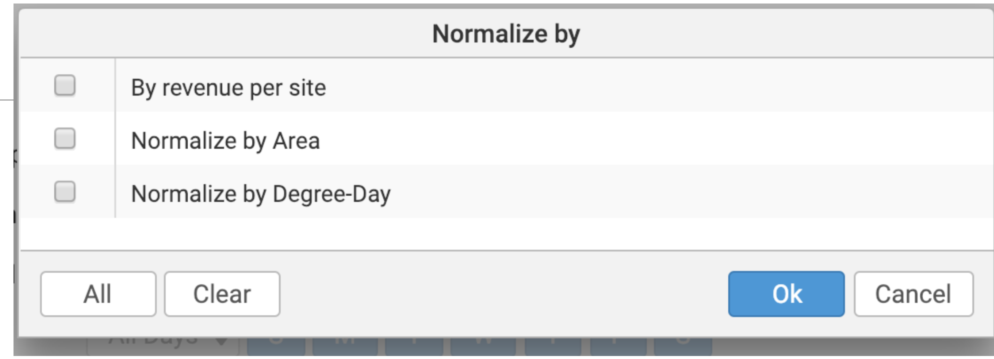
View and analyze energy against baseline using past data, calculated baselines, model based baseline data



Baseline comparison as a Delta Baseline view

Use Case: Analyzing and Visualizing Energy Data

Normalization

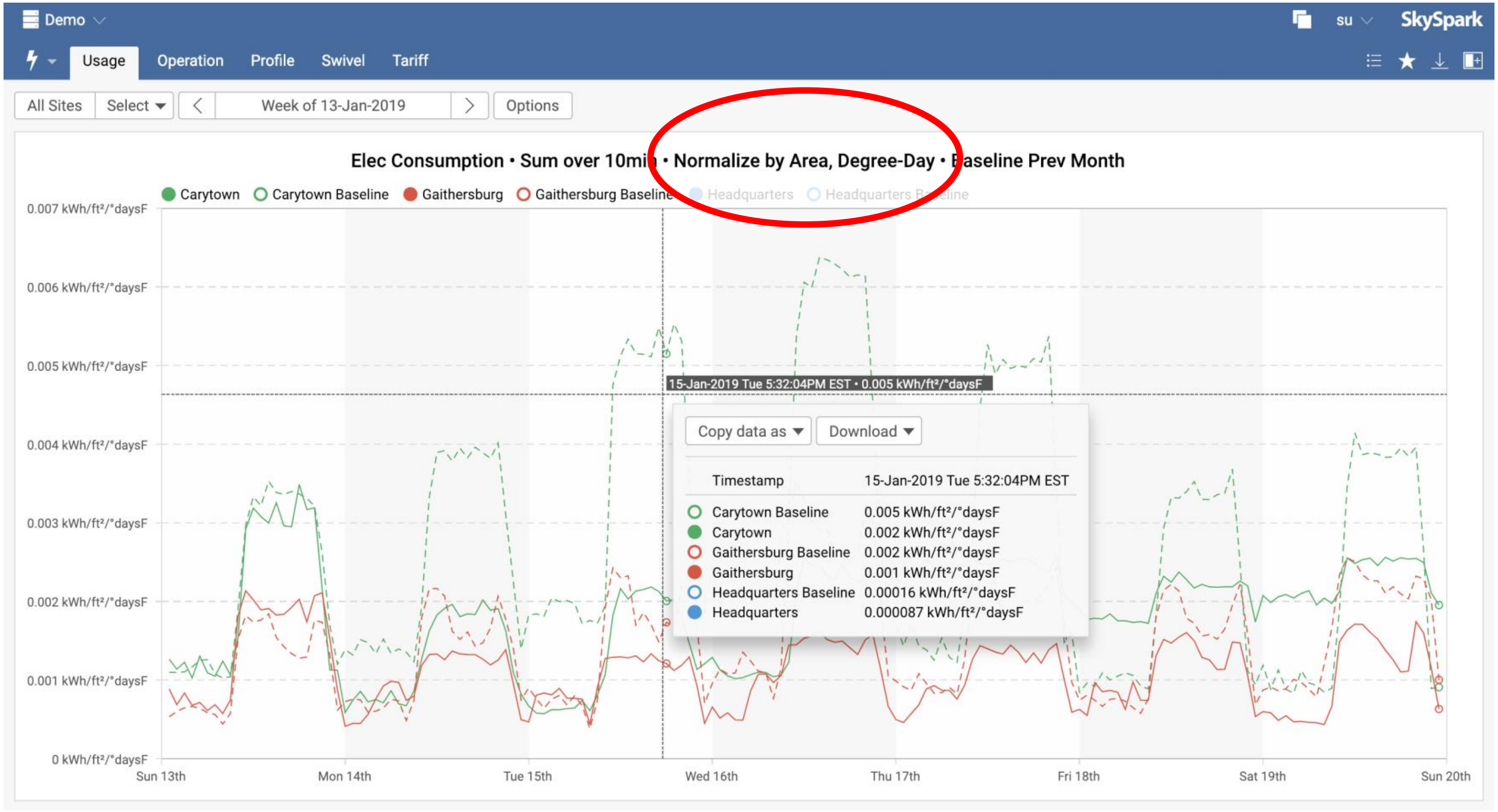


Normalize energy data based on:

- Weather (degree days, temps, other)
- Building size
- Production factors:
  - Occupancy – actual or scheduled
  - Revenue (restaurants)
  - Unit production – factories
  - Site specific
- Normalization of model-generated energy data

Use Case: Analyzing and Visualizing Energy Data

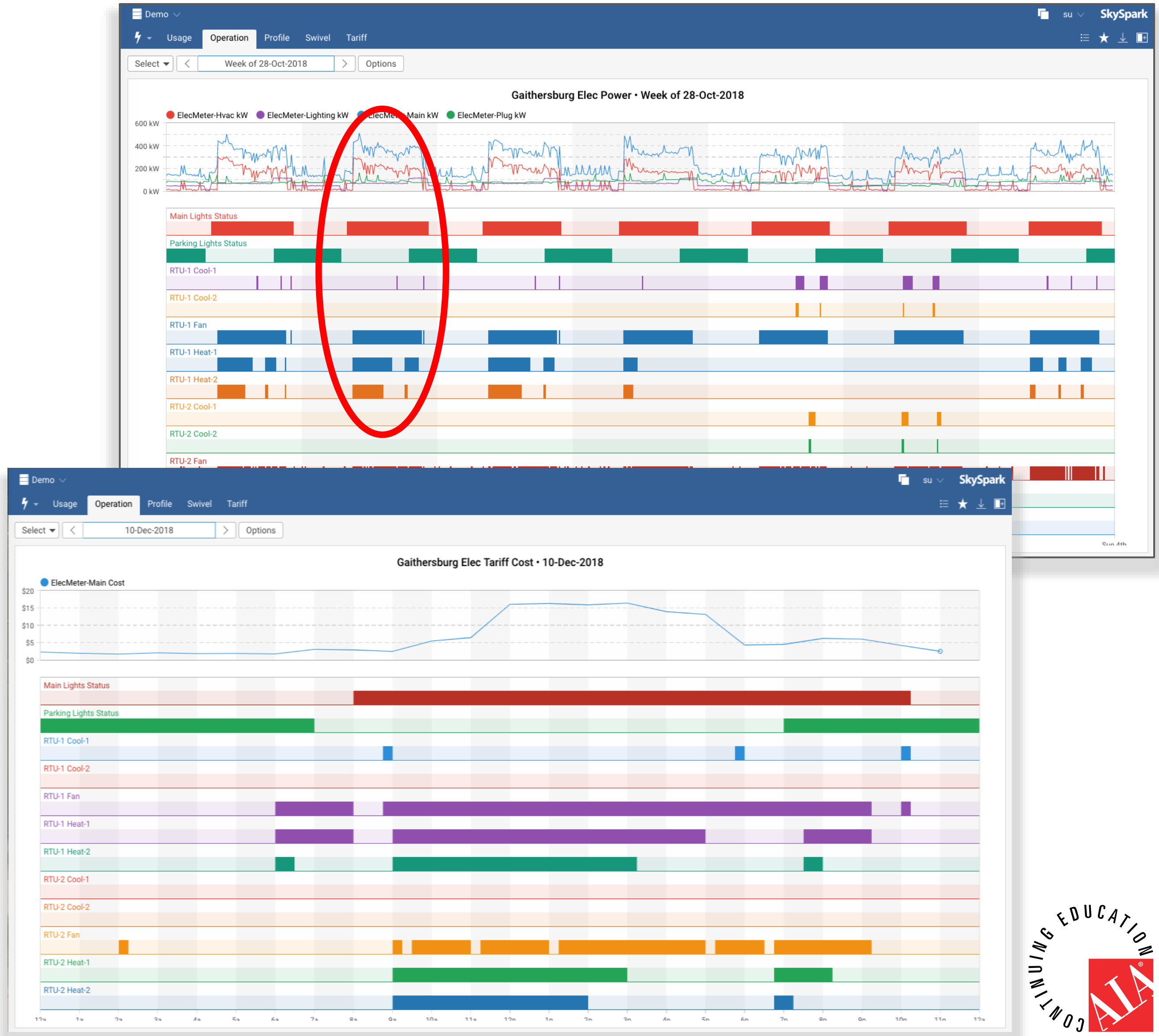
Normalization



Use Case: Combining Energy and Operational Data

Provides visibility to understand the impact of equipment operation on energy use and energy cost based on tariff calculations

Enables operators to more effectively identify and justify maintenance priorities, capital expenditures and ECMs to improve facility performance and reduce operational costs.



Use Case: Impact of Tariff Rates on Energy Data

Complex tariff rates add additional complexity and need for analytic tools

Can have substantial impact on energy costs – *example: you can use more energy for less money if you use it at the right time*

“Tariff engine” capability can turn consumption and demand data into actual costs for evaluation of investments, control strategies and reporting

Timestamp	12-Nov-2018 Mon 4:57:48AM EST
Winter On-Peak Demand	$1,527
Woodly Park ElecMeter-Main kWh	204 kWh
Woodly Park ElecMeter-Main kW	244 kW
Winter On-Peak Consumption	$91.99
Winter Off-Peak Consumption	$69.63
Winter Off-Peak Demand	$0
Rittenhouse ElecMeter-Main kW	103 kW
Rittenhouse ElecMeter-Main kWh	102 kWh
Generation kWh	$213.33
Distribution kWh	$106.66
Demand	$0
Short Pump ElecMeter-Main kWh	86.25 kWh
Short Pump ElecMeter-Main kW	79 kW
Generation kWh	$260.93
Distribution kWh	$130.46
Demand	$0

Impact of Tariff Rates

Rate Modeling. The ability to capture the various charges that make up an electric rate. Costs for energy go beyond simple consumption (kWh) and demand (kW). Typical charges can include:

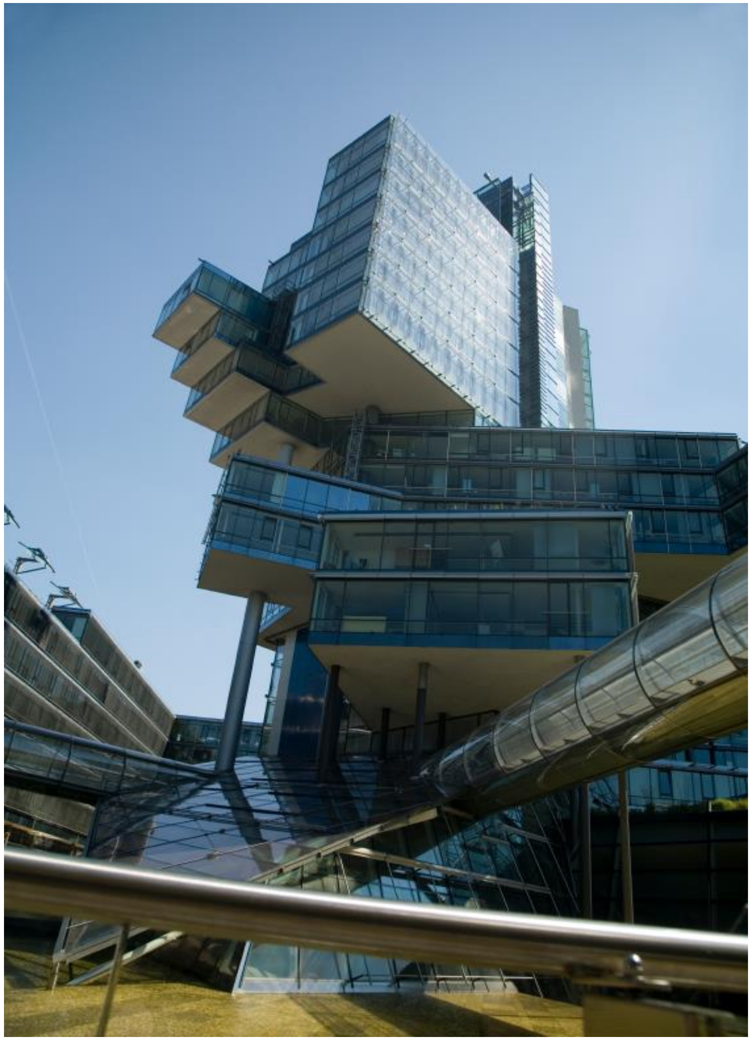
- Consumption
- Demand
- Time of Use including both time of day and monthly use factors
- Service and equipment charges (fixed rate and % based)
- Distribution and Generation charges
- Minimum contract charges
- Ratchets
- Ranges (or blocks)
- Custom charges which can be expressed as math functions
- Definition of billing periods (including variable billing periods)

Once the charges are defined a Tariff Engine calculates energy costs based on the charges and actual energy consumption data. Analytic rules and energy analysis algorithms can use those to calculate costs associated with issues detected in the operation of equipment systems providing precise calculation of costs associated with the use, and misuse, of energy resources.

Impact of Tariff Rates on Energy Data

Automated Analytics: Beyond Manual Analysis The Role of Analytics in Detection of Faults, Deviations, Anomalies, Performance Drift, Loss of Efficiency

Do we know how our building systems really operate?



Detecting Faults, Deviations, Anomalies, Loss of Efficiency

"If I have a computer-based building automation system things must be running properly…"

Right ????

Lots of Technology…

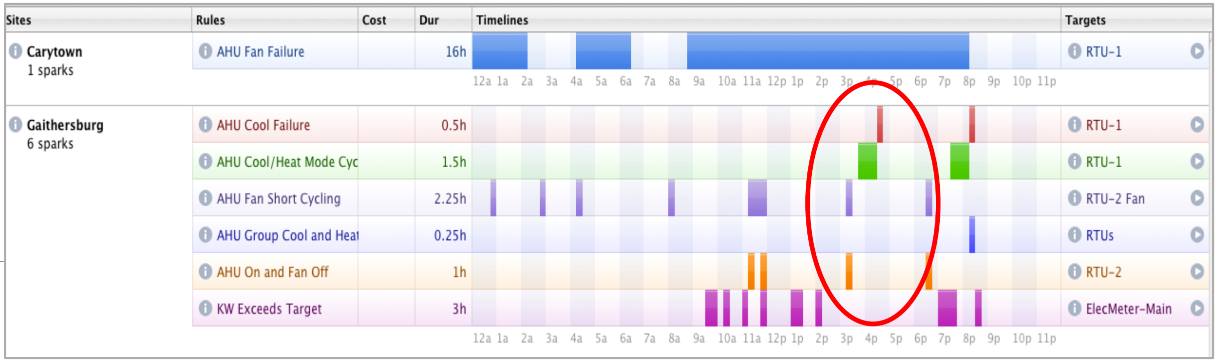
But Still a Big Challenge…

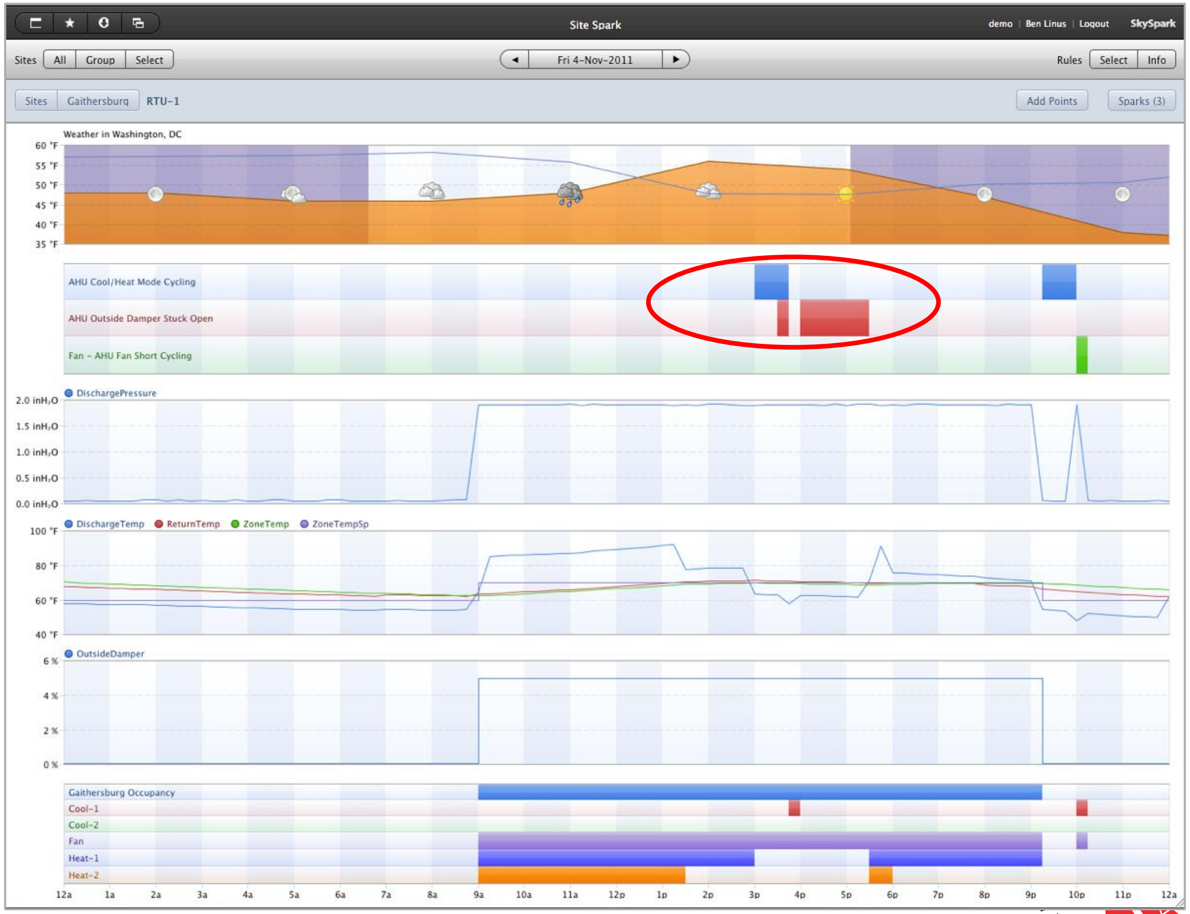
Who's watching to make sure?

- Who verifies that what they are doing is right?
- That control strategies were well designed?
- That assumptions were (are) correct?
- That they are still running as expected… haven't been interfered with or overridden – *a common problem*
- That sensors and other devices have not degraded, performance hasn't drifted…
- Buildings are too complex for this to be done solely by humans
- Too much data… systems too complex…

Analytics Provides the Solution

- Automatically scans your data to detect patterns
- Automatically generates views on issues detected
- From portfolio summaries to equipment detail views
- Continuous, ongoing analysis based on your domain knowledge – *an ever-present expert*





Use Case: Detecting Faults, Deviations, Anomalies, Loss of Efficiency

Available Data Influences Effective Analytic Rules

- The analytic rules you can deploy are always related to the available data available so that's the first question to answer – what data is available?

- For example, if we have only energy consumption data available (KW and KWh), rules can be used to identify patterns representing issues like buildings running 24 hours a day, starting early or running too late, load profiles, and demand peak patterns

Examples of Common Analytic Rules

- Detect improper operation of economizers
- Identifying simultaneous Heating and Cooling
- Short Cycling, Long Cycling, Excessive Mode Transitions
- Issues with Zone or Room Thermostat Dead-bands
- Non-functioning sensors
- Comfort Conditioning Performance
- Schedules not being followed (identify via metered energy use, air flow, equipment status and other means)
- Loss of heat transfer efficiency - delta between return and supply is less than threshold or design

Example: Detail on Economizer Operation Rule

Issues:

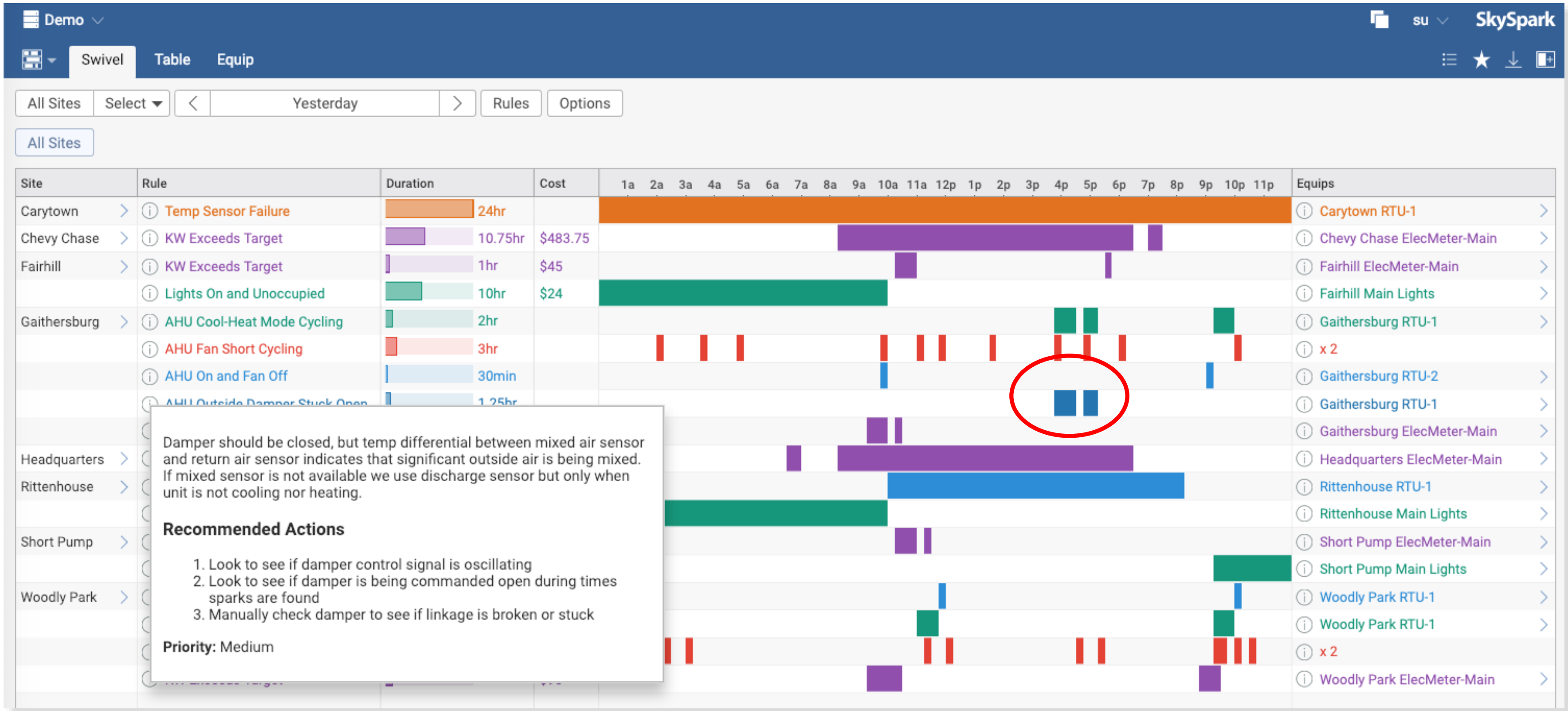
1. Non-modulating damper
2. Temperature sensor problems (including missing/out of range sensor values)
3. Economizer operating when it should not
4. Economizer not operating when it should
5. Ventilation greater than needed
6. Inadequate ventilation

Required data:

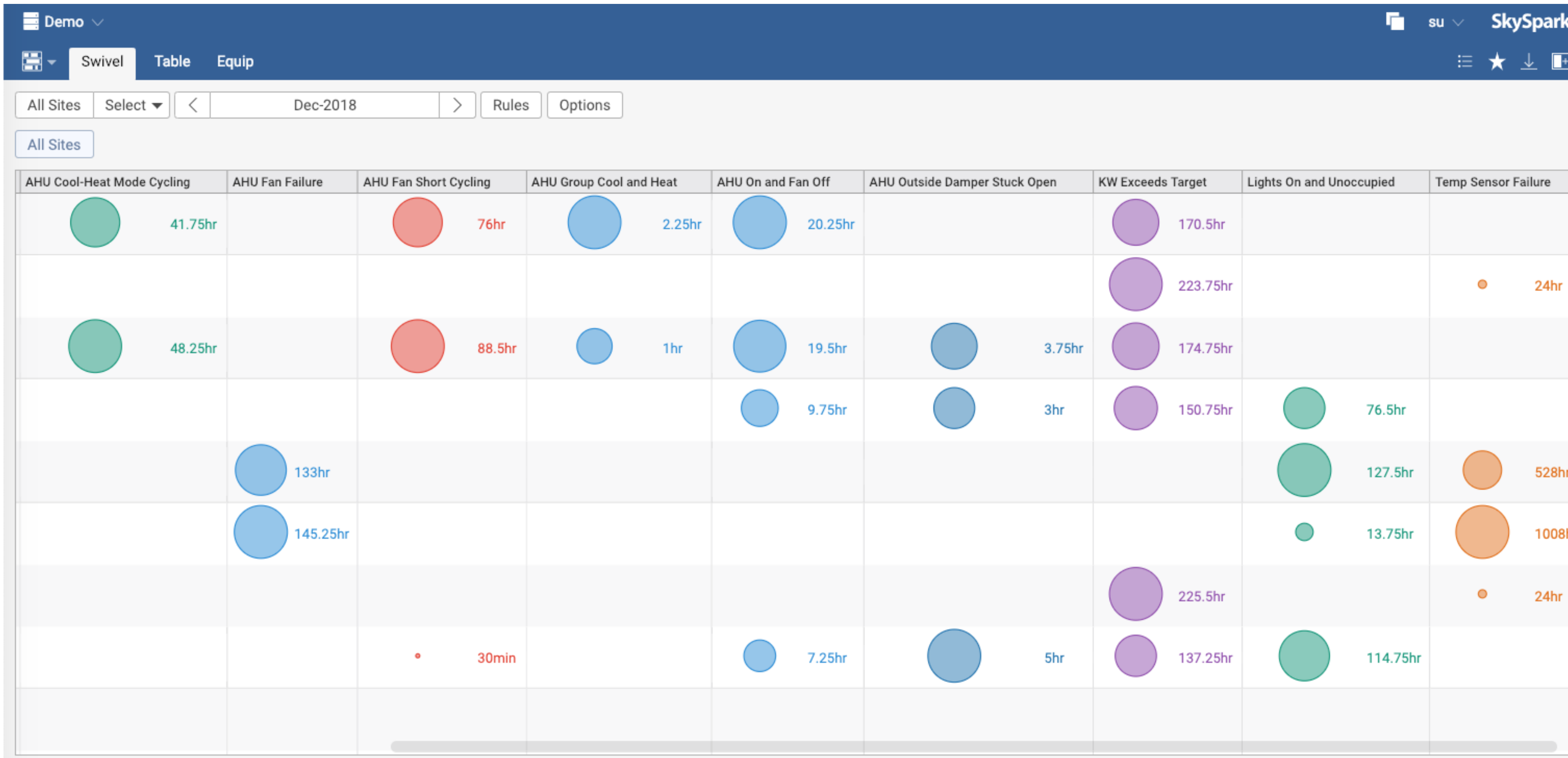
- Mixed air, return air, and outdoor-air temperatures (enthalpies for enthalpy-controlled economizers)
- Damper signal,
- Supply fan on/off status, and
- Heating and cooling on/off status or heating and cooling valve signal
- The measured data can be at any interval but preferably 1-minute (1-minute, 5-minute, half-hourly, or hourly, etc.)

CONTINUING EDUCATION AIA

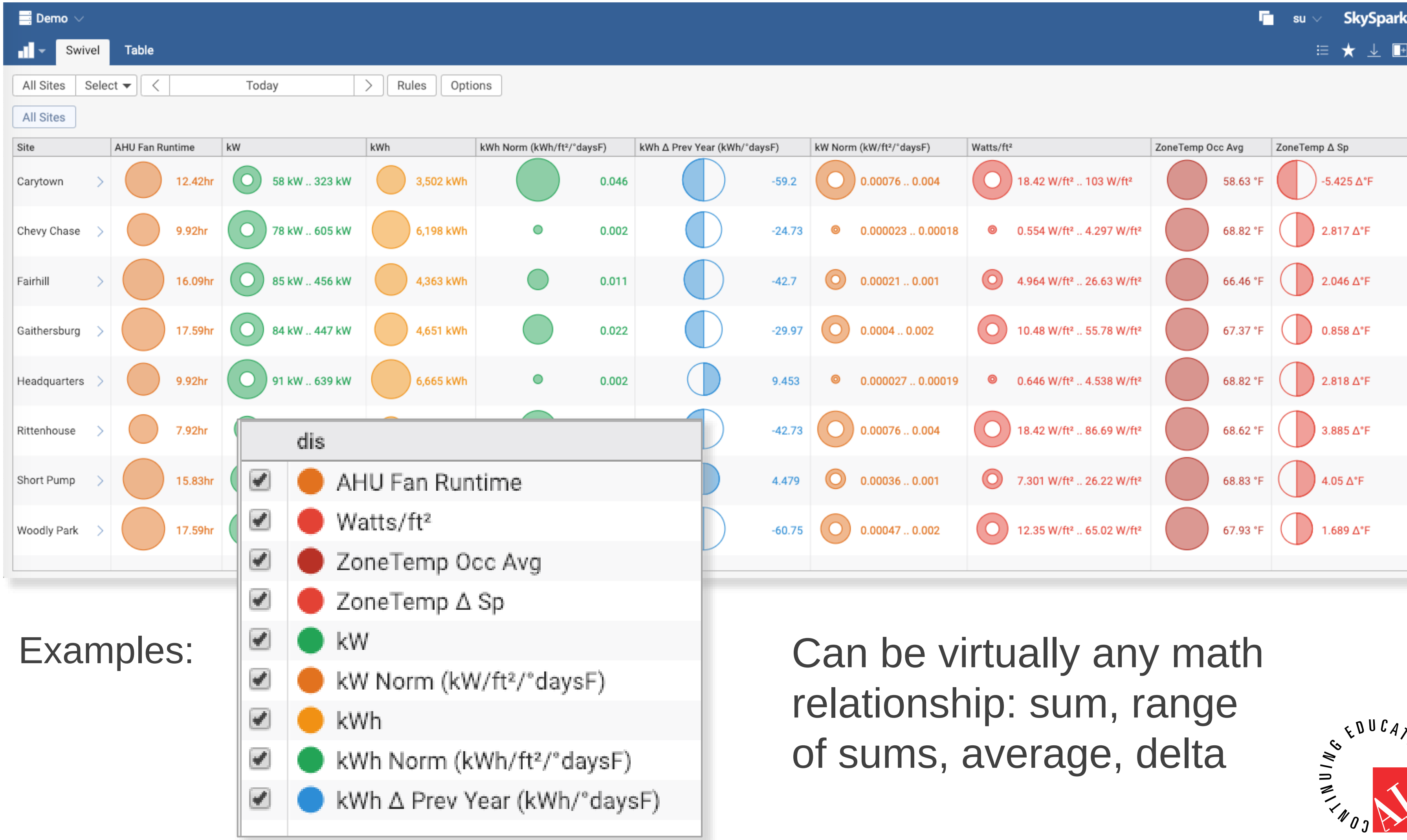
Presenting Results Detected by Analytics:
Timelines – Show Operating Patterns of Faults/Issues



Presenting Results of Issues Detected by Analytics: **Bubble Charts** – Show the magnitude of various factors (duration, cost, frequency)



More Tools of the Trade:
Key Performance Indicators – **KPI's**



Site	AHU Fan Runtime	kW	kWh	kWh Norm (kWh/ft²/°daysF)	kWh Δ Prev Year (kWh/°daysF)	kW Norm (kW/ft²/°daysF)	Watts/ft²	ZoneTemp Occ Avg	ZoneTemp Δ Sp
Carytown	12.42hr	58 kW .. 323 kW	3,502 kWh	0.046	-59.2	0.00076 .. 0.004	18.42 W/ft² .. 103 W/ft²	58.63 °F	-5.425 Δ°F
Chevy Chase	9.92hr	78 kW .. 605 kW	6,198 kWh	0.002	-24.73	0.000023 .. 0.00018	0.554 W/ft² .. 4.297 W/ft²	68.82 °F	2.817 Δ°F
Fairhill	16.09hr	85 kW .. 456 kW	4,363 kWh	0.011	-42.7	0.00021 .. 0.001	4.964 W/ft² .. 26.63 W/ft²	66.46 °F	2.046 Δ°F
Gaithersburg	17.59hr	84 kW .. 447 kW	4,651 kWh	0.022	-29.97	0.0004 .. 0.002	10.48 W/ft² .. 55.78 W/ft²	67.37 °F	0.858 Δ°F
Headquarters	9.92hr	91 kW .. 639 kW	6,665 kWh	0.002	9.453	0.000027 .. 0.00019	0.646 W/ft² .. 4.538 W/ft²	68.82 °F	2.818 Δ°F
Rittenhouse	7.92hr				-42.73	0.00076 .. 0.004	18.42 W/ft² .. 86.69 W/ft²	68.62 °F	3.885 Δ°F
Short Pump	15.83hr				4.479	0.00036 .. 0.001	7.301 W/ft² .. 26.22 W/ft²	68.83 °F	4.05 Δ°F
Woodly Park	17.59hr				-60.75	0.00047 .. 0.002	12.35 W/ft² .. 65.02 W/ft²	67.93 °F	1.689 Δ°F

Examples:

Can be virtually any math relationship: sum, range of sums, average, delta

Alarms vs Analytics
Understanding the Differences

vs Analytics

- An alarm is when you are on the gurney in the ER
  Analytics are the lab tests you take every year to stay out of the ER
- Alarms require that you fully understand the issue ahead of time so you could set them up – have to be pre-programmed
  Analytics find patterns & issues you couldn't have foreseen
  Can be added at anytime
- Controller-based alarms deal with control system data
  Analytics combine operational, energy, production, facility and corporate data to show patterns and correlations across your portfolio of device data
  - Correlation examples – equipment type, age, material, vendor, weather effects, production factors, etc

Alarms vs Analytics
Understanding the Differences

vs Analytics

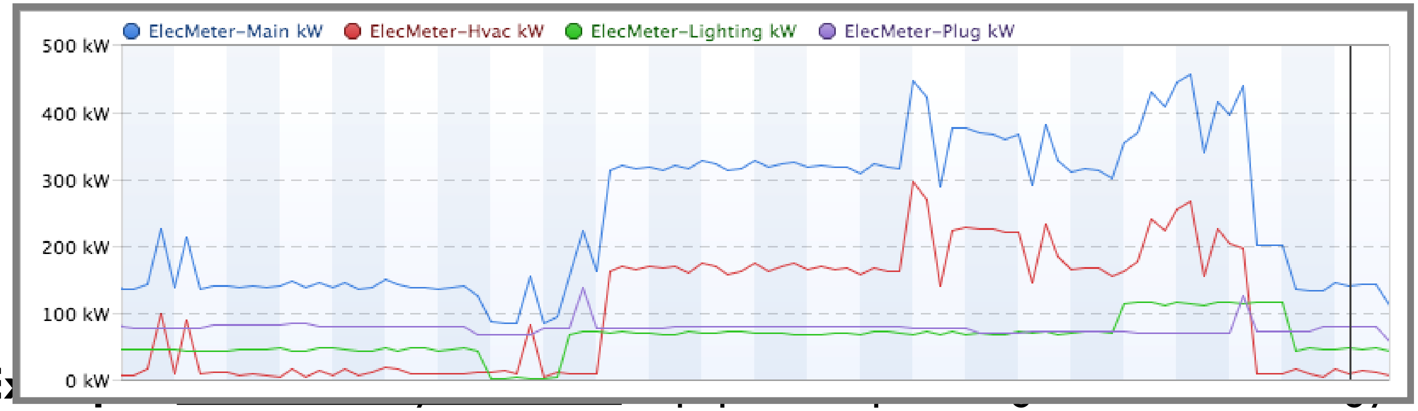
- An alarm is a value compared to a limit “now”
  Analytics look at patterns or signatures in the data – and can include multiple data sets from different systems over different time periods

- Alarms require “touching” the end device programming
  Analytics allows you to add rules as your understanding increases WITHOUT needing to reprogram the end device

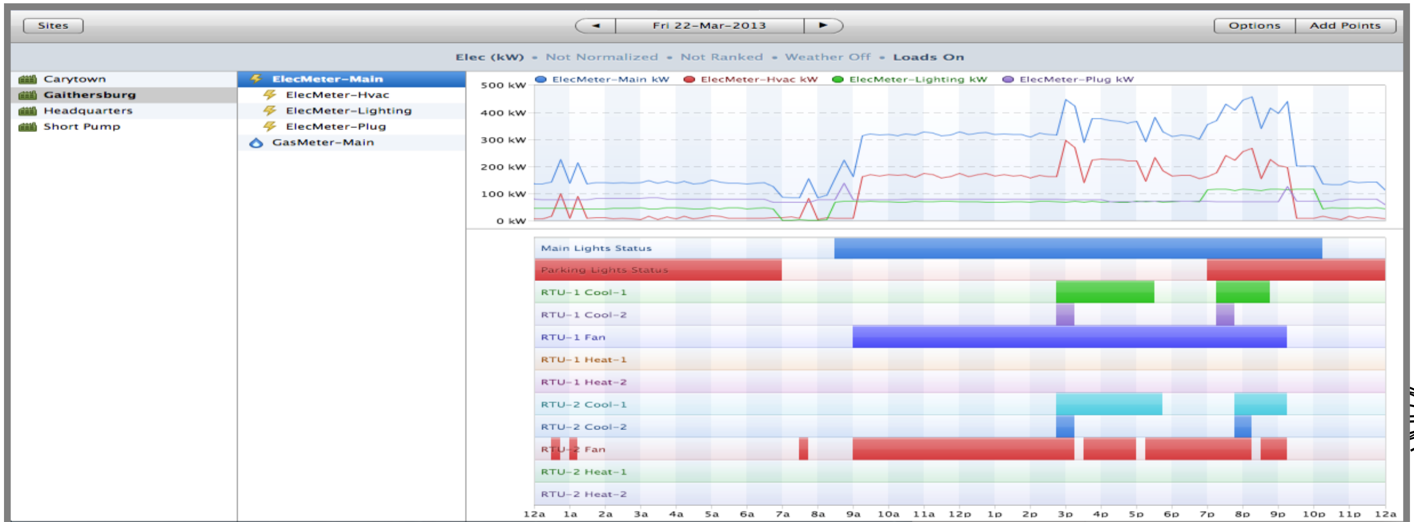
- Alarms often “cascade” overwhelming operators
  Analytics can often replace majority of non-productive alarms – they better explain what is happening and why

Analysis vs Analytics

- **An analysis:** Generate a graph of energy consumption across a specific time. A user would then look to discern patterns, such as peaks or toughs and their duration



- **Analytics Ex** consumption across a specific period of time. This enables users to see how equipment operation influences energy consumption patterns



But Analytics Don’t Save Money !!!

Getting Value from Data Analytics: The Last Mile

- To get value from data analytics organizations need to be prepared to act on the results
- If I could walk into your building and magically detect 100 problems could you address them?
- How quickly? What if they require capital $
- What if they would exceed your planned budget?
- Even if they had a 1 month payback?

Analytics Are Not a Thing

Analytics Is a Journey

- Applying analytics to building systems is not like simply buying new equipment with lower energy consumption
- Not possible to calculate the exact savings ahead of time – can you sell that?
- Don’t look at it as an “install it and forget it solution”
- Analytics are a tool – enables us to see how building systems are really performing
- Identifies faults, deviations from expected performance, anomalies…
- All of which represent opportunities for savings…
- …But require action to achieve benefit

Its not an LED lightbulb!

CEU Questions

1. Name 3 methods for acquiring data from building systems
2. What does a Tariff engine do to energy consumption data
3. Choose all correct answers:
   Project-Haystack.org provides:
   A) a standard naming convention for BAS points
   B) a standard metadata approach to represent the meaning of data items gathered from different systems
   C) a standard for communication to acquire building data
4. Name 2 common energy related KPI’s
5. Name 2 common rules applied to air handlers
6. True or False: Analytic savings can be calculated in the same way as installation of LED lightbulbs
7. True or False: It is possible to determine whether a building is operating according to an occupancy schedule by analyzing interval meter data
8. True or False: Analytics is simply another name for alarms typically found in a BAS

This concludes The American Institute of Architects Continuing Education Systems Course

Using Data Analytics to Automate and Enhance the Commissioning Process

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