SkyFoundry

Real World Examples of Analytics in Action

A Collection of Case Studies

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Analytics in the Real World

One of the most rewarding parts of our business is receiving examples from customers that show how SkySpark directly helped them identify and resolve critical operational issues affecting comfort, energy use and financial results.

The examples in this collection demonstrate not only the power of SkySpark analytics to identify operational issues but also show just how hard-to-find and unexpected those issues would be without analytic capabilities like those provided by SkySpark.

Whether its detecting improper operation of physical equipment due to failure, or identifying issues with control sequences, or calculating and watching KPIs and trends, SkySpark works with the data you have to address the complexities of operating facilities and equipment systems in the real world.

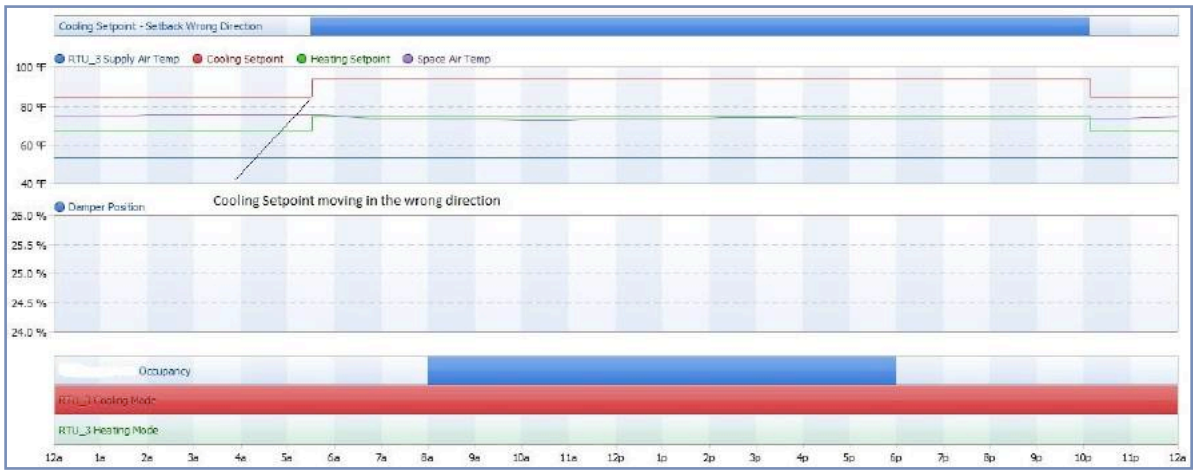
Detecting Root Causes of Comfort Issues in a Commercial Office Building

Analytics Takes You Right to the Issue

We are always excited to get letters from customers showing the results they have achieved using SkySpark. The letter below demonstrates not only the power of analytics to identify operational issues but shows just how hard-to-find and unexpected those issues often are. Would you expect to have this problem in a high-end office building with new controls?

Customer letter: We have a couple of buildings in the mid-Atlantic area that were having some major problems during the hot summer. These buildings were recently retrofitted with new controllers. The local team suspected it had something to do with setpoints and asked if I could use SkySpark to analyze setpoints and temperatures. Surprise! Surprise! Look what we found. Over 50 of the 372 terminal units had one or more of these problems. There is no way busy operators would have been able to spend the time to find all these issues with manual analysis. Thanks again for the powerful platform!"

Issue 1: Cooling setpoint working in wrong direction – making hot spaces hotter!



Issue 2: Heating setpoint working in wrong direction – making cold spaces colder!

SkySpark as a Commissioning Tool

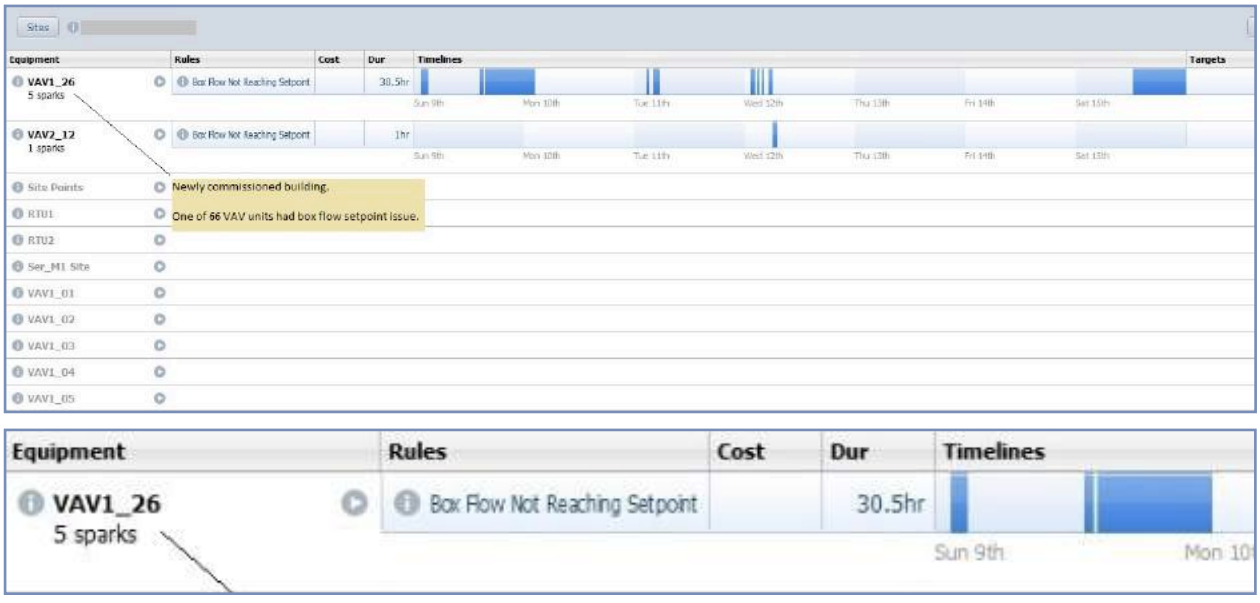
Buildings are complex. No two are exactly alike and virtually every new building is a one of a kind creation. Even when considerable effort is applied to commission equipment systems for optimum performance important issues can be missed. One of the great benefits of SkySpark analytics is that it looks at all of the data all of the time, continuously evaluating rules to detect patterns that represent deviations from optimal performance. This makes it an ideal tool to support the initial commissioning process and to provide automated, ongoing monitoring-based commissioning. Here's a real-world example demonstrating the value of SkySpark in commissioning.

Location: Building type – Class A suburban office building, Southeastern US

Customer Issue Description: "We have had several new buildings come online recently. We have made a concerted effort to bring these buildings into SkySpark quickly and use SkySpark as a tool to support the commissioning process. The following examples show the value SkySpark adds to the commissioning process.

These examples were run within the first couple of weeks after the contractor was finished with manual commissioning of the building. SkySpark identified issues with VAV box operation that had been missed in that commissioning process. It just goes to show that even when you are focused on assessing equipment operation and have allocated resources, there are just too many pieces of equipment and too many data points to manually review and verify."

The Issue: VAV Box Airflow Not Reaching Setpoint: The Spark View shows the issues including description, frequency, duration and the relationship of the Spark to specific equipment.



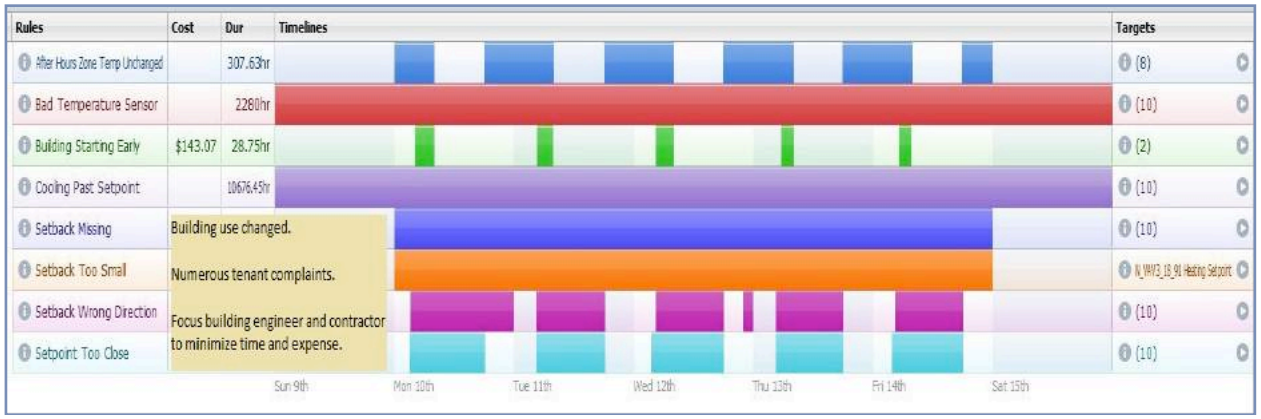
Zoom in detail of the Spark

In this case, a SkySpark rule identifies VAV boxes that are unable to reach the airflow setpoint being called for to satisfy the space comfort conditions. One of the key goals of the commissioning process is to insure that all VAV boxes are able to meet airflow setpoints.

Another issue that SkySpark Identified was overcooling caused by VAV boxes delivering too much airflow to the space, which is a symptom of incorrect balancing. Given that fan horsepower varies with the cube of the airflow ("the fan law"), this can result in significant energy waste in addition to comfort problems.

Identifying the Things That Matter to Streamline Repairs and Corrections

Re-commissioning can be an even bigger challenge than initial commissioning because of limited budget and resources to look at balancing and operational issues across the building when there is a change of use. In another recent example, a change-of-use in a building threw the systems out of balance. Numerous tenant complaints were received. SkySpark was used to identify issues enabling the maintenance technician and contractor to minimize the time and expense needed to research and resolve the issues.



The SkySpark view on the previous page shows 8 significant operational issues that were detected – from setpoint issues and broken temperature sensors to buildings systems starting too early. This information enabled the organization to focus efforts on the "things that matter".

SkySpark case study examples are fascinating, but not unique. Virtually all buildings – old and new – have operational issues. The challenge is to find them in order to eliminate the waste, cost and comfort impacts they cause.

SkySpark is unequaled in its ability to work with systems and data of all types.

SkySpark supports a variety of data acquisition connectors: Bacnet IP, Modbus TCP, Obix, Haystack, SNMP, Sedona, OPC UA, MQTT, SQL, CSV import (manual batch or automated), and a REST API. SkySpark also includes a connector development toolkit.

SkySpark as a Preventative Maintenance Tool

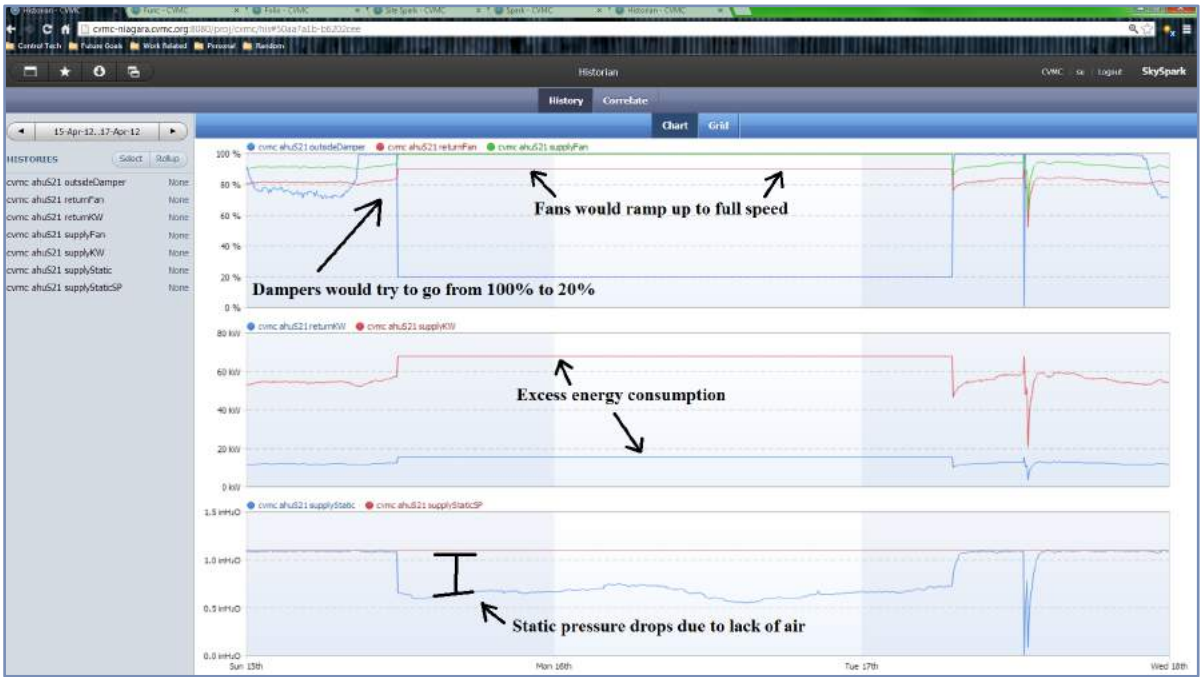
Sensor and equipment failures are not always obvious

Introduction: Large scale buildings usually have a preventative maintenance (PM) program of some kind for their HVAC system. The PM usually includes scheduled filter changes, replacement of belts, and other parts and pieces of major equipment, but one item that is commonly left out is calibration of the controls and sensors on the HVAC equipment. The old way of taking care of the controls was "if it hasn't failed then it still works", but what most people don't understand is that sensors and controls can still be functional but not accurate. These non-calibrated devices can result in excess energy consumption that goes unnoticed for months or even years. SkySpark can be used to identify when calibrations need to be done and what kind of energy impact it will have if left alone. SkySpark can also make a HVAC controls PM more cost effective by autonomously identifying when maintenance work needs to be done and reporting the energy savings resulting from various fixes.

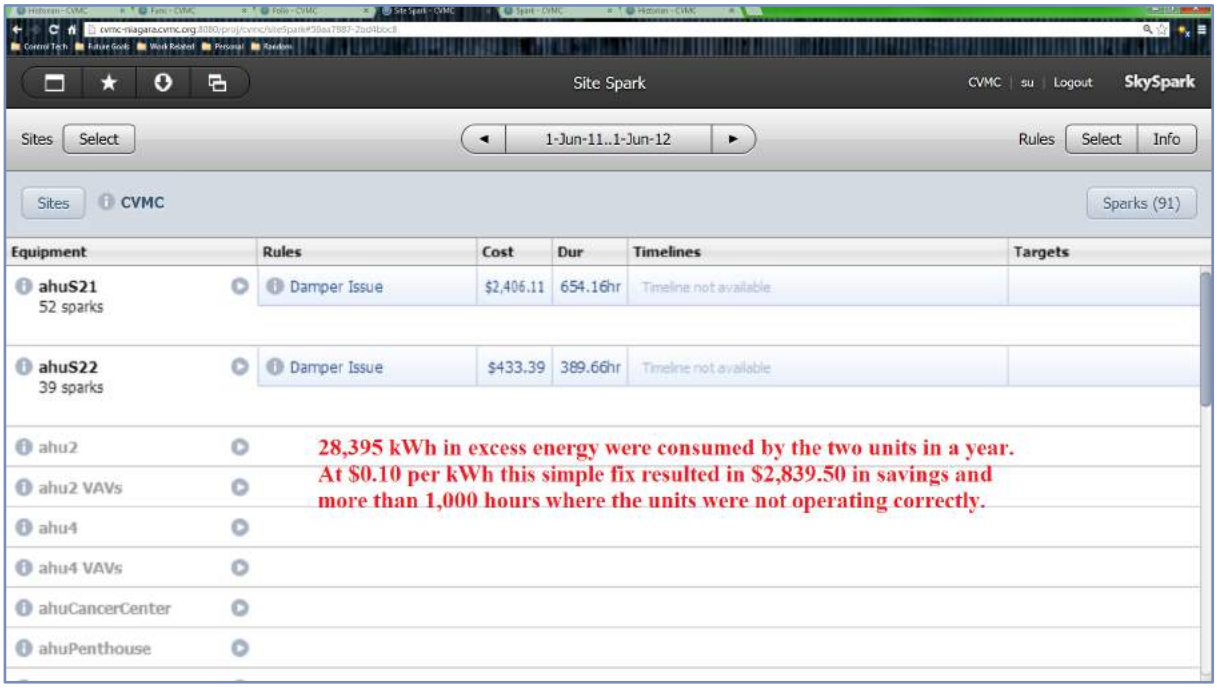
Location: Building type – Large scale hospital (>500,000ft^2), Vermont US

Issue Description: The hospital had a PM program for all the air handling units (AHU) which included frequent filter changes, belt changes, and cleaning of the coils, but there was no program in place for calibrating the controls and sensors for the equipment. The majority of the units didn't even include commissioning of the controls during the original installation. It was also discovered that there were several sensors and control devices that were 20+ years old that have never been calibrated. With the help of SkySpark there were several issues that were identified and for some of the problems SkySpark was able to report the costs of the excess energy being used that went unnoticed.

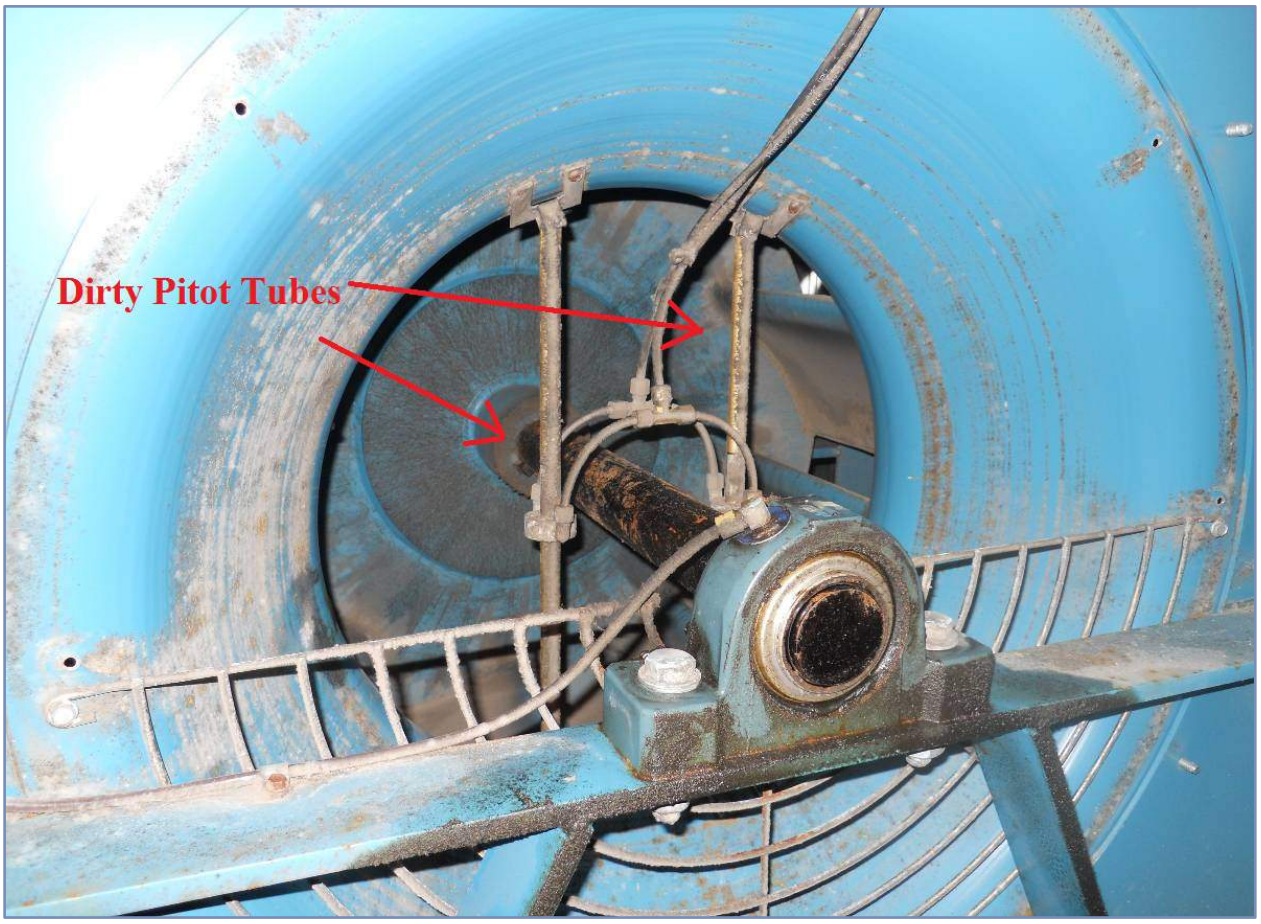
Improper damper actuator linkage: There are two older AHUs in the hospital that were originally controlled pneumatically and in 1996 were converted to direct digital controls (DDC). The return air and outside air dampers were not mechanically linked and each had their own actuators. Over the years the actuators eventually failed and were replaced. Once replaced the facility staff would ensure that the dampers travelled 0-100% as expected but one thing that was overlooked was the fact that the return air and outside air dampers would not travel at the same speed. The economizer control for the unit would modulate the outside air dampers to 100% and the return air dampers to 20%, but once the outside air got too hot the dampers would switch, outside went to 20% and return went to 100%. The outside air dampers would close faster than the return dampers which resulted in so much pressure that the return air actuator would seize and the dampers would remain closed. The supply fan would then have no place to pull air from and the static pressure would drop. This caused the supply fan VFD to ramp up to 100% in an attempt to deliver more air. At this point excess electricity was being used by the fans running at full speed and comfort issues were emerging from the lack of air to the VAVs. Eventually the facility staff would get complaints and they would restart the AHUs, and the overall problem was labeled as "something those AHUs do every now and then".



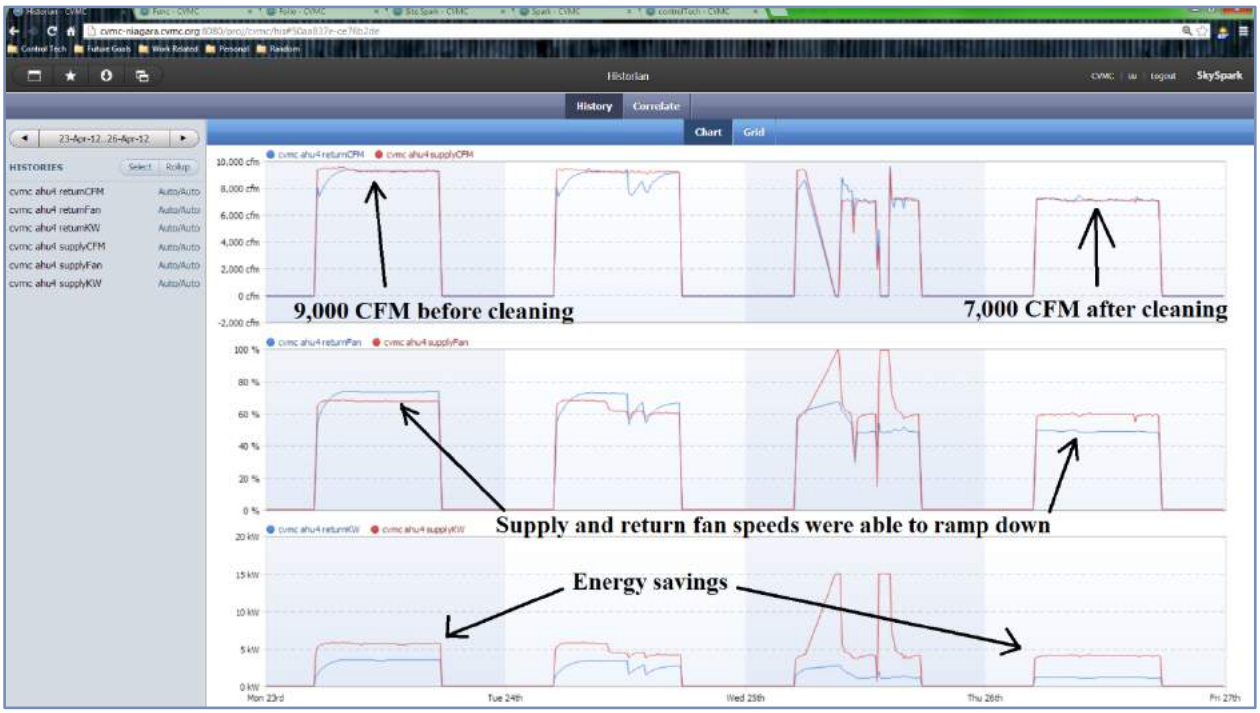
SkySpark helped to identify when this issue was occurring and the resolution was to adjust the linkage between the actuator and dampers so they travelled at the same speed. SkySpark was then used to calculate how many times this issue occurred in the past year and how much excess energy was used due to the fans ramping up to full speed instead of normal operation. Now SkySpark is in place as a monitoring based commissioning system so if this issue occurs again in the future the hospital will be able to respond immediately and avoid excess energy consumption and comfort issues.



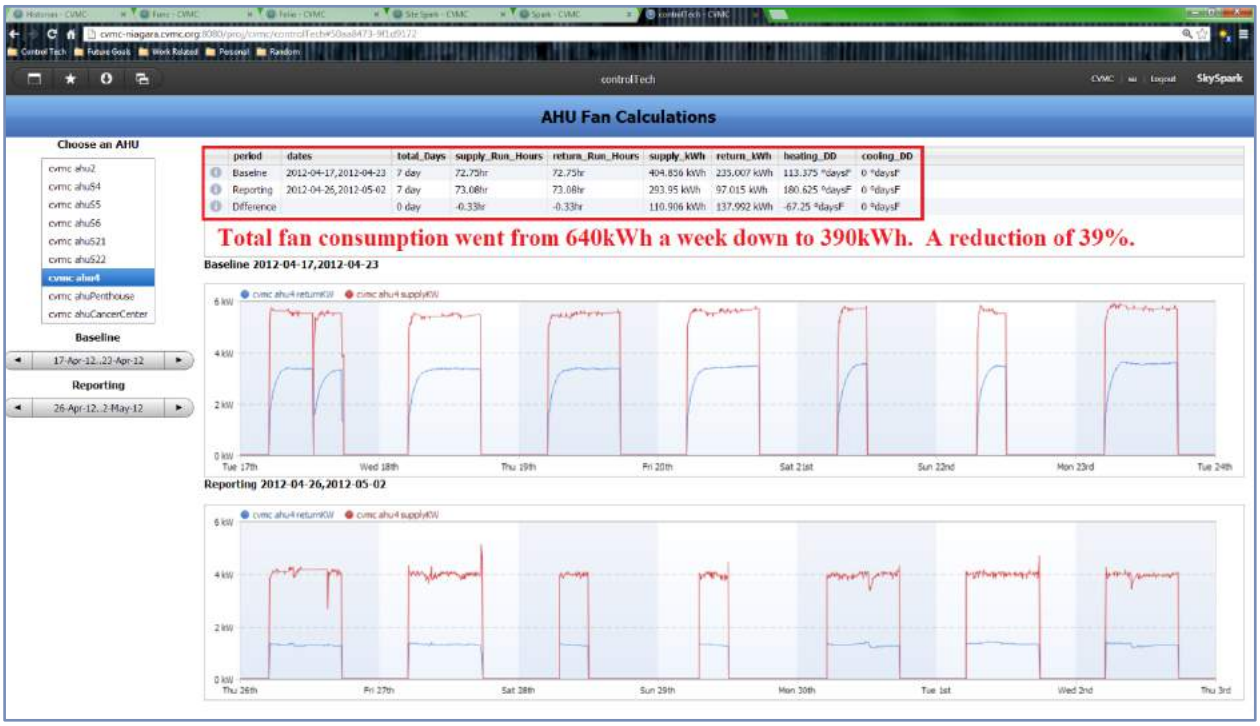
Airflow station maintenance: Airflow stations in AHUs are commonly used to monitor and maintain proper airflow in a building. These devices use pitot tubes and pressure transducers inside the unit to measure air pressures and calculate the flow. These pitot tubes must be kept clean to read accurately and even with frequent filter changes these tubes can become dirty. One AHU at the hospital had this issue on the supply fan where it had never been cleaned and was reading a higher airflow then what it actually was. To maintain proper pressure in the space the return fan VFD would match the airflow of the supply.



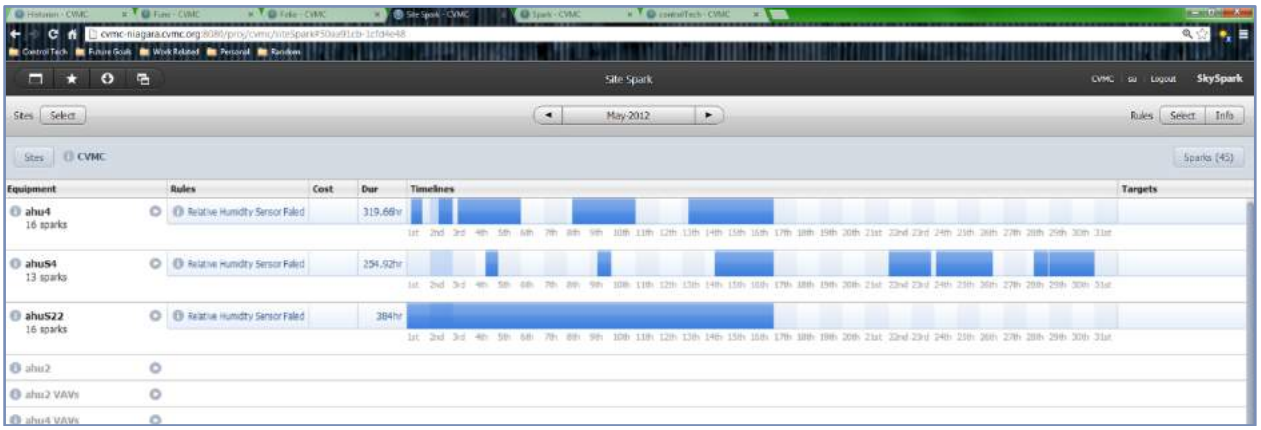
With the dirty pitot tubes reading a higher airflow on the supply side the return fan in turn ran at a higher speed to try and maintain the same return airflow. This resulted in excess fan energy and an unbalanced space with airflow and pressure. Simply cleaning the tubes allowed the airflow station to read a lower accurate airflow and the fan VFDs were able to ramp down which saved energy and produce a better balanced space.



After cleaning the pitot tubes SkySpark was used to calculate the energy saved. In the first week alone there was a reduction of 250 kWh. Assuming a 52 week hospital year that is 13,000 kWh saved or at $0.10 a kWh $1,300 in savings from about 15 minutes of cleaning. SkySpark can quickly calculate and report savings from simple PM measures that would normally require metering or a measurement and verification process.



Failed sensors: Sometimes sensors can fail and get overlooked for extended periods of time. Relative humidity sensors are notorious for having a short life and when they fail it isn't always clear. If the facility staff is lucky the sensor will fail to 100%RH and it will be controlling something that would start acting different than normal and it will be discovered relatively quickly. In most cases though the sensor will slowly fail and drift within 5%-10% of the real %RH. This is much harder to notice and normally would only get discovered through a calibration or PM process. SkySpark can analyze sensitive sensors like relative humidity sensors and determine when they start to drift out of an acceptable range.



Summary: A preventative maintenance program for the HVAC system in a large facility is an important process that keeps a facility running smoothly and efficiently. The control systems are commonly overlooked for the PM, but failed sensors and controls that go unnoticed can result in poor equipment performance and excess energy use. SkySpark can help make a controls PM more cost effective by analyzing the data and determining when devices fail or are drifting out of range directing service people to important issues. SkySpark can also calculate, visualize and report what the energy impact is of failed devices different pieces of equipment.

Detecting Unexpected Demand Peaks

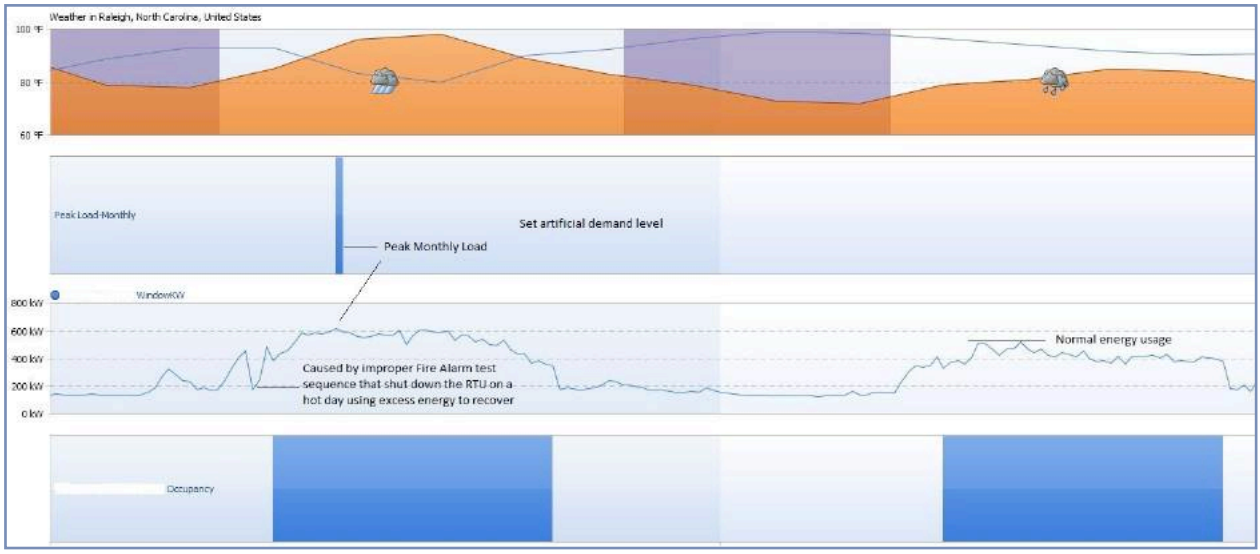
The Fault That Keeps Costing You Money

One of the great benefits of SkySpark analytics is that it discovers issues no one is aware of. That also creates a challenge in helping building owners and managers understand the benefits and financial value that analytics can bring to their facilities. Real world examples like the ones captured in our Case Studies show the role of analytics in helping building owners reduce and avoid costs. Here's an interesting example of how anomalies in electrical demand were detected and charges were avoided.

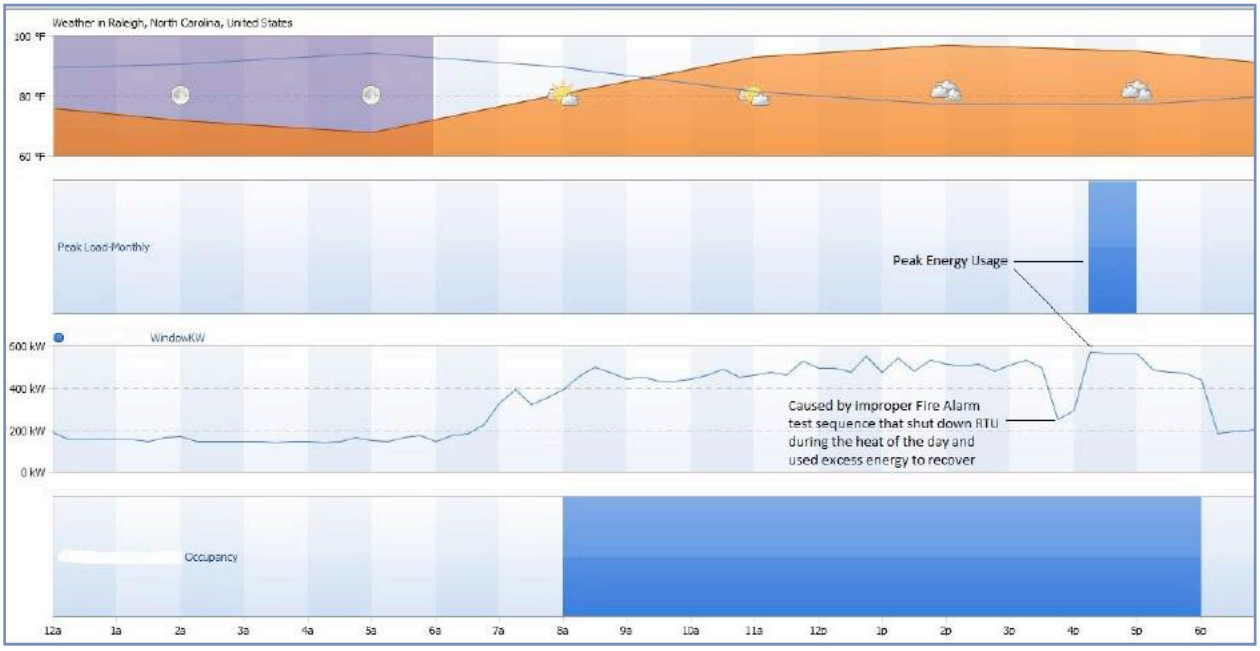
Location: Building type – Class A suburban office building in a market with significant demand charges.

Issue Description: A maintenance technician wasn't trained in the proper Fire Alarm test sequence and ended up shutting down the air handler on a hot day. The air handler then used an excessive amount of energy to recover and set an artificial demand charge threshold. A SkySpark rule identified the issue with a spark and drew attention to peak energy use at a time when it wouldn't have been expected. In this case, significant demand charges were avoided with a call to the utility to explain what happened. Training of the technician insured that it wouldn't happen again.

The Spark View shows the issue clearly



The SkySpark views show the weather conditions, the Spark generated by the demand peak, a plot of actual demand, and the occupancy of the building. (Comments added for clarity).



Zooming in on the Spark view timeline shows more detail and the clear impact made on electrical demand when the AHU was shut down and then started back up. SkySpark's unique visualization tools help operators understand exactly how their buildings are operating and where improvements can be made.

SkySpark case study examples are fascinating, but not unique. Virtually all buildings – old and new – have operational issues. The challenge is to find them in order to eliminate the waste, cost and comfort impacts they cause.

SkySpark Analytics in Monitoring & Verification

*Tools to Support **IPMVP** Projects*

Introduction: Pacific Northwest National Labs (PNNL) has a building retuning program that is designed to use the building automation system (BAS) along with firsthand knowledge of building use by the occupants and facility staff to identify no-cost/low-cost energy saving solutions for the HVAC system. The majority of these solutions can be conducted through the BAS with little to no hardware or equipment changes. Typically, once all the solutions are implemented the total savings is in the range of 5%-20%. It is sometimes difficult with energy saving projects to quantify the savings since it is an absence of energy that is trying to be measured. This can become even more difficult when the energy that is being saved falls within the monthly variance in the whole facility's energy use. Measurement and verification (M&V) is the process of developing a plan to estimate energy savings by creating a baseline period (before the project) and a reporting period (after the project). The data collected is analyzed and calculated to accurately and transparently estimate the savings realized by the project

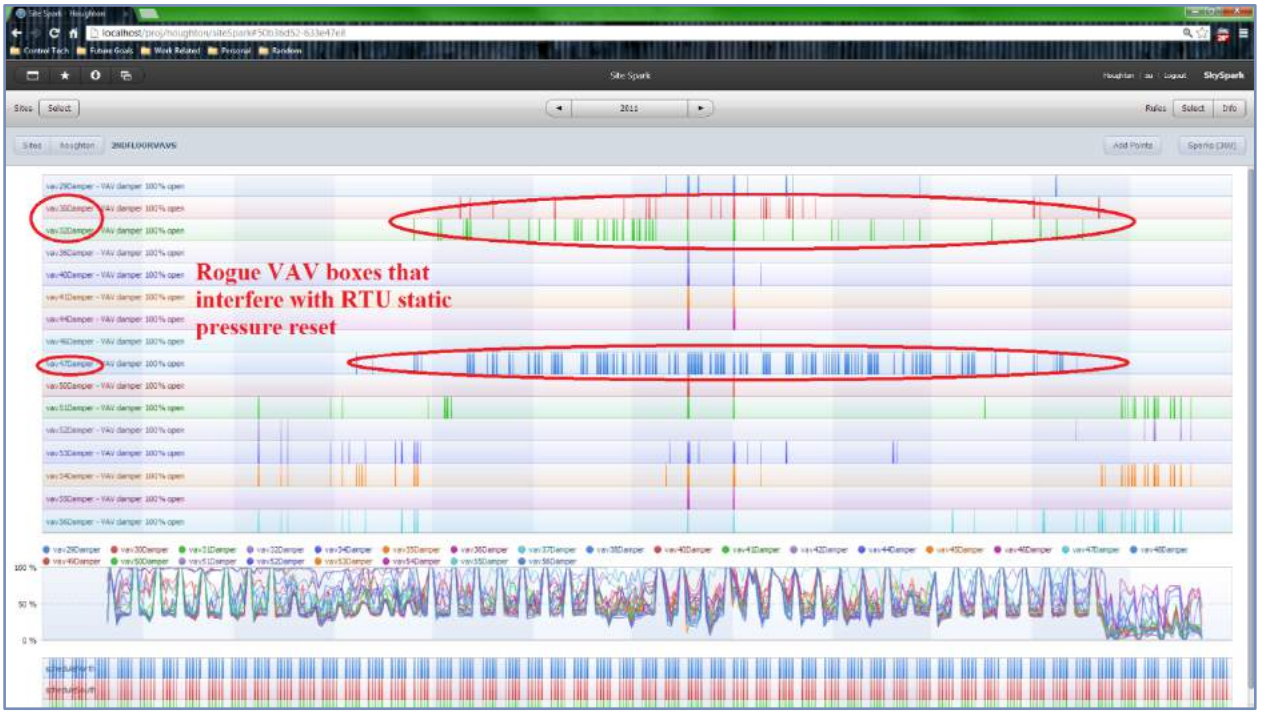
M&V is important because it can help determine how cost effective a project is and make similar future projects more viable. There are some issues with the process though that can impede whether M&V is conducted or if it even produces accurate results. The process of deploying temporary meters and data loggers and the time involved with collecting and analyzing the data manually can become challenging and expensive, and if the data gathered is lost or gets corrupted then the accuracy of the results may not be precise enough to come to an absolute conclusion. SkySpark can help with identifying building retuning strategies and determine how effective the strategies would be before they are implemented. SkySpark can also simplify the M&V process by collecting and analyzing the data autonomously and can use potentially several years' worth of previous data to compare to real time data to see if the savings persist for the future. This Case Study example provides an overview of such a project and the results produced by SkySpark.

Location: Building type – Medium size state office building (50,000ft^2), Vermont US

Issue Description: Control Technologies was trained by PNNL to provide building retuning as a service and certified with the International Performance Measurement and Verification Protocol (IPMVP) to conduct M&V projects. With this particular state office building SkySpark was used as a tool to identify a number of retuning strategies. There were several retuning strategies for the HVAC system and M&V was required for each strategy. It was decided to use the IPMVP method of M&V as the primary way to identify the savings and then use SkySpark as a second method to validate the first method and to also determine the effectiveness of SkySpark as an M&V tool.

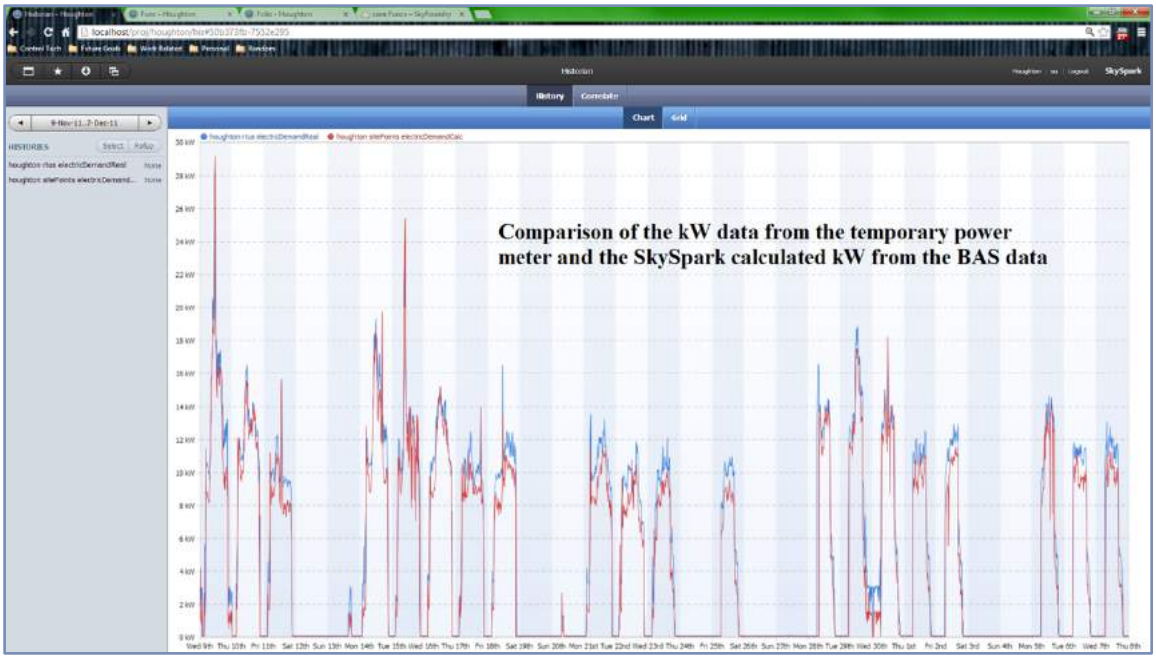
Issue 1 - Rogue VAV Identification: This particular building had a typical variable air volume (VAV) system with variable frequency drives (VFD) on the supply and return fans of three roof top units (RTU). There were several retuning strategies identified with this system that needed to be implemented. Some of the strategies focused on using the static pressure reset on the RTUs to ramp down the VFD speeds. Static pressure reset is designed to increase or decrease the static pressure set point (SP) based on the VAV box with the highest cooling demand or simply the VAV with the most open damper. Decreasing the SP causes the fans to ramp down and save energy but maintains the same comfort levels required. Ideally there would be a small handful of boxes all at 95% open dampers and static pressure SP would be somewhere below maximum, but what commonly happens is there are one or two VAV boxes that are always 100% open and forcing the static pressure SP to maximum. These VAV boxes are called rogue VAVs and can be caused from being undersized, a mechanical or control issue, or even the space use changes without re-evaluating the HVAC requirements.

Implementing retuning strategies that use the static pressure reset without fixing any rogue VAV boxes would not produce the desired energy savings. Before any M&V could be done the rogue VAVs had to be identified and fixed first. The problem with finding rogue VAVs is that they usually occur in the summer during the cooling season and it has to be determined if they are truly rogue VAVs all the time or if they just have an occasional high cooling demand. With 83 VAVs under three RTUs and a year's worth of data this can become time consuming and difficult to separate a rogue VAV from a normal VAV. SkySpark was used to quickly analyze a year's worth of data to identify all the rogue VAVs. Of the 83 total VAVs SkySpark found 11 that were rogue and causing the fans to run at a higher speed then they needed to.



Issue 2 – VAV and RTU Retuning: This state office building had several different departments, all with their own schedules and hours of operation. The RTUs and VAVs all shared the same schedules which started between 3am and 4am depending on the morning warm-up and ended at 8:30pm. The majority of departments operated from 6:30am – 4:30am with only a small handful running till 8:30pm. It was determined to schedule each VAV individually based on the department it served and when the space was unoccupied close off the VAV so the RTU fans could ramp down in the afternoon. Another strategy implemented was not allowing the RTUs to be used for morning warm-up and instead use only the baseboard radiation throughout the building thus saving fan energy in the morning.

Once these strategies were implemented the energy savings needed to be estimated for the M&V report. A power meter on the VFDs was used to gather four weeks of kW readings (two weeks for both baseline and reporting periods). The data gathered was then used with the IPMVP method to estimate the savings. SkySpark was also used to estimate the savings, but instead of using four weeks of temporary logging data SkySpark used the VFD speeds from the BAS to calculate the kW for the entire previous year along with the most recent data to calculate the savings.



In the end there was **40% reduction in the total kWh for the three RTUs. The IPMVP method estimated the savings at 18,987kWh or $1,593.00 a year and SkySpark estimated 19,090kWh or $1,601.64, a 0.5% error between the two.**

Summary: SkySpark can help identify retuning strategies by analyzing years' worth of data quickly and finding recurring issues. When M&V needs to be done to confirm the project was a good energy savings project SkySpark can use the data to estimate the savings without using temporary data logging.

For more detail on how SkySpark supports the IPMVP process refer to this detailed document on the subject: https://skyfoundry.com/file/337/Applying-SkySpark-for-MV-Using-the-Intl-Performance-MV-Protocol.pdf

Detecting Issues Causing Energy Waste in a School

Simple Issues Can Remain Hidden Until Analytics are Applied

Buildings and equipment systems are complex. The building automation systems that orchestrate their operation contain hundreds (and even thousands) of sensors and electronic components. When they outright fail, building occupants notice because they get hot (or cold), or the lights go out. But what happens when control systems malfunction and produce erroneous data? Typically, the control system responds to the bad data and controls equipment incorrectly, resulting in energy waste and other operational problems that can continue unobserved for years. The case study below is a real-world example demonstrating the value of SkySpark in detecting sensor failures that resulted in significant energy waste.

Location: Redmond Middle School, Lake Washington School District (LWSD), Washington.

The Issue: AHU Simultaneous Heating & Economizing – Air handling units simultaneously operating mechanical heating with the outside air damper open more than a predefined minimum, resulting in unnecessary energy waste. With the issue clearly identified, ATS worked with school district's Resource Conservation Manager (RCM), Jed Reynolds of Cascade Power Group, to determine the problem. Cascade Power Group provides RCM consulting services to LWSD to efficiently manage and reduce utility costs as much as possible.

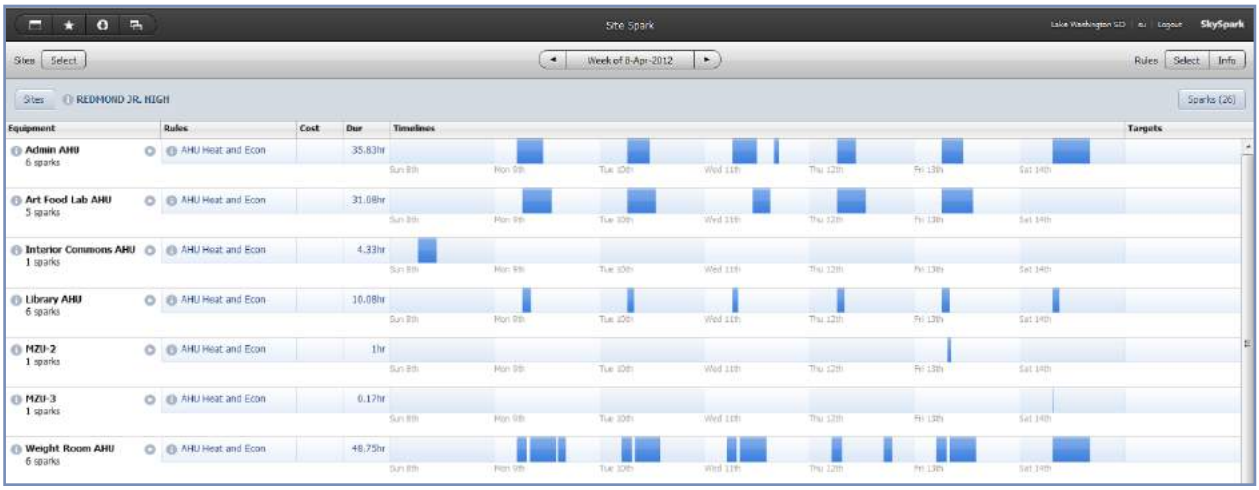
Customer Issue Description: Shortly after SkySpark was implemented at Redmond Middle School the AHU Heat & Econ rule started generating sparks at a significant rate on several single zone Air Handling Units. The SkySpark rule generates sparks if the Heating Control Signal is opening the AHU's hot water valves for heating while an economizer command is simultaneously opening the outside air dampers to near maximum levels as if the unit was in a cooling mode.

The Investigation: All of the AHUs that had generated this spark had factory-installed outside airflow measuring sensors. The control system was using the airflow signal to maintain the design minimum outside air (OSA) flow volumes. But there was a problem! The airflow measuring stations had failed and begun to send erroneously low readings to the central controls. This caused the control system to open the outside air dampers more than necessary and bring in excessive amounts of OSA. This energy wasting failure was not visible to operators and would not have been found without SkySpark or an extensive field balancing and verification effort.

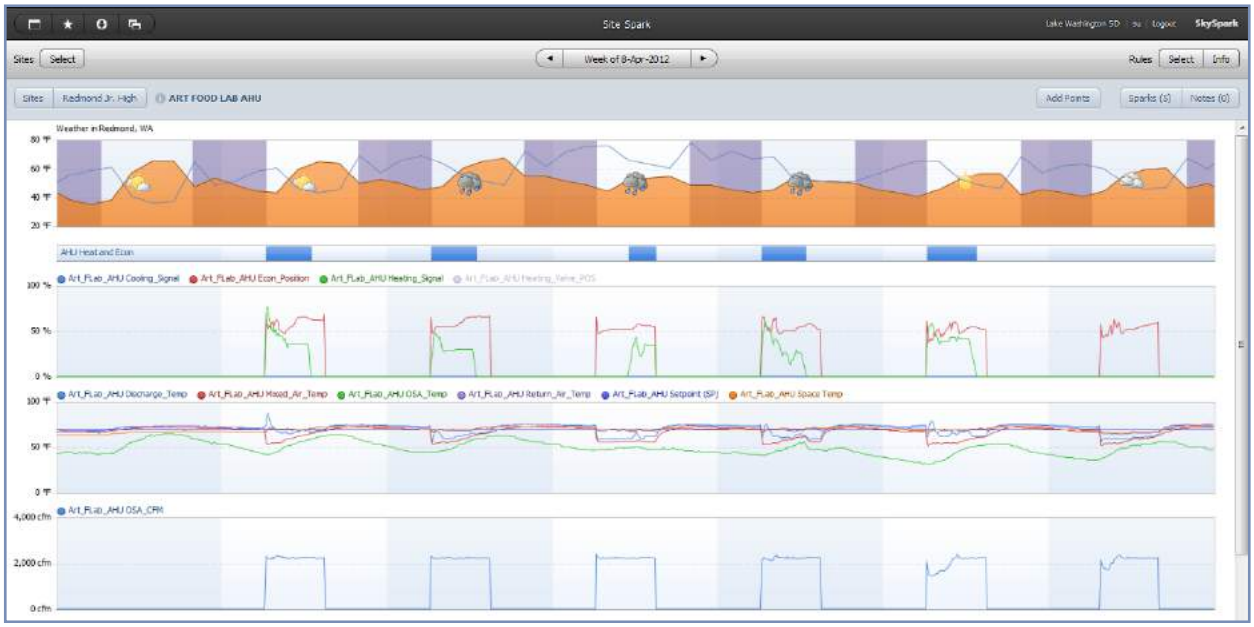
These SkySpark findings led the LWSD to implement a demand-controlled ventilation retrofit in which the malfunctioning airflow sensors were replaced with CO2 sensors in the return duct. Outside air intake is now controlled only to maintain appropriate CO2 levels. But wait – CO2 sensors could fail sometime in the future as well! No problem, a SkySpark rule watches for failure of the newly installed CO2 sensors as well.

Now let's look at the Spark details in the following views:

In the view below we see Heat and Econ sparks occurring consistently on 7 AHU's during one week in April, 2012:



The following view shows full details on the Heat and Econ spark for a specific AHU during a one-week period.



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SkySpark® – Analytics for a World of Smart Device Data

The past decade has seen dramatic advances in automation systems and smart devices. From IP connected systems using a variety of standard protocols, to support for web services and xml data schemas, it is now possible to get the data produced by the wide range of devices found in today's buildings and equipment systems.

Access to this data opens up new opportunities for the creation of value-added services to help businesses reduce energy consumption and cost and to identify opportunities to enhance operations through improved control, and replacement or repair of capital equipment. Access to the data is just the first step in that journey, however. The new challenge is how to manage and derive value from the exploding amount of data available from these smart and connected devices. SkyFoundry SkySpark directly addresses this challenge.

*The new frontier is to efficiently manage and analyze data to **find what matters™**.*

About SkyFoundry

SkyFoundry's mission is to provide software solutions for the "Internet of Things". Areas of focus include:

- Building automation and facility management
- Energy management, utility data analytics
- Remote device and equipment monitoring
- Asset management

SkyFoundry's software helps customers derive value from their investments in smart systems. Learn more and request a demonstration at www.skyfoundry.com.

SkyFoundry

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