DATA CONQUERS CHALLENGES OF FACILITY OPERATIONS MANAGEMENT

Condition-based maintenance along with fault detection and diagnostics use data and analytics to help building owners and facility managers save money and provide better service.

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INTRODUCTION

Large commercial and institutional facilities have the opportunity today to use data to better manage their facility assets. Building system problems can be identified — and fixed — before complaints are even made. Existing staff can better prioritize and accomplish essential maintenance tasks. Money can be saved on energy contracts while occupant service improves.

Individual pieces of this building management digital transformation are being accomplished now, in facilities large and small. Data is the foundation, and building owners and facility managers are seeing significant benefits.

Whether you're responsible for a single building running a packaged HVAC unit or an entire campus of many dozens of buildings and multiple power-generation systems, it's critical to understand how real-time asset data can improve operations and deliver bottom-line value.

This eBook covers two important types of asset management operational use cases that can protect building systems: condition-based maintenance (CBM) and fault detection and diagnostics (FDD).

CBM is used with large critical assets like central utility plants to predict and prevent operational issues that could cause the systems to fail or cost more to operate.

FDD is used with HVAC systems and equipment to help engineers determine when building systems aren't performing optimally, and decide how and when to fix them.

CBM and FDD both apply business or engineering rules to real-time asset data and return insights that facility professionals use to fix problems and save money. Both rely on an underlying infrastructure that can gather and present time-based data for analysis. This eBook describes the uses and benefits of each through examples of facilities that have implemented them, and explains how the PI System — a data infrastructure for real-time operational intelligence — supports asset data collection and analysis.


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WHAT OPERATIONAL DATA CAN DO

Building systems have thousands of things that move — dampers, motors, valves, and fans — and when small things fail, the system self-adjusts, responding to the problem without knowing there is one.

If a filter is clogged, for example, the system creates more airflow in order to keep cooling a room to its setpoint. Increased airflow, then, is one operational data point that could reveal the hidden problem of a clogged filter.

Unless the underlying problem is addressed, the harder-working system costs more than necessary to operate and is at risk of failing completely.

Individual assets, such as boilers and chillers, already have sophisticated control systems that use real-time operational data, but multiple pieces of equipment connected into a building system create additional points where the risk of failure and opportunity for improvement exist. Analyzing operational data from these assets enables facility professionals to proactively maintain systems, rather than run them to failure or wait for a call from a dissatisfied occupant.

THE GETTY IMAGE

CBM FOR MANAGING CENTRAL PLANTS

On large campuses, like those for universities, corporate research facilities, airports, or hospitals, facility professionals who monitor and maintain the central utility plant have a complex set of asset management challenges. Consider a typical central plant facility maintenance team that oversees the power and space conditioning for 200 buildings, serving tens of thousands of occupants. This group monitors a combined heat and power plant, as well as a substation, chiller plants, and a utility distribution network with miles of underground steam piping and dozens of underground feeder loops. The facility executive may have people dedicated to operations and maintenance or may outsource these functions.

FACILITY PROFESSIONALS FACE SIGNIFICANT CHALLENGES

- A lack of situational awareness of what's happening in real time at their plant.
- No visibility into asset health, which means an inability to hold vendors accountable if asset maintenance has been outsourced.
- Hidden costs related to energy contracts or maintenance activities.
- Difficulty adapting to new technologies, such as renewable energy.

We'll look at these challenges in greater detail and see how data, analytics, and condition-based maintenance (CBM) can meet them. But first, let's understand CBM.

UNDERSTANDING CBM

Condition-based maintenance uses data from equipment sensors and plant control systems to determine when maintenance is best performed to 1) reduce the risk of equipment failure and unplanned downtime and 2) increase asset health and overall equipment effectiveness.

Data for CBM can come from equipment that provides on-line monitoring of things like temperatures and start/stop sequences. Data may also come from offline eddy current, oil analysis, and other diagnostic tests, as well as from portable test equipment like infrared cameras.

CBM requires a shift in mindset for facility maintenance professionals. Previously, maintenance was performed on a fixed schedule, so assets would be maintained at regular intervals. However, assets don't degrade at a fixed rate, so this is not the optimum way to maintain them. Rather than rely on vendors or staff to make assumptions based on time and experience (e.g., "We know that after 500 hours of operation the performance will probably have degraded 25 percent"), CBM lets staff use real-time data to perform maintenance when it makes the most business sense to do so.

BENEFITS OF CBM

Implementing CBM extends maintenance cycles, thereby reducing maintenance costs. At the same time, as costs fall, asset reliability and availability actually rise. That's because calendar-based processes often generate unnecessary maintenance that takes equipment out of service more often than required. Or worse, a calendar-based approach may fail to catch a serious issue that arises before scheduled maintenance and cause equipment to fail. And just performing maintenance has the potential to cause problems with equipment.

Perhaps most important of all, CBM helps avoid the high price tag of unexpected failures and emergency repairs. Those costs can go well beyond the dollars paid for the work on the equipment itself, as expensive as that can be. Loss of critical power or HVAC systems often entails additional hard and soft costs when buildings cannot be used for their intended purposes.

Condition-based maintenance software can make use of real-time data and analytics to tackle critical challenges faced by facility professionals.

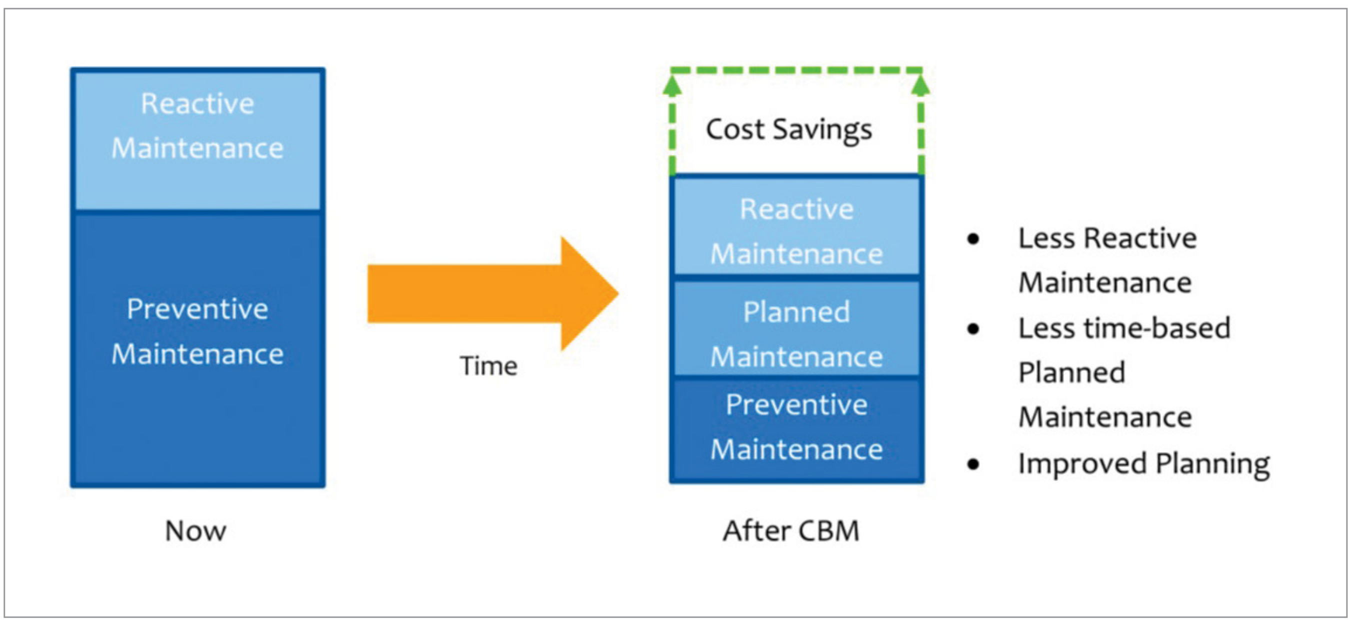


Figure 1. Condition-based maintenance reduces costs by changing the distribution of maintenance activities and reducing the overall amount of time spent on maintenance.

Finding Hidden Costs

Central plant managers who have access to real-time operational data, who know the costs of their energy contracts, and who know the cost of failure can monetize that knowledge with CBM. Managers can optimally design maintenance programs based on actual conditions such as real-time pricing for utilities; interruptible gas supply contract prices, penalties, and penalty triggers; demand charges for the region; power loads for the time period; etc. Analyzing these energy-management data points can reveal cost-reduction opportunities.

CBM data also can be used to find hidden problems in specific systems. The Central Plant at MIT makes chilled water, electricity, and steam that it distributes to approximately 120 campus buildings. After installing the PI System to get a better view of their operations, they discovered that the chilled water differential (the difference in temperature of water going to a building and water coming out) was virtually zero.

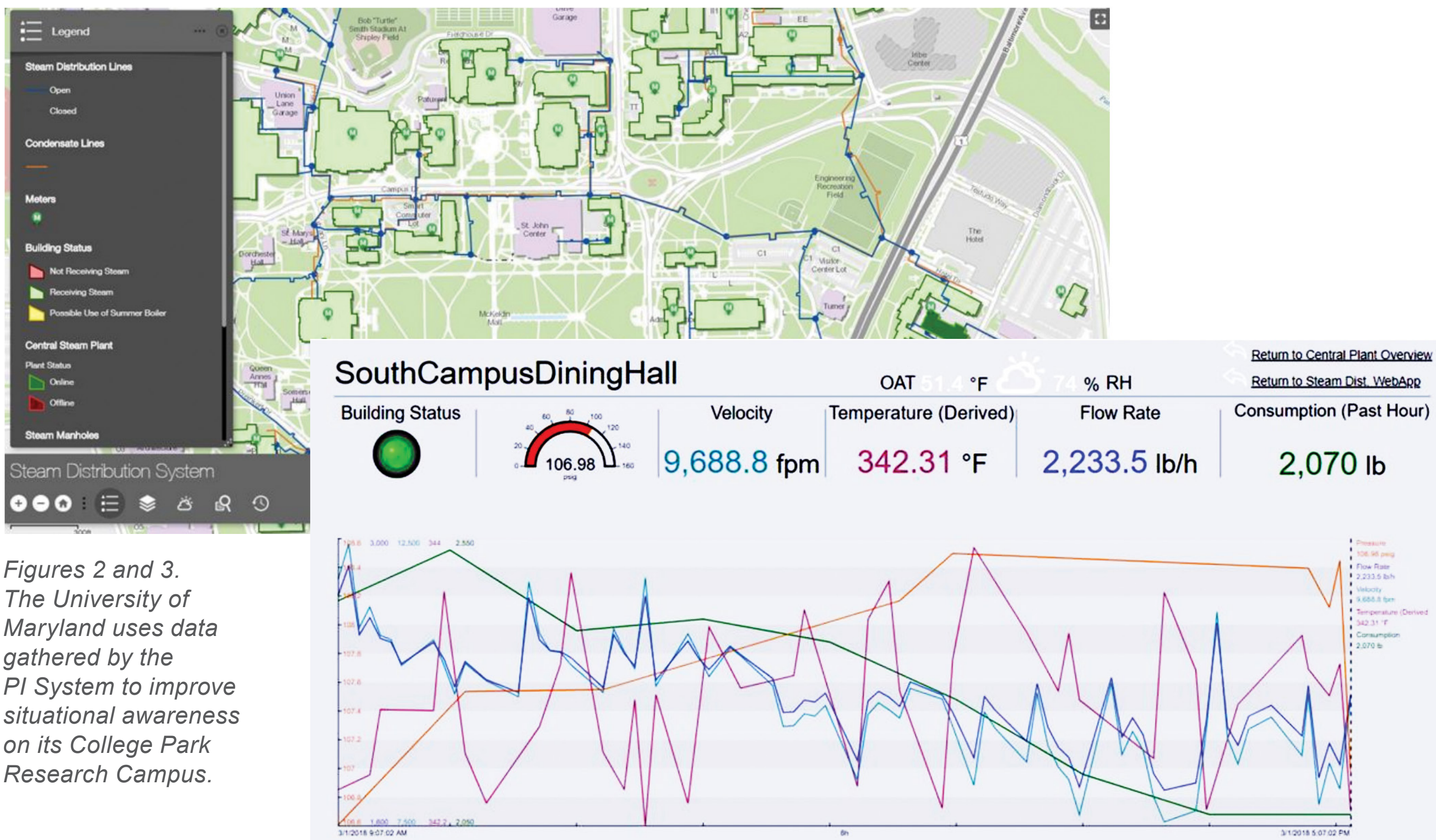
Further analysis of the meter data revealed a very costly problem: a stuck-open control valve with no sensor on it to reveal that it was stuck. Broken, the valve allowed chilled water to flow at an astronomical rate of 1,200 gallons per minute. Fixing the stuck valve changed the flow rate to 150 gallons per minute — and delivered estimated savings for a single year of $60,000 to $80,000.

Improving Situational Awareness

When a massive power outage dropped the University of Maryland, College Park, research campus into darkness in 2015, the university was forced to close for several hours as the central plant's facility management team sought to restore steam, power, and lights to buildings serving 49,000 students. At that time, the only place personnel could see what was happening at the power substation was at the cogeneration plant control center.

With that lack of visibility, personnel didn't know where the problems were, and it took more than five hours to restore power to the campus.

According to Assistant Director of Facility Management Don Hill, that sent the university on a quest to find a more effective way to gather, visualize, and analyze critical facility data. They ultimately installed the PI System from OSIsoft and built their own CBM system on top of it. The PI System was able to pull in data from several legacy systems, data that was then visualized to show the power status of buildings and feeder loops so staff could monitor the operation of steam pumps in real time.



Figures 2 and 3. The University of Maryland uses data gathered by the PI System to improve situational awareness on its College Park Research Campus.

Clear View of Asset Health

Outsourcing the operation of central plant facilities can make good sense, allowing an organization to reduce costs, to tap expertise that the organization doesn't have in-house, and to improve operations. But this performance-contract method of asset management can mean the central plant building owner loses awareness of the condition of essential equipment. That puts the owner at the mercy of the vendor.

The vendor could decide that it's cheaper to not maintain an asset and still meet the deliverables in the contract. But if something goes wrong, it's the owner who could be subject to unexpected costs.

One facility in the Northeast outsourced the operation of its central utility plant under a performance contract model. The facility had an interruptible gas supply contract, so they paid a lower rate for gas because their service could be interrupted at the utility's discretion. Typically, when gas service was interrupted, they switched to oil. Because the vendor had not performed good maintenance, they lost the ability to switch to oil. This happened when those assets were needed to fulfill their energy contracts. As a result, the facility had to pay a more than $1 million penalty to the gas company for not being able to execute that interruptible gas supply contract.

As with any outsourced or performance contract, it is important to maintain situational awareness in order to monitor the vendor to ensure compliance with the contract as well as to protect mission critical infrastructure and assets of the facility.

BETTER ABILITY TO PLAN FOR CHANGING TECHNOLOGY

Campus central utility plants are facing changing demands that are difficult to plan for, with more renewable generation, less use of steam, and increasing demand across the board as a result of facility growth. What's more, regulatory and policy demands may force a strategic shift, requiring the organization to become zero carbon, to increase resiliency, or to achieve certifications for energy efficiency.

These factors could change the nature of central plant operations: They bring an increased number of control systems and data sources as well as increased reliability demands because facilities must balance the availability of traditional assets — for power, steam, chilled water, and hot water — with new systems and new energy contracts.

CBM has a role in maintaining these systems, and the ever-increasing interdependencies and increased expectations of availability. If these systems go down unexpectedly, the failure could lead to financial penalties from loss of basic services.

PI SYSTEM PROVIDES DATA

The challenge with implementing CBM is ensuring that the system has the data it needs. That's no small task. Asset data may exist in a wide variety of systems and in a range of formats, from delta pressures to corrosion-inspection results to thermography information. And the different types of equipment that provide the data generally don't talk to each other, leaving the information stranded in siloes.

The PI System provides an open infrastructure to automatically pull together data from a multitude of sources across the central plant or the campus. Gathering data automatically is both faster and more reliable than manual data gathering.

The PI System integrates, standardizes, and centralizes data to connect sensors, operations, and people across the enterprise. It organizes and converts raw data streams into meaningful events and values. It can deliver data to other advanced analytical tools and engines. And the PI System does all that in a highly efficient, highly secure manner.

Event Frames and Notifications are features of the PI System and turn the asset data being collected into useful and actionable information. They capture, store, and enable the viewing of related data all in one place in a consistent format, so users can more quickly identify problems, discover the root causes of outages, or monitor systems to prevent problems.

An "event" can be many things: the start-up of the HVAC system, a single room sensor detecting "occupancy," or an attempt to access a control panel. The Event Frame captures the start time, end time, and duration of the event, and as well as any other events or data happening simultaneously. The Notifications feature lets users configure "notification rules" to send email messages or to call a web service when a specific event happens. The user can configure message content and set up escalations, and all notification actions — such as notification send times, acknowledgments, entry of comments, and escalations — are stored for later retrieval and examination.

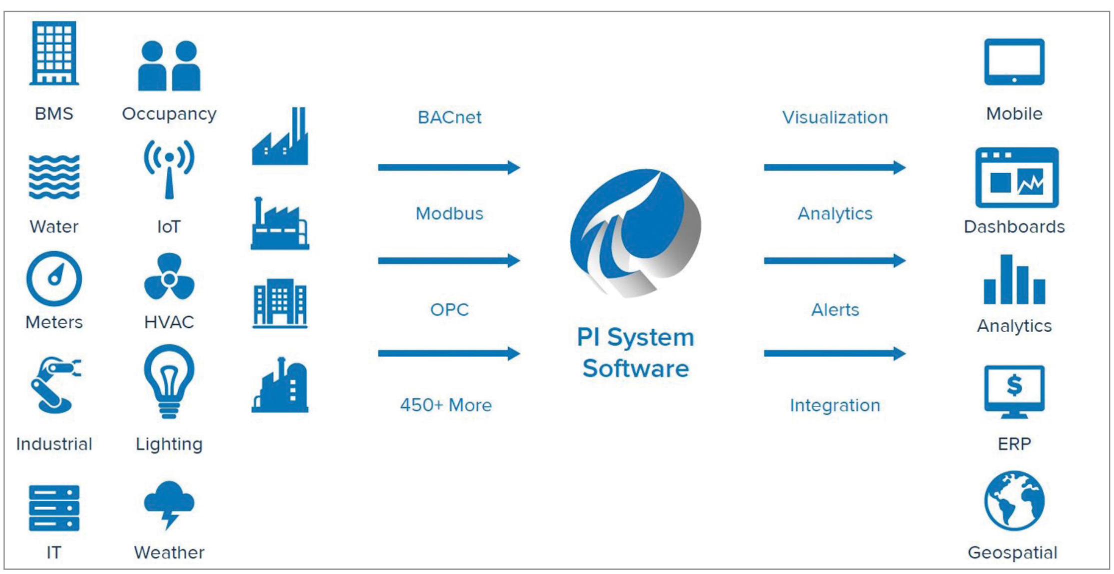


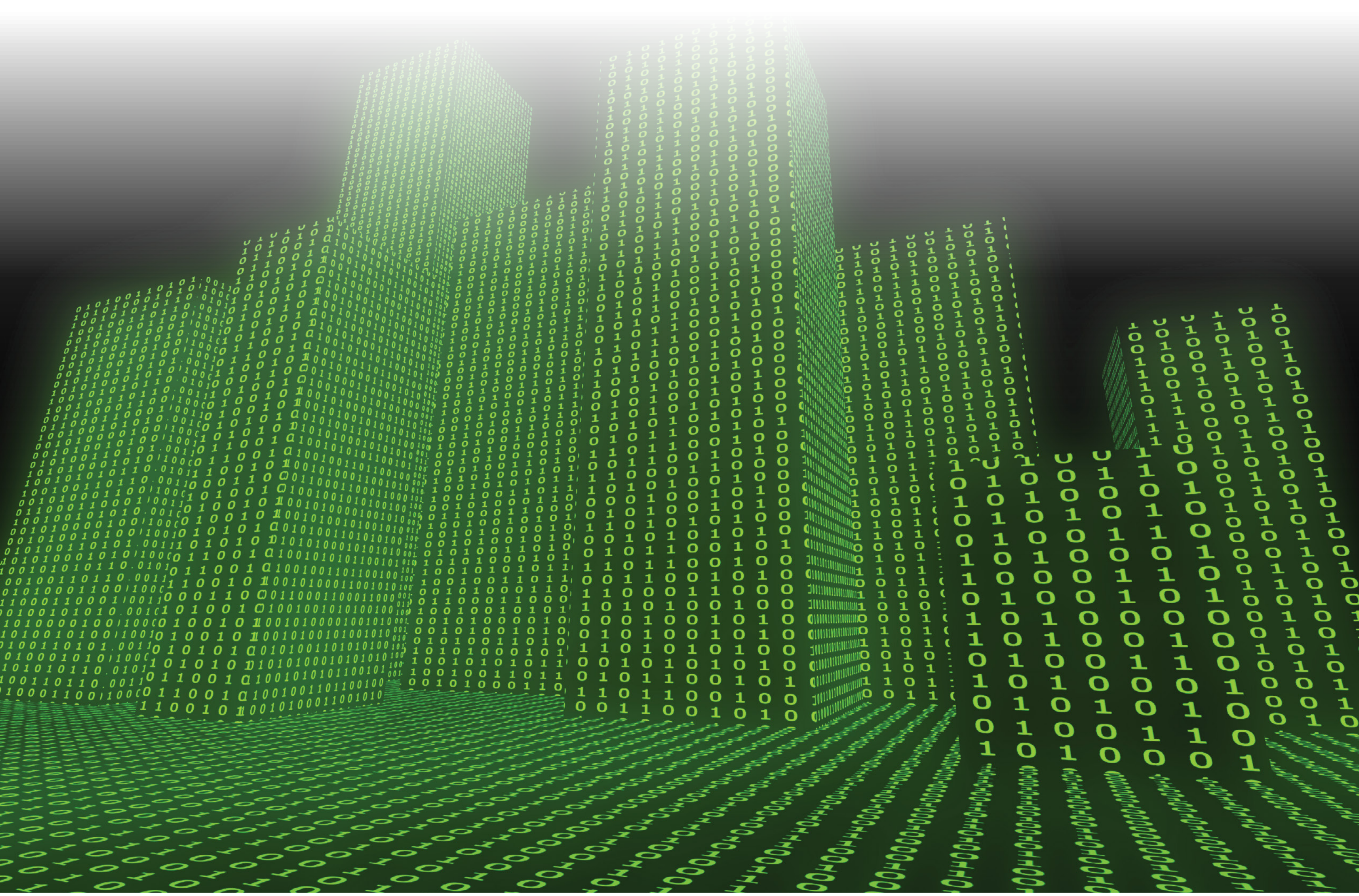
Figure 4. The PI System provides an efficient, secure way to standardize, integrate, and centralize data from disparate sources, and make it useful to other powerful software tools.

FDD FOR MANAGING INDIVIDUAL BUILDING SYSTEMS

When it comes to individual building systems, most facility managers aren't used to looking at data. They address comfort complaints and respond to maintenance needs, but they seldom go back to understand why problems occurred. In most cases, they don't have time to trend and solve those issues.

Facility staff typically attend to systems from a control point of view: They check if equipment is on or off, or if temperatures or voltages are correct. Historical data may be looked at monthly — or not at all. Facility managers don't know how their building systems are actually performing, which can mean costly problems are missed.

Fault detection and diagnostic (FDD) software can use real-time data generated by building systems to identify root cause issues and help facility staff take action. Like CBM, FDD is a set of analytics performed on real-time data that enables facilities to identify and respond to problems, and helps engineers determine where to put their time and attention.



BENEFITS OF FDD

QUICK PROBLEM IDENTIFICATION AND REPAIR

FDD helps facility managers find problems and fix them. Real-time data, like supply temperature, outside temperature, or air flow rates, is combined with formulas and algorithms that indicate when something is wrong with a system — before a complaint call is received. FDD can also indicate why a problem occurred so technicians can fix the underlying issue.

On one campus, PI System data revealed that one building had simultaneous heating and cooling going on. Upon further investigation, technicians found a broken three-way valve that was allowing both hot and chilled water to flow into the pipes at the same time. They were able to correct that unreported problem and eliminate a potential risk to the whole system. And, because the working valve reduced the flow of water, the fix reduced operating costs by about 5 percent.

PRIORITIZING MAINTENANCE TASKS

One benefit of FDD is maintenance prioritization: Minimizing cost, time, and effort without adding facilities people while still maintaining a comfortable environment. FDD identifies problems by applying rules to data from a control system. For example, the system might have a rule that sets minimum and maximum values for delta T in the chilled water loop. If the data doesn't conform to the rules, the system will identify a fault. One challenge with FDD is the very large number of potential faults it might find.

FDD solutions should put a dollar value on the cost of problems — for example, by tracking the amount of energy wasted as a result of a fault like a damper being stuck open — so that maintenance can be prioritized to address the most costly issues first.

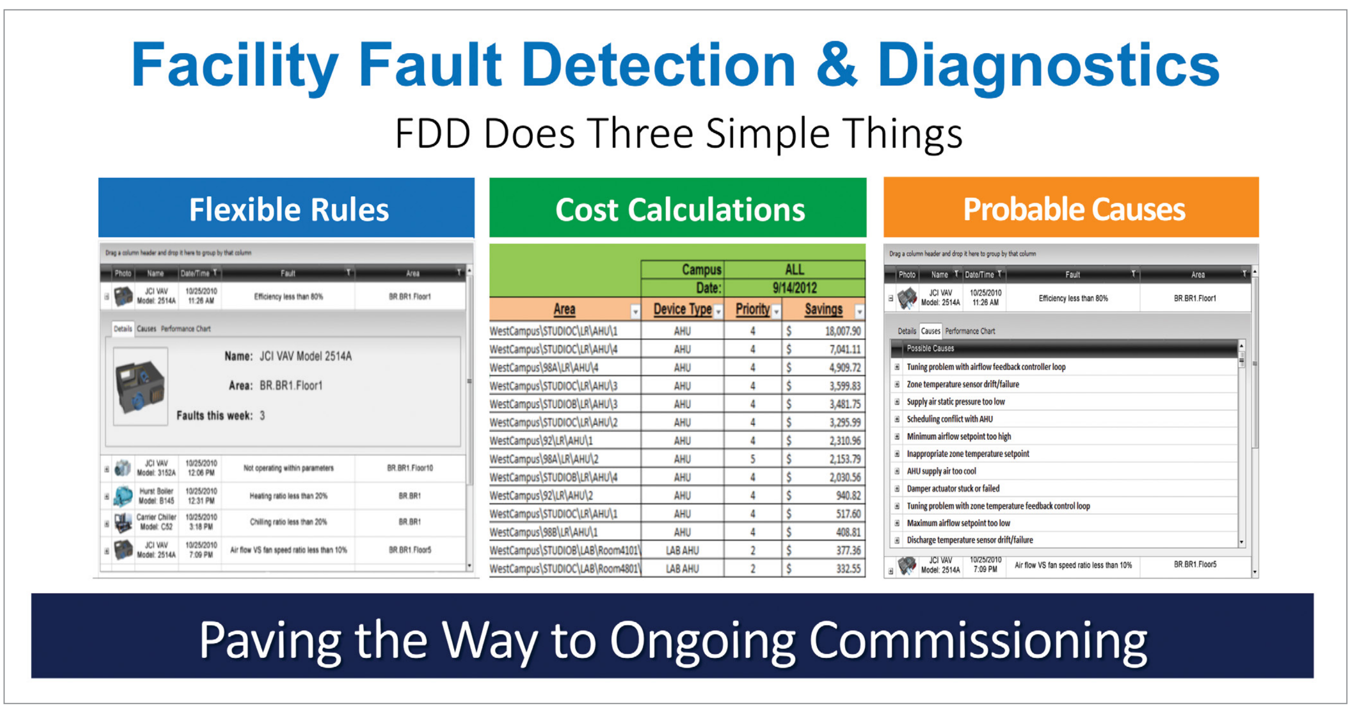


Figure 5. FDD solution by Rovisys.

Energy Optimization

FDD systems can be used to optimize energy use in building systems. The University of California, Davis, for example, set out to reduce energy use through ongoing commissioning using FDD. Ongoing commissioning is a process that seeks to ensure that building systems continue to operate as they were intended to do; it often combines powerful software like FDD with human expertise to identify and correct problems that waste energy.

Having already improved performance through commissioning existing building systems and a review of building management system (BMS) controls, UC Davis chose two buildings in which to pilot FDD software, which is designed to preserve those savings and enable deeper analysis with continuous monitoring.

The types of optimization opportunities uncovered by FDD include: temperature sensor failures; valves cycling on and off unnecessarily; smoke dampers stuck closed; and HVAC operation not matched to occupancy.

With those faults uncovered and corrected, the two pilot buildings have shown a 22 percent and 24 percent savings in energy use costs (savings include those from both the building-commissioning and FDD systems).

Kellogg used the PI System to create consumption benchmarks prior to setting 10-year energy targets for a critical facility; Kellogg also installed air and gas metering as well as voltage monitoring. Since then, it has done 30 projects using data from the Pi System.

Since 2005, the facility is saving $3.3 million annually, and PI System data has helped it qualify for $1.8 million in rebates.

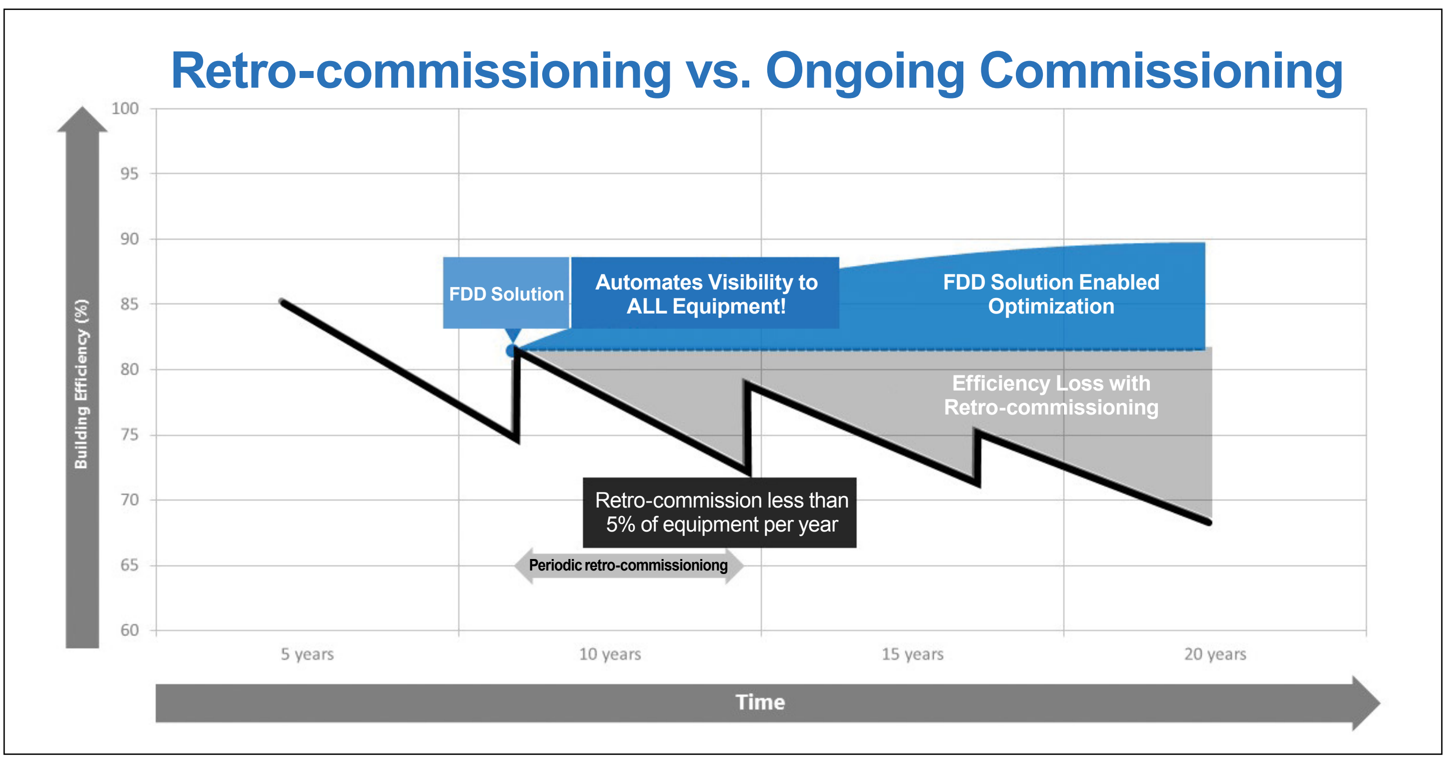


Figure 6. FDD enables ongoing commissioning, which improves building efficiency compared to periodic retro-commissioning.

PI SYSTEM PROVIDES DATA FOR FAULT DETECTION

Many building systems already collect data in some form, and FDD algorithms can identify a wide range of specific problems. The challenge for facility managers is to gather the data from disparate sources and feed it to the FDD system. A building may have many different systems that do not communicate with each other. For example, the lighting control system may not talk to the BMS, while the proprietary protocols in different BMS may not share data with one another. And new technologies like dynamic glass or automated blinds may not be able to communicate with the automation system. Even if equipment is communicating, getting the data into a form that will make it useful for FDD can be a challenge.

As with condition-based maintenance, the PI System can play an important role with fault detection and diagnostic efforts by integrating, standardizing, and centralizing data so that it can be used by the FDD system. The PI System can organize and convert raw data streams into meaningful events and values, and combine data from wide-ranging sources.

At UC Davis, even though 70 percent of the larger buildings on campus used the same BMS, the facility staff couldn't use sensor data to actively understand what was happening with equipment. Building automation/control systems often lack analytics to allow facility staff to easily identify problems from data, even data from within the BMS. So the energy team at UC Davis imported data from the BMS into the PI System.

The PI System was used to create and edit tags in bulk, an important tool as UC Davis generated 11,000 tags for the two buildings in the pilot study. The PI System supplied granular data to help staff understand problems more quickly. Analytics in the PI System were used to reduce wasted air flow, saving energy costs. And the PI System templates developed for the pilot project can be applied to other buildings as UC Davis expands the program; the target is 70 buildings with 300,000 tags.

CONCLUSION

Condition-based maintenance and fault detection and diagnostics are increasingly being implemented to take advantage of real-time data from buildings to improve equipment performance, reduce costs, and keep building occupants satisfied. Pulling that data together and putting it into a form useful to CBM and FDD can be a daunting challenge.

The PI System can serve as a bridge between sensor data and powerful applications like CBM and FDD. It provides an efficient and secure means to standardize, integrate, and centralize data from disparate sources.

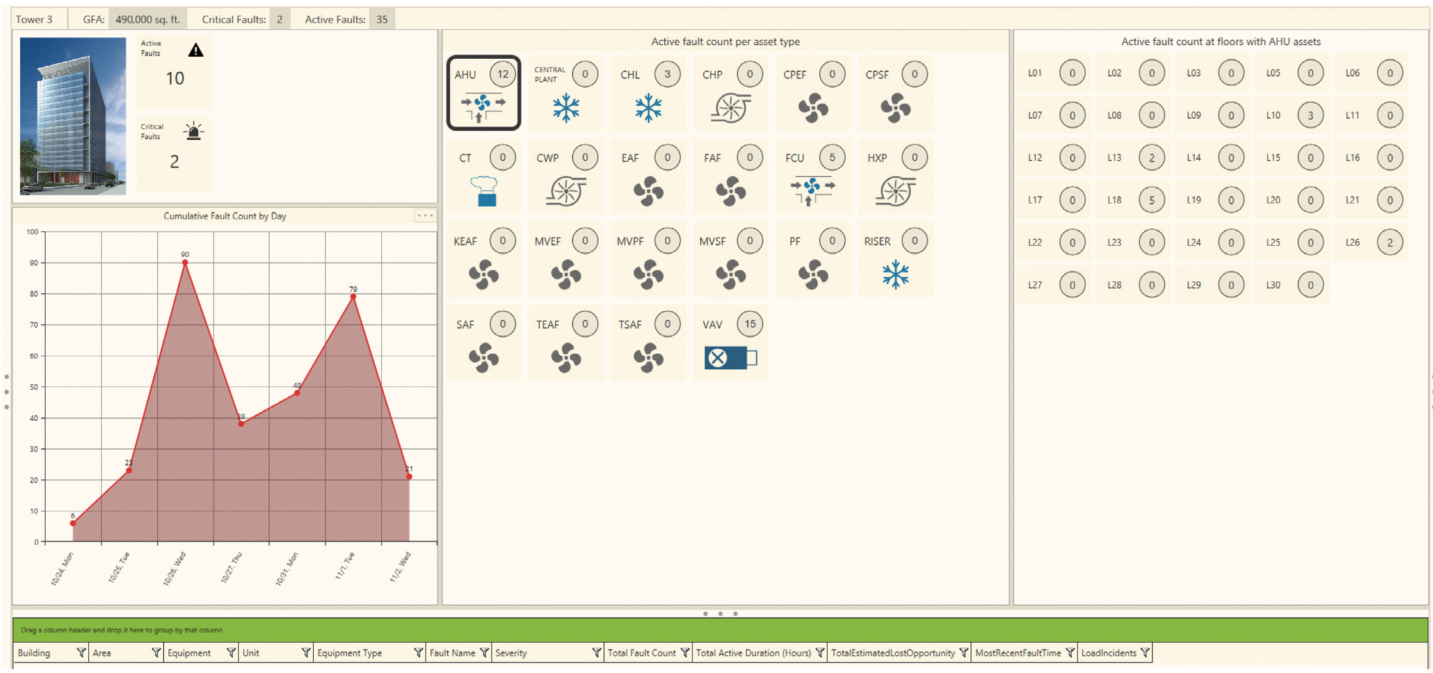


Figure 7. Rovisys FDD solution powered by the PI System.

ABOUT OSISOFT

For over 37 years, OSIsoft has been dedicated to helping people transform their world through data. Our software turns the vast data streams from sensors and other devices into rich, real-time insights. You'll find the PI System in oil refineries, mining sites, wind farms, national labs, pharmaceutical manufacturing facilities, distilleries, data centers and even stadiums helping people save energy, increase productivity or develop new services. Worldwide, the PI System handles more than 2 billion sensor-based data streams across 19,000 sites, and is embedded in operations and critical infrastructure in over 125 countries. Founded in 1980, OSIsoft has over 1,200 employees and is headquartered in San Leandro, California.

Visit https://explore.osisoft.com/l/facilities to learn how our customers are using the PI System to improve their facilities, or visit http://explore.osisoft.com/l/osisoft-and-pi-system to learn more about OSIsoft and the PI System.

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