Taking the first steps toward condition-based maintenance

Utility maintenance managers are increasingly coming to realize that it‘s wasteful to perform maintenance on a fixed schedule. Many of them are making the transition to a condition-based maintenance strategy. This white paper summarizes a four-step process for successfully making that transition.

In a meeting with a maintenance services supplier, a utility’s maintenance manager described the scenario of his wife and her new car. He explained how the car displays messages on the dashboard regarding potential maintenance issues and suggests the appropriate response or action. It simultaneously sends a message to the dealer alerting them to the issue. “Why,” the utility manager asked, “couldn’t the same scenario play out with my transformers, breakers and other assets?”

Why indeed. That utility is, in fact, now far along in the process of deploying a condition-based maintenance (CBM) solution that is accomplishing just that. Managers and engineers in a growing number of utilities are realizing that successful CBM deployments result in lower maintenance costs with increased reliability. Several years ago, the Aberdeen Group found that nearly half of survey respondents planned to implement this type of solution.

The transition by utilities from time- or interval-based maintenance to CBM is accelerating. Resistance to the transition is eroding as the financial, performance and reliability benefits become clearer, and as the next generation of maintenance personnel, not steeped in the culture of interval-based maintenance, enters the field.

In this white paper, we will describe how utilities are capitalizing on the increasing availability of digital asset data and improved communication infrastructure as they adopt CBM to optimize their maintenance efforts. We will describe

a four-step process to transitioning to CBM, and identify common barriers to successful implementations and how those barriers can be overcome.

Resistance to change

The appeal of CBM is highly intuitive. No facility owner would automatically repair or replace their roof after some fixed-time interval. While the warranty may indicate the owner could expect 15 years of life, weather conditions and other factors will greatly shorten or extend actual life. Based on the condition or performance of the roof, the owner will devote money, time and attention to it only when it begins to show trouble. Similarly, with power equipment, actual duty levels and asset condition should drive specific maintenance schedules.

Regardless, many utilities continue to cling to an arbitrary and often overly cautious, time-based approach for a variety of reasons. They appreciate the simplicity of a system that requires little more than a calendar or checklist to determine when it's time to perform maintenance. Some believe the technology needed to do otherwise is too costly. And for many, it is a simple matter of tradition; they do maintenance the way they have always done maintenance.

Overcoming these barriers requires culture change, combined with a knowledge refresh on the technology available, its cost and how it can be appropriately applied.

Creating the culture change

The first incorrect belief to dispel is that CBM is a more expensive approach.

"There is an upfront investment, which varies with the scale of the utility and the scope of their implementation," says Shawn Lyndon, Senior Vice President & General Manager of Asset Health Solutions at Ventyx, an ABB company. "But the payback is fairly swift, typically in the two- to three-year range. According to a Ventyx analysis, a catastrophic transformer failure can cost from three to 10 times the price of the equipment itself. Considering the fact that CBM is much more likely to identify transformer problems prior to failure, the financial prudence of monitoring transformer health becomes even clearer."

The manufacturing and industrial markets have already largely accepted the fact that CBM enhances performance.

"Many industrial operations have adopted the CBM approach," says Jeff Barker, Business Development Manager of Breaker Monitoring for ABB High Voltage Products. "They were driven by the need to be more productive and cost-effective."

Metrics related to CBM in manufacturing are impressive. The ARC Advisory Group reported that the cost of performing predictive maintenance could be up to five times less than

preventive maintenance, and 10 times less than corrective maintenance, before factoring in downtime costs.

"Utilities are early in the cycle but the transition to CBM is underway," Barker continues. "In addition to financial pressures created by recently enacted FERC- and NERC-imposed penalties for loss of service, utilities are responding to the accelerating attrition of skilled techs. Power generation has seen success with CBM, and those practices are increasingly migrating to other areas as utilities strive to automate and simplify maintenance."

Power generation has seen success with condition-based maintenance, so those practices are increasingly migrating to other areas as utilities strive to automate and simplify maintenance.

Whether it's a driver or the result of the shift to CBM, another essential cultural change now underway is a convergence of Information Technology (IT) and Operations Technology (OT). Functional silos within utilities are crumbling as IT and OT personnel increasingly work together to capitalize on the value to be garnered from organization-wide data streams. Other walls are also coming down, bringing together transmission and distribution maintenance, or transformer and breaker maintenance. Multiple work-order systems between functions, areas and operating companies are increasingly combined and synchronized in a more streamlined approach.

A four-step strategy to successful CBM

Once a utility overcomes the cultural impediments to a CBM implementation, how do they prepare to embark on this new path?

Randy Schrieber, head of ABB Marketing & Sales for ABB's Power Equipment Service in North America, offers this framework:

1. Gather the data already available
2. Add new data collection/sensors
3. Aggregate the data
4. Analyze the data

Gather the data already available

Many utilities are sitting on a rich trove of asset-health-related data with the potential to provide tremendous insight into the status of their assets.

"Utilities are already collecting data to assess the condition of their equipment, even those that have no formal monitoring or data management system in place," says Bob Stoner, the Marketing Manager for ABB High Voltage Service. "At almost every utility, operators go out and look at gauges and operating conditions and record their findings in some kind of system. They already have the data. They just need to do something with it."

"They have records about the kind of maintenance they have done in the past," adds Brian Friedrich, VP of ABB Power Service Sales. "What kind of system issues have happened? What is the history of that equipment regarding switching surges, number of operations, known problems and asset age? The asset history may be in many forms. When we are asked to do equipment assessments, we often get a box full of paper records as the starting point. That's all good data."

Data gathering is something the utility can do as a low-cost first step toward a CBM system. The data collectors should throw their net wide. What exists in their maintenance management system? Are individual engineers or maintenance managers already capturing data in homegrown repositories? More data is always better, gathered from the widest range of sources possible.

"While it's good to have as much asset information as possible, keep in mind that each piece of data isn't equal," says Barker. "For example, heater monitoring isn't as critical as trip count on an active breaker, although it adds clarity to the view of the asset's health. The algorithms used in the CBM analytics assign appropriate weights to the different metrics and integrate them appropriately into a holistic view."

IT can be a valuable partner in this effort, supporting the data collection, consolidation and organization. It can be a big effort to bring all the information back to one point and a bigger effort to do that as a routine process. But a unified data repository is a foundational element of successful CBM implementations. Utilities taking this first step of seeking out and aggregating asset data often find that the answers to many questions regarding how to most effectively use maintenance time and resources were there the entire time.

The manual collection of data on the required regular basis may prove too time-consuming, and many utilities discover gaps in their asset health data. With that realization, they move to the next step and determine what sensors

or monitors should be added in order to automate data collection and provide the total, required picture of the condition of their power assets.

Add new data collection/sensors

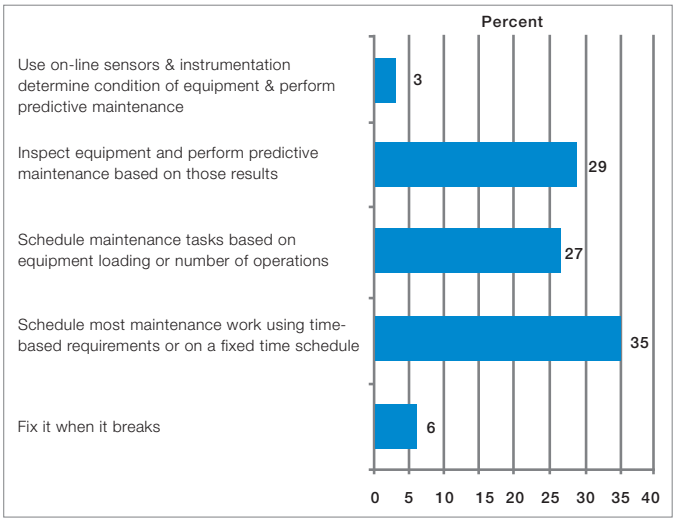
With the exception of transmission substations, sensor penetration is very low on the grid. Investment mainly occurs where the assets being monitored are very high value, serve critical loads or are particularly troublesome. Even for high-value assets like large power transformers, though, the penetration of sensors is estimated at less than 20% in the United States and Europe. In other regions, penetration is even lower.[1]

As utilities consider the best approach to deploying sensors, they should be guided by the experience of utilities that have already traveled that road.

"Customers tell me that any decision to invest in monitoring must be made prudently," relates Schrieber. "It is neither feasible nor necessary for every component to be monitored. A cost-benefit analysis will point to specific needs for improved data collection in localized segments of the system — such as those that serve particularly sensitive customers or that represent ongoing reliability issues. To this end, utilities will invest in monitoring capabilities on assets whose failure would present a significant impact on reliability. Other information gaps may be allowed to remain."

For each class or type of asset, there are key operational metrics that can be readily monitored and that provide good indicators of asset condition and maintenance requirements. For a transformer, they include trends in temperature, and gas and oil condition. For a load tap changer or high voltage breaker, the number of operations provides the best indication of contact wear. These are the logical places to capture data.

What is the most typical form of your maintenance management practice?



Optimizing Deployment of Next Generation Maintenance Strategies, The McDonnell Group

"The business case still isn't there to add sensors to an entire power network and all of the equipment found there," observes Lyndon. "That business case, though, is shifting with recent sensor development. Falling prices, increased simplicity and greater reliability of sensors are spurring a growth in penetration. Further, the increasing availability of IP communications networks in facilities is making it easier to gather and collect data from these sensors, further driving their proliferation."

Sensor simplicity is a recurring theme in many successful CBM implementations.

"One utility opted originally for very smart sensors," Lyndon recalls. "Those sensors turned out to be overly complex, so the crews ended up doing more labor because the sensors themselves required maintenance. Better to rely on simple sensors and put more of the intelligence downstream in the software performing the analytics."

Aggregate the data

With the appropriate sensors in place, what's needed next is the pipeline to gather and convey that data to an electronic database for consolidation, processing and utilization in creating a complete and clear image of maintenance requirements. Beyond being the basis for the utility's CBM processes, this consolidated data also can be leveraged for supply chain management and other applications.

The cost and difficulty of data aggregation continue to decline as the communications network required to interconnect them expands in both size and capability. Although mainly discussed as a consumer resource, the "internet of things" is taking shape in not only consumer, but also industrial and utility devices as more smart devices come online.

The scale of this new IP connectivity and indication of the ubiquity of these wireless networks are demonstrated by Gartner research. It shows that in 2009 there were 900 million internet connected devices, not including PCs and smartphones. They project by 2020 that will grow to 26 billion.

The growth of smart grid initiatives and the related communications networks continues to drive development of standards and protocols related to IP communication for industrial and utility applications, ensuring consistent architecture and high functionality.

Widespread IP communications, low processing costs and continued deployment of intelligent equipment provide a prodigious data stream, ready to be converted into actionable

information supporting enhanced maintenance crew effectiveness.

Analyze the data

"The final element is the analytical software that makes sense of the data to guide maintenance activities," says Barker. "Analyzing this data is no trivial task, considering the volume of information and the disparate sources and formats."

Some organizations seek to extend the application of their existing asset-management systems by repurposing them for CBM analytics. Those systems are often not up to the task because they were originally designed to house relatively simple, planned maintenance programs — not dynamic CBM programs. Tasking these older systems with CBM is likely to result in overloading the system and under-utilizing of the data collected.

Many utilities have in-house experts who can define the basic rules or algorithms to drive the CBM system. Typically, though, this area is best left to experts who possess experience with equipment-performance models related to the targeted asset classes being monitored.

"Utilities are typically staffed with very intelligent and experienced engineers," says Craig Stiegemeier, Technology Director for ABB Transformer Service in North America. "What they often lack is extensive knowledge of transformer or breaker degradation and failure, and few of them have the analytical tools needed to create an optimal CBM plan. OEMs know the thousands of ways transformers break and can apply that knowledge to predict issues with the customers' assets."

That experience ensures that the analytics consider the best metrics to assess current asset health and predict potential issues.

"In days past," Stiegemeier continues, "veteran maintenance techs would take a transformer oil sample and use it as the primary guide for required maintenance. That's kind of like looking at a blue piece of a jigsaw puzzle and assuming the puzzle is a picture of the ocean. The actual picture could be the view out a window, with only a small area of water. Strong algorithms consider many pieces of asset data, weight them appropriately and consider how they interact."

"Selecting the right analytical tool is critical," states Schrieber. "Utilities need to select an open architecture solution that doesn't lock them into a narrow range of sensor types or data formats.

That way the sensors can be off-the-shelf and the processors generic. The power of the system resides in the algorithms processing the asset data. Most technology refreshes and

Advantages of condition based maintenance

- Extend asset life
- Improve equipment reliability
- Enable root-cause problem solving
- Minimize maintenance spend
- Minimize overtime costs
- Minimize spare parts requirements
- Optimize maintenance intervals
- Improve worker safety
- Minimize unscheduled downtime
- Reduce maintenance errors
- Reduce unplanned outages
- Lower planned-outage costs
- Simplify regulatory compliance and reporting

capability enhancements can then be accomplished at the software level."

Utilities should understand that their CBM applications are not a set-it-and-forget-it proposition. The algorithms are moving targets that need regular updates to incorporate the most current asset experience.

Baby steps and giant leaps

Deployment of a network-wide CBM system is a daunting task, deterring some utilities from launching this initiative. Many utilities have tested the water and met with success by limiting their efforts to a narrow slice of their assets.

"You can't start too small," Stiegemeier believes. "You don't have to eat the elephant in one meal. Determine which assets to monitor based on the potential savings in routine maintenance or improvement in reliability. Based on their criticality, power transformers and high-voltage circuit breakers are often good places to start. They also tend already to have existing service and performance history. Spending not very many dollars can make a big improvement in reliability, so this is where utilities often launch their CBM efforts."

Some utilities, though, make a major, initial commitment to their CBM systems. AEP, for example, is a North American utility with 5 million customers and greater than 25,000 transformer, breaker and substation battery assets across 40,000 miles of transmission infrastructure. It was concerned that taking a piecemeal approach would lead to failure. To ensure success, they committed to creating the entire, underlying infrastructure to capture data from sources across the company and collect it in a single asset management database.

With their network and database in place across their transmission business unit, AEP brought their various asset classes into the system, first transformers, then breakers and other assets, by priority.

CBM successes

The benefits of CBM seem readily apparent, but are utilities actually realizing those potential benefits? Many are.

"Working in partnership with Deloitte," Mike Ruth, Senior Director of ABB Industry Solution Marketing, explains, "ABB helped develop an asset-health model that captures the savings potential around moving to condition-based asset management and adopting an asset-health-solution approach. While the model is proprietary, it has been validated by AEP as representative of the savings they are realizing and expecting to accrue over time."

Other large companies using CBM tools include EDF, Exelon, Duke and Rochester Gas and Electric.

"RG&E successfully experimented with a CBM approach on a dozen of their critical breakers," explains Friedrich. "They looked at the fact that the normal, 10-year breaker inspection and interrupter overhaul could be a week long process and decided to try to reduce the frequency of those overhauls. Their CBM approach is generating maintenance savings by reducing the frequency of breaker teardowns. In some cases, they have been able to skip several scheduled breakers service intervals by relying on data about their condition rather than a fixed maintenance schedule."

CBM has also boosted their reliability by reducing the need to reroute power during breaker service, avoiding heavy loading on the contingency assets, that can push them above their normal operating levels.

Savings example

	Deployment Ramp	OPEX	CAPEX
Year 1	50%	$6,352,136	$5,448,370
Year 2	75%	$9,528,204	$8,172,556
Year 3	90%	$11,433,845	$9,807,067
Year 4	100%	$12,704,272	$10,896,741
Year 5	100%	$12,704,272	$10,896,741

TOTAL SAVINGS: $23,601,013

North American utility projected 5-year savings based on Ventyx Value Model. Example assumes moving operations from time-based to reliability-based maintenance. CAPEX savings based on projected reduction of catastrophic events. OPEX savings based on projected reduction in contracted labor fees, overtime costs, fleet costs, material costs, and labor productivity savings

Acquiring deeper knowledge

Utilities hungry for in-depth guidance on their transition to CBM can turn to many resources. One of the challenges,

though, is that CBM practices travel under other flags such as the more-fundamental predictive-maintenance approach as well as the more-encompassing asset heath management. Identifying literature and resources under any of these topics will prove helpful.

Industry events also present rich opportunities to learn more. The CBM concept is far from new, but it remains a topic of great interest and therefore discussion.

Many OEMs see the handwriting on the wall. They increasingly recommend CBM over time-based maintenance for newly installed assets, and therefore offer customers training on this approach. This despite the fact that some of those OEMs were in the business of providing scheduled maintenance services, and will try to migrate that service revenue stream to CBM.

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Summary

Most major utilities are taking strides — albeit of different lengths — toward condition-based maintenance. Successful implementations are being made and benefits being captured at installations that range in scale from network-wide to single-assets.

Regardless of size, every successful implementation begins with the data, capturing what already exists in the organization and deploying sensors to fill critical information gaps. The data must then be consolidated in a single database and should be made accessible to all functional areas in the organization to maximize its value throughout the utility. Finally, analytical software is required to identify issues, predict trends and generate highly efficient maintenance work plans.

Once CBM is in place, maintenance managers can capitalize on the common sense approach of servicing assets when they require it, not based on an arbitrary schedule. The bottom-line benefits are highly focused maintenance activities that ensure the highest possible asset reliability and life.

References

[1] Navigant Research Report: Asset Management and Condition Monitoring

For more information please contact:

ABB Power Products & Power Systems
940 Main Campus Drive
Raleigh, NC 27606
Phone: 1-800-HELP-365

www.abb.com

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