White paper

Leveraging technology to reduce risk and optimize reliability

In an increasingly complex world, where regulatory pressures, reliability demands, and the risks of natural and man-made disasters are rising, utility managers and engineers are under a microscope. They simply cannot afford a wrong decision about where to focus their resources. Yet, the old methods of risk management won't cut it anymore. Only by leveraging smart technology and turning data into actionable intelligence will utilities be able to quantify the risks they face, prioritize repair/replacement decisions, and then apply their limited resources effectively to optimize overall system reliability.

Fragile systems and graying workers

Hurricane Sandy was not a singular event. Neither was Katrina, nor any of the other massive natural disasters to hit aging, and evermore fragile, U.S. grid systems in recent years. In fact, as a recent RAND report states, "Infrastructure exposure to natural hazards is expected to increase – in some cases substantially – across the continental United States." According to RAND, even the most optimistic projections of sea-level rise, precipitation, and extreme temperatures suggest that more assets – such as power plants, along with transmission and distribution systems – will be exposed "to more natural hazards of high intensity." [1]

While storms like Sandy steal the headlines, they represent only some of the issues and risks keeping utility managers awake at night. In addition to natural disasters, there are the ever-present threats of physical and cyber attacks and the related costs of complying with federally mandated Critical Infrastructure Protection (CIP) regulations, which consume an escalating portion of utility resources.

Then there are the operating risks resulting from an increasingly fragile system. It's widely understood that many key assets such as large power transformers (LPTs) are decidedly on – or approaching – the right side of the classic bathtub-shaped failure curve. "Age is certainly a contributing factor to increases in transformer failures," a U.S. Dept. of Energy report declares. "Various sources, including power equipment manufacturers, estimated that the average age of LPTs installed in the United States is 38 to 40 years, with approximately 70 percent of LPTs being 25 years or older." The report further cautions that LPTs more than 70 years old are still in operation and that 60% of circuit breakers are more than 30 years old. [2]

But LPTs are not all that's aging. Utilities are in the process of losing decades of technical expertise and institutional knowledge due to the retirement of highly qualified technicians and engineers. In fact, over half of the current utility workforce will be eligible to retire in the next six to eight years, and 72% of energy employers are having difficulty finding quality replacements. [3]

Making matter worse, all this comes at a time utilities are under pressure from:

a) Restraints on capital expenditures (CAPEX) and reduced operation and maintenance (O&M) budgets;
b) Customer expectations of higher power quality and greater reliability;
c) Increased regulatory oversight, and;
d) Increased penetration of distributed energy resources (DERs).

Without a doubt, every operational decision utilities make will have profound consequences for customers, investors, and regulators alike.

Selecting the path forward

The following sections of this white paper present three action plans to create a path forward for utilities. All rely on a smarter grid – one that employs intelligent devices and software, as well as state-of-the-art communications – to remove the walls between operational and information technologies. This not only opens the door to improved operational efficiencies, but also makes available critical data necessary to target the investment, operation, and asset replacement decisions that will ultimately reduce risk and optimize reliability.

Action plan #1: Reducing risk through analytic-based predictive maintenance

Customers and regulators are demanding that utilities deliver ever-higher-quality electric power – with greater reliability – but, as noted earlier, aging infrastructure and the loss, through retirement, of highly experienced workers are forcing utilities to make hard decisions.

At any other time in history, the path forward may have been difficult to see. But while today's disruptive technologies – the mobile internet, cloud technology, intelligent software, and the Internet of Things (IoT) – are being deployed more widely in other industries, the case studies presented later in this white paper showcase what's now possible in the utility industry. For some utilities the future is already here.

In this new digital age, utilities will no longer have to rely on fixed, time-based maintenance schedules and/or staff experience and judgment to make grid-critical maintenance/replacement decisions. "With widespread communications, low [data] processing costs and continued deployment of intelligent equipment," a recent Greentech Media (GTM) white paper noted, "businesses can collect and analyze far more data from the field than ever before." [4] By leveraging smart technology and systems, utilities can move into active, data-driven conditioned based maintenance (CBM), focusing their resources where they are most needed and the benefit greatest, whether we're talking about frequency converters, switches, or high-voltage transformers.

But the full benefits of this transition can be much greater. Done right, this convergence of information technology (IT) and operational technology (OT) will also provide utilities actionable intelligence on which to base asset replacement decisions and allow them to precisely target the investment, operational, and maintenance decisions necessary to reduce risk of failure and optimize reliability – both during normal operations and under the stress of storms or other natural disasters.

And utilities are beginning to see the benefits. "A global survey of over 200 utility executives confirmed they increasingly believe that IT-OT integration is a key component of any effective asset management strategy," notes Jeff Barker, Business Development Manager, High Voltage Products, ABB. "More than half of the respondents have, or are planning to have, a strategy such as ABB's Internet of Things, Services and People (IoTSP) program for asset management."[5] However, this transition will not only require the adoption of flexible processes, but also the incorporation of intelligent devices and enterprise management systems.

"Of course there is an upfront investment that will vary with the scale of the utility and the scope of the implementation," adds Barker. "But payback comes quickly, typically in the two- to three-year range." For example, according to an ABB analysis, a catastrophic transformer failure can cost from three to 10 times the price of the equipment itself.

Solutions in a flood of data

It's no surprise this new digital machine age relies on mountains of data. "While utilities already collect data to assess the condition of their equipment," says John Barnick, Industry Solution Executive, ABB Enterprise Software, "many are unable to adopt condition based maintenance because the sensor penetration of their grids is very low." However, where they need additional data – for instance, on assets whose failure would significantly degrade reliability – utilities are becoming more willing to add sensors because sensor prices are falling and their reliability is increasing. The same can be said about the availability of the IP communications networks needed to transmit that data, all of which makes those investment decisions much easier. In fact, adds Barnick, “We see the transition from time- or interval-based maintenance to CBM accelerating because of it.”

“Naturally, once utilities have aggregated all this data, they have to do something with it,” continues Barnick. “They need the analytical capability to make sense of the data and to make thoughtful, strategic, and fiscally sound decisions about which assets should be replaced and when the rest ought to be scheduled for maintenance and repair.” But analyzing this data is no trivial task, especially with volumes of information coming from disparate sources in multiple formats. Until utilities address the issue of asset health management systemically – with an end-to-end solution offering the right combination of integration, embedded intelligence, and automation – they will struggle to develop actionable intelligence.

Case study: Asset Health Center*

“You can’t look at the health of utility assets from a single perspective,” says Dr. Siri Varadan, Director, Product Management, ABB Enterprise Software. “You have to look at it holistically. Otherwise, it’s like the old story of five blind people touching an elephant – your views depend on the part you come into contact with.” For instance, he says, “If you are in the operations department, you’re concerned about voltage, current, and outages. If you’re in the maintenance department, you focus on work orders. In procurement you want the lowest cost for the reliability you get.”

In short, he adds. “At the end of the day, it’s all one elephant. You need a single view, and everything needs to be connected.” That’s why ABB worked with American Electric Power (AEP) to develop the Asset Health Center (AHC) concept. It’s an approach to 21st Century asset management that combines operational and information technologies to help utilities integrate existing grid-monitoring infrastructure and systems with business intelligence.

Asset Health Center combines:

- Equipment-based operational technology (OT) with
- Enterprise information technology (IT) and
- Embedded intelligent hardware

The idea is to aggregate a wide range of asset information – including years of employee wisdom – into a cohesive and usable format that will provide actionable intelligence on everything from strategic repair/replace decisions to parts inventory and the scheduling and prioritizing of maintenance.

“This became especially critical for AEP when a review revealed that a third of our power transformers were at least 50 years old and approximately 18% were 60 or older,” Jeff Fleeman, AEP’s Director of Advanced Transmission Studies and Technologies, told *T&D World*. This would raise red flags at most utilities, but for AEP – an integrated utility operating in 11 states with more than 1,700 transmission power transformers in 900 transmission substations – this presented a massive challenge.

While AEP realized the solution lay in harnessing the flood of data from grid and equipment sensors and monitors, it also knew that effort would require special expertise and a combination of technologies, so it partnered with ABB to:

- Leverage the utility’s existing infrastructure and IT systems
- Employ simple, robust, affordable sensing that targets failure modes
- Focus intelligence at a central collection point

With only one of four phases complete, AEP hasn’t disclosed financial figures on the operational and maintenance benefits it’s seen so far, but it has cited big reductions in the time, cost, and engineer-hours required for the tasks that Asset Health Center has now automated.

Although AHC was developed for AEP’s extra-high voltage (EHV) equipment, the utility will expand the effort to monitor lower voltage equipment (138 kV and lower) and has started a

*January 2018: Asset Health Center is now known as ABB Ability™ Ellipse® APM pilot program to monitor underground transmission facilities. "We are also looking at how this technology may benefit our generation and distribution businesses," said Fleeman.

Action plan #2: Implementing a storm preparation and recovery strategy

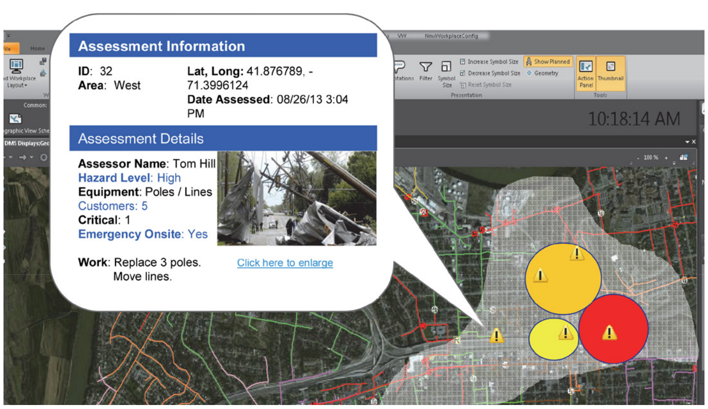
As noted earlier, in 2012 Super Storm Sandy caused more power outages than any single storm in U.S. history. Yet, incredibly, it was just one of four devastating storms to hit the country in 18 months, and the cumulative effect of these natural disasters lit a fire under regulators, consumers, and the industry not only to prepare for future disasters – which will surely come – but also to lessen their impact by shortening storm recovery times.

"Every storm makes utilities a little smarter about the weak points on their systems," says Gary Rackliffe, Vice President, Smart Grids North America, ABB. "Utilities can take the obvious steps to harden their grids by raising or moving those substations that tend to flood, replacing old poles, or installing more resilient breakers, switches, or transformers at critical locations." But now the pressure is greater and the stakes are higher, Rackliffe says, "and with the flood of data streaming in from the smart grid, utilities are asking themselves how they can use all this technology to manage risk and optimize reliability before, during, and after the next Sandy."

Leveraging technology

"The key," says Barnick, "is the smart technology, including enterprise software and intelligent devices, available to utilities today. Together, they can monitor and control the entire grid – everything from asset condition and performance to work management and overall network control."

"Over the last five or six years," continues Barnick, "utilities across the country have embraced advanced metering infrastructure (AMI), which streams time-based grid data over remote communications to central data collection points. With the proper enterprise software, utilities can now leverage this data to reduce risk and optimize reliability before, during, and after storms."



Today's advanced distribution management systems (ADMS) provide actionable intelligence on the location and geographic extent of storm damage. This allows operators to prioritize work and dispatch crews faster than ever before to reduce both the impact and length of outages.

For instance, during a storm, enterprise software, aided by smart sensors and intelligent devices, can use real-time data to automatically reconfigure grid systems to isolate faults or outages. And by giving utilities greater visibility in the farthest reaches of their distribution systems – places they couldn't see before – this new technology provides critical real-time information on voltage, so operators or closed loop enterprise software applications can tell when there is a need to operate taps, capacitor banks, DERs, or other devices to keep the grid functioning properly.

Additionally, adds Barnick, "enterprise software has the ability not only to identify the location of a fault along a feeder, but also the exact pieces of protection equipment that operated and the geographic extent of the outage. This allows utilities to dispatch repair crews exactly when and where needed. No consumer phone calls required."

Game-changer

Perhaps even more critically, utilities are no longer limited to a reactive-only role when it comes to storms. Today, they have the ability to be proactive.

Smart technology enables utilities to turn reams of historical data into vital intelligence to simulate future storms and thereby predict the location of likely trouble spots on their grids. As Rackliffe noted earlier, this enables utilities to get smarter with each storm, refining their ability to place crews and locate replacement equipment and supplies – trucks, poles, cable, and other supplies – in advance of storms, thus reducing both outage time and the number of people affected by those outages and, as a consequence, optimizing overall grid reliability. Given all these benefits, and the multiple potential uses for this operational data in other utility systems, managers now have a solid business case to justify the acquisition of enterprise software along with the sensors and intelligent devices necessary to make it all work.

Case study: CenterPoint Energy

Just over a year ago CenterPoint Energy completed a $750 million initiative to enhance reliability and improve the restoration capabilities of its Houston-based electric system.

Buoyed by a $200 million DOE Smart Grid Investment Grant, the utility installed an advanced metering system (AMS) capable of detecting power outages and also added:

- Enterprise software – including an advanced distribution management system (ADMS) integrated with a mobile workforce management system and an advanced outage analytics package to collect and analyze data for a host of utility departments from field crews to financial planners.
- Intelligent devices – including remote monitoring equipment at 31 substations and 771 automated field switches, and monitoring devices placed on 226 distribution circuits.

Known generally as a fault location, isolation, and service restoration (FLISR) system, CenterPoint's new self-healing grid leverages the ADMS software to: a) identify and isolate power outages and reroute power around the damaged circuits to restore electricity to as many customers as possible as quickly as possible; and b) to aid work crews in restoring power to the rest of the grid faster than ever before. In fact, last year Greentech Media reported that as of mid-2015, the new CenterPoint system had prevented more than 102 million customer outage minutes during more than 1,000 separate outage events. [6]

Additionally, "CenterPoint has signed up more than 400,000 customers to its outage auto-alert system, giving them up-to-date notification of when power will be restored," Greentech Media reported. "Further, the utility has used its smart meters' outage-detection capabilities to restore power to more than one million customers without them having to pick up the phone."

Now that CenterPoint has built a smarter grid, it's focusing on maximizing its return on that investment. The utility is currently working to employ its new software and hardware assets to predict equipment failures and forecast the effects of new rooftop solar and changing customer loads on the distribution grid.

Action plan #3: Adopting synchronized microgrids

Many of the same utilities that have begun to employ smart technology and systems to improve and maintain asset health – and to prepare for and to recover from storm damage – are now also looking at a third option to reduce risk and enhance grid reliability: microgrids. "Whilst often viewed as a means of encouraging the uptake of renewable energy, or addressing challenges of peak demand, microgrids can make a significant contribution to disaster preparedness and recovery," according a recent International Electrotechnical Commission (IEC) white paper. [7]

Overall, there are three principal drivers behind the increasing interest in microgrids:

- The same fear of asset failure and massive damage from new super-storms like Sandy that is driving Action Plans #1 and 2.
- The availability and affordability of smart technology that is making microgrids both possible and commercially viable.
- Increasing awareness that microgrids can take many forms and can adapt to various system configurations.

And according to Gary Rackliffe, there are basically three types of microgrids.

"The first – an isolated microgrid – can literally be an island, in the Caribbean for example, or a remote military facility," says Rackliffe. "There is no larger grid to connect to, and often the purpose of such a microgrid is to use as much renewable energy as possible. But renewables are intermittent or variable resources, so energy storage may be required, and all this needs to be controlled and optimized."

The second type, a connected microgrid, according to Rackliffe, is often found at university campuses, community centers, data centers, and the like. In normal mode these facilities take power from the grid, but when the main grid goes down, they can separate and operate as an island, using multiple on-site generation sources. "In these situations there might be multiple feeders on the customer side of the meter feeding loads from on-site generation, renewable resources, and redundant back-up generation systems," Rackliffe notes.

The third type is a utility-owned embedded microgrid. "A utility can create a microgrid in a section of its overall grid and use local generation to power critical customers (e.g., commercial centers, grocery stores, gas stations, etc.) in the event of a grid disruption," says Rackliffe. "It's an investment in reliability and resiliency."

Reliability: The driving force

Of course, the reliability benefits of microgrids have been known for years, and as such hospitals, military bases, and other vital facilities were the first to adopt them. Very simply, when a natural or man-made event disrupts the main grid, the microgrid switches to island mode and uses existing distributed generation – local diesel, microturbine, wind, solar, hydro, or battery power – to keep the lights on and to power essential services. When power is restored to the main grid, and after a "synch check," the microgrid reconnects to the grid and local generation can shut down. But microgrids can also be used to stabilize the grid itself. "By rapidly absorbing power surges from the renewable energy sources, or by injecting power to make up for short term lulls, a stable voltage and frequency can be

The Marble Bar microgrid in remote western Australia consists of four 320 kW diesel generators, a 300 kW solar array, and ABB's PowerStoreTM kinetic flywheel grid stabilizing technology. This hybrid microgrid supplies nearly 60% of the town's power, saving approximately 400,000 liters of diesel fuel and 1,100 metric tons of greenhouse gas emissions each year.

maintained [both] in the microgrid and main grid," according to the IEC [7].

Additional benefits

There are other reasons interest in microgrids is growing. They can provide the means to control and coordinate disparate distributed energy resources to increase their reliability and efficiency. They also represent an entirely new way of powering remote or rural communities. According to the IEC, "Rather than one centralized (often diesel-powered) generating station, these communities can be powered by a large number of low-emissions generators, linked with appropriate load control." Finally, they can provide enhanced power quality, which is absolutely critical for customers engaged in advanced manufacturing.

Faster payback

Naturally, cost is a consideration. While microgrids involve investment in power generation, controls, sensing, and communication technologies, the capital outlay is often much less – and payback significantly faster – than other approaches to reducing risk and optimizing reliability. "While payback for utility-scale power generation can take several years or even decades, microgrid payback is most often measured in terms of a few years, if not months," says Rackliffe.

Conclusion: A smarter path forward

Managers and engineers in today's electric power industry are under pressure from all directions. On one side, customers and regulators are insisting on higher quality power and greater reliability than ever before. On the other, they are facing a future of more super-storms like Sandy, potentially crippling cyber and physical attacks, and demands for more renewable energy – all of which hike operating risks, especially with fragile systems and a graying workforce. Very simply, to get a handle on all of this, utilities need a smarter path forward.

As the case studies outlined in this white paper clearly show, smart technology – including intelligent software and devices – provides utility managers and engineers a new kind of leverage. First, it converts streams of data into the actionable intelligence necessary for utilities to identify, quantify, and rank operational risks. Then, armed with this new information, utilities are able make smarter repair/replacement decisions, employing limited resources more effectively than ever before, to reduce risk and optimize the reliability of system operations.

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9AKK106930A0443 Rev. B October 2016