



GUIDE SOURCEBOOK

transmission
& distribution
automation



Getting Smarter

NEW APPROACHES TO DISTRIBUTION AUTOMATION

By Warren Causey

Most people are aware that the electric distribution and transmission systems are aging and subject to periodic failure—with some of those failures being rather spectacular. But that's just one side of the coin. The other side is that the distribution systems have proven remarkably reliable in most areas, major outages are rare in most parts of the country and the industry is not sitting still while these assets and technologies age.

Many people are also aware that the electric distribution system, based on Thomas Edison's original work, continues to incrementally improve through new science and technology. However, while new and better products with higher capacities and materials have emerged, Edison's fundamental scientific concepts remained unchanged for many years—that is until the arrival of distribution automation (DA) in the 1980s and 1990s.

DA emerged after the discovery that remote communications systems could be overlaid on the grid to remotely—and in some cases automatically—manipulate basic switches, capacitors, relays and other devices necessary to control a large and complex array of power lines, substations and other elements of the system. This made correcting a fault and rerouting power around it much quicker, further reducing the impact and duration of outages. DA handles this remote manipulation along with a software application system called SCADA (Supervisory Control and Data Acquisition). SCADA allows dispatchers to see what is happening on the system and make changes remotely.

Now, a consortium of utilities and vendors called DV2010, (Distribution Vision 2010), led by WE Energies, in Milwaukee, Wis., is working to bring DA to another level, making the distribution system so automated that it virtually corrects itself without human intervention. The basic idea is to take high-speed, fiber-optic based communications systems, overlay them on the distribution grid, and develop intelligent devices that can do the switching and adjustments remotely, using more than one pathway for the electricity—in effect “dynamic reclosing.”

“We did some self-examination and found that the practical limit of U.S. distribution systems is four nines of quality,” says Russell P. Fanning, principal engineer, distribution automation, for WE Energies. “Customers equate reliability to electric service availability. Radial feeder electric distribution systems deliver levels of perceived reliability that are typically in the range of 99.98 percent available service.” That equates to about 100 minutes of annual outage time on a given system, as indicated by what's called SAIDI (System Average Interruption Duration Index). The goal of DV2010 is to deliver less than one minute of qualified

outages to customers per year, or 99.9998 percent available service.

“New technology in commercial and industrial processes have created an environment where some customers have zero tolerance for any type of power interruptions, where a one-second outage may just as well be a one-hour outage because their critical processes have tripped off-line and product is lost at a significant cost,” Fanning points out. “Reliability goals are attained by reducing response times to system problems and performing partial feeder restoration as soon as practicable. This approach is the core focus of most DA currently operating or under development throughout the industry. So, our first approach was to examine the industry to implement the best technology available to meet our objectives, which were reducing the SAIDI to one minute. Unfortunately, we did not find the perceived revolution in DA taking place at that time.”

“That time” was in 2000 when WE Energies had a new vice president of distribution operations who challenged the engineering department with the question: “What can we do to improve our system reliability? If you were to start over, what would the distribution system of the future look like?”

To answer this challenge, WE Energies engineers brought together their peers from five other major utilities to form DV2010. They were Public Service Electric & Gas (PSE&G), Newark, N.J., Alliant Energy, Cedar Rapids, Iowa, Oklahoma Gas & Electric Co., Oklahoma City, Okla., American Electric Power (AEP), Columbus, Ohio, and BC Hydro, Vancouver, B.C. Since then, PSE&G, currently involved in a merger, has dropped out, but Long Island Power Authority, New York, and the Salt River Project, Phoenix, Ariz., have joined. The utilities each pay an annual membership fee to provide funding for research and development.

The major DA/outage vendors that became a part of DV2010 are Cooper Power Systems, Waukesha, Wis., and CES International, which later was acquired by SPL Worldgroup, San Francisco, Calif. The consortium also has worked extensively with NovaTech, a company that specializes in remote terminal units (RTUs). NovaTech originally was a Canadian company, but now lists its world headquarters as Bethlehem, Pa. NovaTech is not formally a part of DV2010, but has worked with the group to develop a more dynamic DA master device. The vendors themselves also have contributed to the R&D effort.

“There's a misconception about what DV2010 is,” Fanning says. “DV2010 is an organization created to look at developing new technologies for improving operational reliability and bring new automation technologies to the market faster. We're trying to streamline research and development work with vendors to bring new concepts to the market more quickly.”



Part of the misconception is due to the Premium Operating District (POD) concept WE Energies is using to test the development of new technologies. The company is developing a POD in a commercial area of New Berlin, Wis. This pilot project will demonstrate a four-tier level of new switching, designed to make the district virtually outage proof. The system uses three different feeder lines to the district, thus incorporating the concept of a “matrix” so that if one feeder is interrupted, the system automatically switches to another. The switching, with new devices created or enhanced by Cooper, NovaTech and SPL, is designed to occur within four cycles of current. The four-tier system also ensures that each “end” of the traditional radial distribution system is treated as though it were the front instead of the back of the system.

WE Energies engineers had hoped the New Berlin POD would be in operation by 2004, but internal funding at the utility has slowed the process. However, the first three of the four tiers are in place, and Fanning says that has created some interesting responses from the company’s dispatchers.

“We have been anticipating turning on the full (New Berlin) system ‘any day now’ for the last two months,” Fanning says. “The DV2010 stuff is all installed, but we refuse to put it in service until we finish all the communications links back to the dispatcher. If the dispatcher is not

kept in the loop and informed if something is happening automatically, they may have one conception of how the system is configured, when it’s actually something else. The last place is the interface between DV2010 and the EMS (Energy Management System developed by SPL/ CES, a major part of the concept) to bring the information back to the dispatcher’s desktop.”

However, Fanning says the dispatchers have warmed to the idea of having part of the system that automatically reconfigures itself without their intervention. In tests and simulations conducted in laboratories, the dispatchers indicated they didn’t care if they didn’t have to do anything. “When a storm hits, we have other things to worry about. We’re comfortable with letting DA do its thing and simply inform us when it’s done,” they said.

While the New Berlin POD is not fully operational, DV2010 already is bearing fruit in terms of greater system reliability there and in other parts of the country. “I see that most DA schemes will not have the full New Berlin design,” Fanning says. “We have chosen to use Cooper electronic reclosers over the last few years in all automated switching applications. DV2010 has worked with Cooper to enhance their standard Form 6 control and I expect these enhancements will be incorporated into a commercial offering by Cooper, but I don’t know the timeframe for that.”

Meanwhile, other DV2010 members are making their own system improvements:

BC Hydro demonstrated a project to reverse standard protection controls on main lines to include the devices on the underground portion distribution feeders to provide automated sectionalizing and bridging capabilities.

Oklahoma Gas & Electric Co. currently is working on a DV2010 pilot project to network two different substations utilizing a primary voltage network between two feeders.

All of these rather esoteric changes are sometimes difficult to follow for a non-engineer. But what they represent is a concerted effort by utilities to move electric distribution up another major level to the point where automated systems use high-speed communications to automatically switch power flow, reroute around problems and use multiple feeders in a matrix-like configuration to provide virtually uninterrupted power to customers.

Of course, improving distribution automation may some day bring end-use customers to the point of having that one minute or less per year of interruption on the local distribution system. But they still could experience outages caused in the transmission system, such as the Northeast blackout of 2003. But that’s the subject of another story.

Interstate Highway for Power

A POLITICAL AND ECONOMIC ISSUE

By Warren Causey

While engineers in the DV2010 consortium are developing new concepts for local distribution networks that may be able to achieve a guarantee of less than one minute of outage per year, those concerned with transmission have an entirely different problem. Rather than being technical, as is the case with improving the distribution system, their challenge is more political, cultural, historic and economic.

In fact, as one chief information officer of a major utility put it, "The United States doesn't have a national transmission grid. Rather, it has a linked network of local, state and regional grids that are being forced to do things they were never designed to do." The CIO went on to use an analogy of the highway system. The country has a nationwide network of interstate highways that ties all regions of the country together. Then, from that network, you can access local, secondary roads that take you to your local destination.

The problem with the transmission grid is, as the CIO put it, that the United States never built an interstate highway system for electric power, and political and economic conditions now make it very difficult to do. Instead, there are "nodes" where power is exchanged between parts of the grid. These nodes increasingly are controlled by quasi-government entities (Regional Transmission Organizations-RTOs) at a group of less than 10 interchange points. It is virtually impossible to move power from the East Coast to the West Coast and back again. It has to go through so many exchange points that it virtually disappears. Instead, the exchanges are handled as financial transactions, each section paying to receive power from one side and then charging to transfer other power out the other side.

The reason the country finds itself with a collection of interlinked regions but no national grid is because of political decisions made in the New Deal era and earlier. Utilities

lost much of their independence as private businesses to governments—federal and state—in return for protection of service territories and guarantees of rates of return on their investments. Then, they concentrated their investments in their territories in both generation and distribution. Any transmission that was built was internal to their service territories, or perhaps to link to the next utility over—in case of emergency. Links to other regions and beyond were an afterthought. There was no economic incentive to look any further.

That lack of an economic incentive continued during "deregulation" and in fact investment in transmission has continued to lag. The Federal Energy Regulatory Commission (FERC) has pointed out there is less transmission capacity today compared with what is needed than there was 30 years ago.

When the idea of deregulation came along, the system was already in place. Deregulation envisioned nationwide competition among real businesses rather than highly regulated, quasi-government entities. But no regulators voted themselves out of office. Regulation continued, eventually becoming a mishmash of varying stages of competition and power transfer regulations, even before that effort ground to a halt with the collapse of the California effort.

The need for an effective national grid had been established during deregulation, but the political will and the financing to build one has never caught up with the need. It now seems unlikely an interstate highway for power could ever be built because of environmental and public resistance. It is very hard for a utility today to get approval for installing the large towers and wide rights-of-way necessary for major, high-voltage transmission lines—even internal to their service territory, much less from region to region.

The technology for an interstate system exists and is improving all the time. New

composite transmission technologies make it possible to carry more power on smaller lines. New conducting technology can reduce heat and line losses over long distances. But if you can't get rights-of-way or government permits to build large systems through the countryside and near the core of major cities, much of that technology is gathering dust on developer's shelves. Economics is also an issue. No one really knows what it would cost to build a truly effective nationwide transmission system. By the time you factor in NYMBY (not in my backyard) resistance, environment restraints, varying regulation in 50 different states and at the federal level, and the technological improvements necessary, there probably just isn't enough money—anywhere.

Without a nationwide transmission grid, major regional blackouts such as those in the Northeast and Northwest are likely to continue, because the system wasn't designed for today's requirements of transferring large loads between regions—or even between utilities.

The new Energy Policy Act encourages transmission development. FERC actually has some legal clout to help push new transmission routes through legal and bureaucratic obstacles. But it has rarely exercised that authority. A new 765-kilovolt line American Electric Power has been trying to build in Virginia and West Virginia will take an estimated 15 years to complete.

The governors of four Midwestern states have proposed building 1,300 miles of transmission lines at a cost of \$2 billion from Wyoming, into Utah, Nevada and Southern California. But that's a drop in the bucket compared to what is needed. If those 1,300 miles could be built at \$2 billion, consider what it would take to build the other tens of thousands of miles needed to link all parts of the country.



Technology Transforming Distribution

By Charles W. Newton

The term distribution automation can be applied to many aspects of the electric power delivery system, from the control center to the substation, to the feeders and indeed to the customer revenue meters. As the Institute of Electrical and Electronics Engineers defines, distribution automation (DA) is “a system that enables an electric utility to remotely monitor, coordinate and operate distribution components in a real-time mode from remote locations.”

DA has been discussed, written about and worked on for more than a quarter century, and even further back in time, if we include the early days of computer-based Supervisory Control and Data Acquisition (SCADA) technology, dating from the late 1960s. Even today, we often hear about the coming “self-healing grid.” However, given the level of investment and attentiveness of utility management being paid to the distribution network, as measured by study after study, a self-healing grid actually coming to fruition is many years away.

Today, the DA field can encompass any and all aspects of a distribution network automation scheme, from the control center-based SCADA and distribution management system on out to the substation, where RTUs, PLCs, power meters, digital relays, bay controllers and a myriad of communicating devices now help operate, monitor and control power flow and measurement in the medium-voltage ranges. Today, one will also find transformer monitors at the nation’s critical substations.

Beyond the substation fence, further down into the primary and secondary network, we now find reclosers, capacitors, pole-top RTUs, automated OH switches, automated feeders, line reclosers and associated smart controls. Meanwhile, things have not stood still at the customer premises either. Automation of the revenue metering function has occurred at many millions of points in the country’s 135 million metered customer locations.

DA Components

Fundamentally, there are three components of a system-wide distribution automation system. These include control center-based control and monitoring systems, including distribution SCADA or distribution management systems; the data communications infrastructure and methodology required to acquire and transmit operating data to and from various network points in addition to substations; and the various distribution automation field equipment, ranging from remote terminal units to intelligent electronic devices required to measure,

monitor, control and meter power flow.

Taken together, expenditures for this wide range of electric power grid distribution automation activity exceed \$1 billion dollars each year.

Rationale for DA

System operators can more efficiently monitor and control power delivery functions in real time if they have field automation assistance. Field devices such as circuit breakers, reclosers, switches, capacitors, transformers and even substation batteries can all be monitored—if not controlled or operated—remotely. Operators can also remotely measure voltage, current, power factor, as well as overall demand and load flows.

Taken together, this information provides systems operations with the current conditions of the power delivery system, and this knowledge directly affects the efficiency with which the power delivery system works. Adjustments to optimize operating efficiencies are more easily made, and increases in power delivery reliability are provided. When system failures occur, automation of the distribution network implies a much enhanced ability to pinpoint outage locations and causes and to restore power swiftly, thus minimizing the frequency and duration of unplanned power outages.

Budgeting for DA

Even though utilities are forced to operate with a keen eye to the bottom line, it makes little sense to continue overlooking the need to reinvest in our aging electric power delivery infrastructure. This becomes especially important as thousands of our aging senior operations and engineering people are about to retire from the industry during 2006-2012. These are the personnel who could “duct tape” the system’s cracks and keep it tweaked and running.

Today, the need for greater investment in distribution automation systems and equipment is growing. Unfortunately, the actual investment levels continue to slacken, despite passage of the recent energy legislation, some of which is focused on reliability measures. Disinvesting in an aging infrastructure of our nation’s electric transmission and delivery system portends some rough sledding for the continued reliability of our energy delivery system in the near future.

Significant sums are now being spent on control systems, smart field gear, communications services and equipment, IEDs and RTUs,

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automated metering subsystems and other DA-related equipment; however, this is quite insufficient to strengthen or even maintain our power delivery system that brings in revenues approaching \$300 billion. We cannot move from shipping 3,500 billion kilowatt-hours today to a Department of Energy forecast of more than 5,000 billion kilowatt-hours in another 15 years with the same infrastructure. It simply cannot be done.

However, the level of investment as a percent of national electric power sales is miniscule, and a sense of urgency to upgrade the electric power T&D infrastructure does not exist among most of our top utility executives, nor can it be found within the ranks of the largest power delivery utilities. DA in general continues to be a “hard sell” upwards within the utility organization. Why this is the case is somewhat perplexing, but it comes down to a few points:

- » near-term cost avoidance
- » business mentality that suggests “if it ain’t broke, don’t fix it!”
- » Competing with other utility budget priorities
- » “We’re piloting some DA now!” (And probably have been for 20 years!)

However, some hopeful signs are out there. Automated metering systems continue to win new customers. More field automation-ready gear is being installed, yet it is more difficult, more cumbersome and perhaps more expensive to retrofit and upgrade the existing distribution grid—some of which is now a century old—than it is to start afresh, as developing nations can do in their greenfields approach to development of an electric power grid.

We simply cannot secure our nation’s electric energy future without a dependable and reliable transmission grid and distribution network.

One development that has spurred increases in DA-related spending has been the promulgation in several states of performance-based (or, conversely, penalty-based) rates. Studies have observed significant 10 to 15 percent increases in distribution infrastructure and automation spending in those states and in those rate cases where utilities have sought and obtained rate structures based on their performance. Performance measures used for PBR cases have been qualitative (frequency and number of complaints to the PSC) and quantitative (using one or

more of the de facto standard measures such as SAID, SAIFI and CAIFI).

You might ask “What has DA got to do with PBRs?” Well, there is no better way in the minds of many utility officials to improve performance of the distribution network, the cause of most unplanned outages, than to implement some level of automation systems and subsystems to more effectively cope with determination of location, isolation of the incident and restoration of service to the affected areas. It simply does not matter whether the work begins with or continues with integrating communications and automating functions within the substation. Nor does it matter whether the program will begin with feeder automation, sectionalizing techniques or an AMR program using meters that can sense and report back status of power delivery to the customer site.

What Should Be Done

Utility senior officials should request an operations and engineering review of where the business is, in respect to DA. Suggestions for the next steps, together with recommendations and budget proposals, can follow. One such step would be to prioritize the DA direction from either a customer or marketing perspective (automate the system working back from the meter) or an engineering and operational perspective (automate the power delivery system from the substation down the line to the customer premises).

What’s to Gain

Clearly, the utilities of all types and sizes that are moving ahead with investments in DA are not turning back. Their focus is clearly on improved performance—a new-school view that is customer focused. Their customers are sensing better power delivery performance, obtaining more reliable and more secure power delivery with minimized outage duration and frequency. In the end, the cost of acquiring and installing DA will be more than offset by concrete improvements in power quality, an issue so vital to the key industrial and commercial accounts, and a cause of customer erosion and lost revenues for the utility. In the end, fewer outages and fewer complaints brought about by DA investments will certainly mean more revenue flow delivered to the bottom line.

Charles W. Newton is president of Newton-Evans Research Co.

on topic

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Itron Case Study: Xcel Energy-Distribution Asset Analysis

Identifying/Forecasting Energy Load Increases Accuracy, Customer Satisfaction

In the summer of 2003, Xcel Energy, based in Minneapolis, Minn., experienced an increase in distribution transformer failures in its Colorado service territory. Hot summers, new subdivisions, and retrofitting of older homes with new heating and cooling systems all took their toll. Utility officials searched for solutions to identify heavy growth loads and underutilized areas, increase reliability and keep customer satisfaction a top priority.

AN OPPORTUNITY FOR IMPROVEMENT

Xcel focused on identifying load growth in the system in order to respond before demand overwhelmed the infrastructure. They needed precise customer load data-information to identify those assets that should be replaced before they failed, and underutilized transformers. In addition, the utility wanted to reduce outage duration and frequency in metro areas.

“We needed a tool to help us identify asset loading which would also help us prioritize our investment dollars.”

“Energy data is the bloodline of a distribution utility,” said Lynn Worrell, manager of electric capacity planning at Xcel. “Distribution costs are generally the highest expense for most utilities and the demand placed on distribution assets is steadily growing at a sometimes taxing rate. We need accurate tracking of outages with rapid response and remediation.”

The utility already had the data sources required to model electrical utilization and loading at a very granular level. However, they lacked a tool to bring the data together and complete the complex calculations, analysis and reporting.

“Load growth at Xcel Energy has been rapid and has challenged our distribution infrastructure,” said Worrell. “We needed a tool to help us identify asset loading which would also help us prioritize our investment dollars.”

A TOOL FOR PRECISION FROM ITRON

In September, 2002, Xcel decided to implement the Distribution Asset Analysis (DAA) software solution from Itron. DAA identified load patterns and asset utilization for each circuit and distribution transformer. Using historical billing and meter data, weather patterns, and proprietary analytics, DAA provides year-round, hourly load profiles for all transformers and related assets associated with the 1,850 circuits identified in Colorado, Minnesota, North

Dakota, South Dakota and Wisconsin. This represents more than 460,000 transformers, serving about 3.5 million customers.

DAA allows Xcel to identify those circuits and transformers that are at risk for overloading or under-loading, as well as a pro-active replacement program, saving money and increasing customer satisfaction.

DAA provides a precise engineering methodology of predicting circuit and transformer loading. In cooperation with IBM Global Services, Itron receives data daily from 11 of Xcel Energy's existing customer and operating systems. DAA automatically filters and corrects any missing or incorrect SCADA or customer data, creating an accurate database of customer, device, and SCADA information.

“Through the use of DAA, we have discovered overload conditions in our system that would have otherwise gone undetected until a failure occurred,” Worrell said.

RESULTS

In one of its first deliverables to Xcel, Itron identified 300 transformers that were likely to fail based on loading and weather modeling. Xcel used this information to help target transformer replacement in May of 2003, just before the beginning of a hot summer season.

According to Xcel, the summer of 2003 saw a 5 percent reduction in outage-related complaints after DAA was implemented. Multiple interruption and long duration outages declined by 25 percent through efforts to quickly replace transformers after the first outage.

Since the summer of 2003, indicators have been refined by learning from the results from previous years. Xcel now factors in peak load growth and peak hot spot temperature changes from previous years. As a result, 600 transformers were proactively replaced in 2004 and 206 in 2005.

Xcel also uses sub-feeder device loading produced by DAA to improve service reliability by correcting overloaded switches and fuses, balancing loads, and investigating causes of outages downstream of the feeder breaker. Since 2004, more than 200 work orders were created to proactively alleviate overloaded taps. This information was not readily available prior to DAA.

“We expect our reliability to improve since we now have more information about system loading on our feeders, taps and service transformers,” said Worrell. “Ultimately, the customer wins with more accurate, reliable information.”

FOR MORE INFORMATION, CONTACT DEBBIE HENDERSON AT 510.844.2826 OR DEBBIE.HENDERSON@ITRON.COM.



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