Kentucky Utility "Fires Up" Its First SCADA System

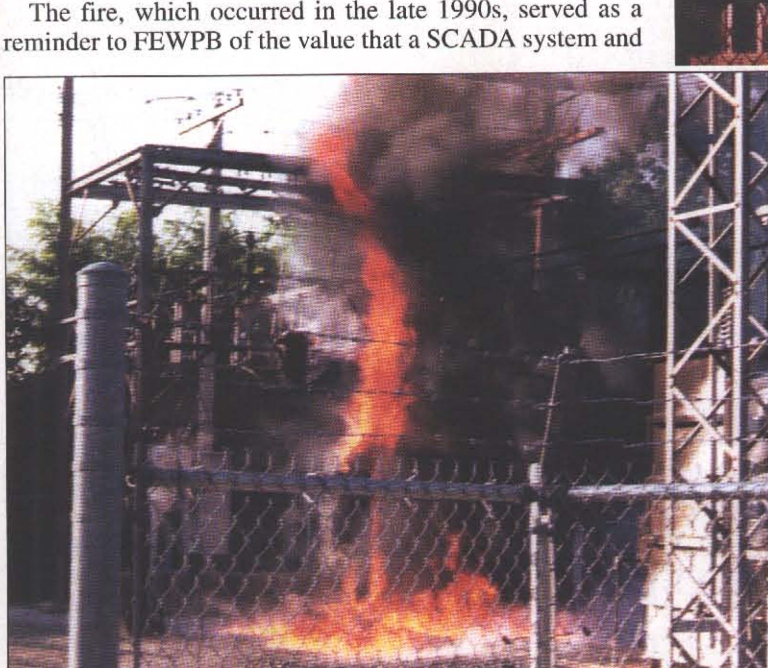
The Frankfort Electric and Water Plant Board takes advantage of a "clean slate" opportunity to communicate with 16 substations.

By Dave Carpenter and Vent Foster, Frankfort Electric and Water Plant Board, and John McDonald, KEMA Inc.

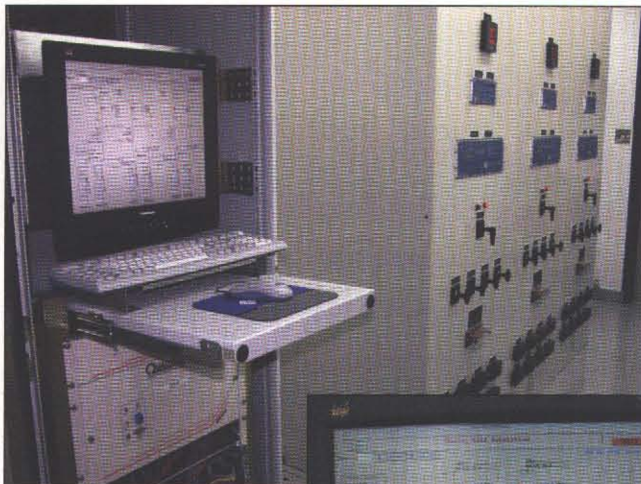
A major substation fire underscored in dramatic fashion the need for a SCADA system at the Frankfort Electric and Water Plant Board (FEWPB). An internal failure in a single-phase regulator caused erratic voltage fluctuations and an eventual explosion that destroyed much of the substation and disrupted power to thousands of customers.

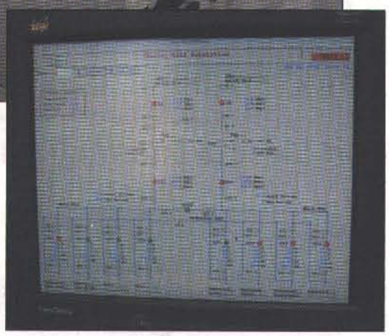
FEWPB (Frankfort, Kentucky, U.S.) personnel were still inspecting the smoldering substation when a neighbor appeared on the scene and wondered aloud if the fire had anything to do with his lights acting funny in recent weeks. Though he had intended to notify the utility, he just never got around to it. Without his call, FEWPB was unaware of the fluctuations and contact breakdowns, which ultimately cost the utility an outage, two regulators and a substantial transformer repair.

The fire, which occurred in the late 1990s, served as a reminder to FEWPB of the value that a SCADA system and



A voltage regulator fire in the FEWPB substation causes the utility to rethink operational procedures and monitoring.





Example of a primary substation control room.

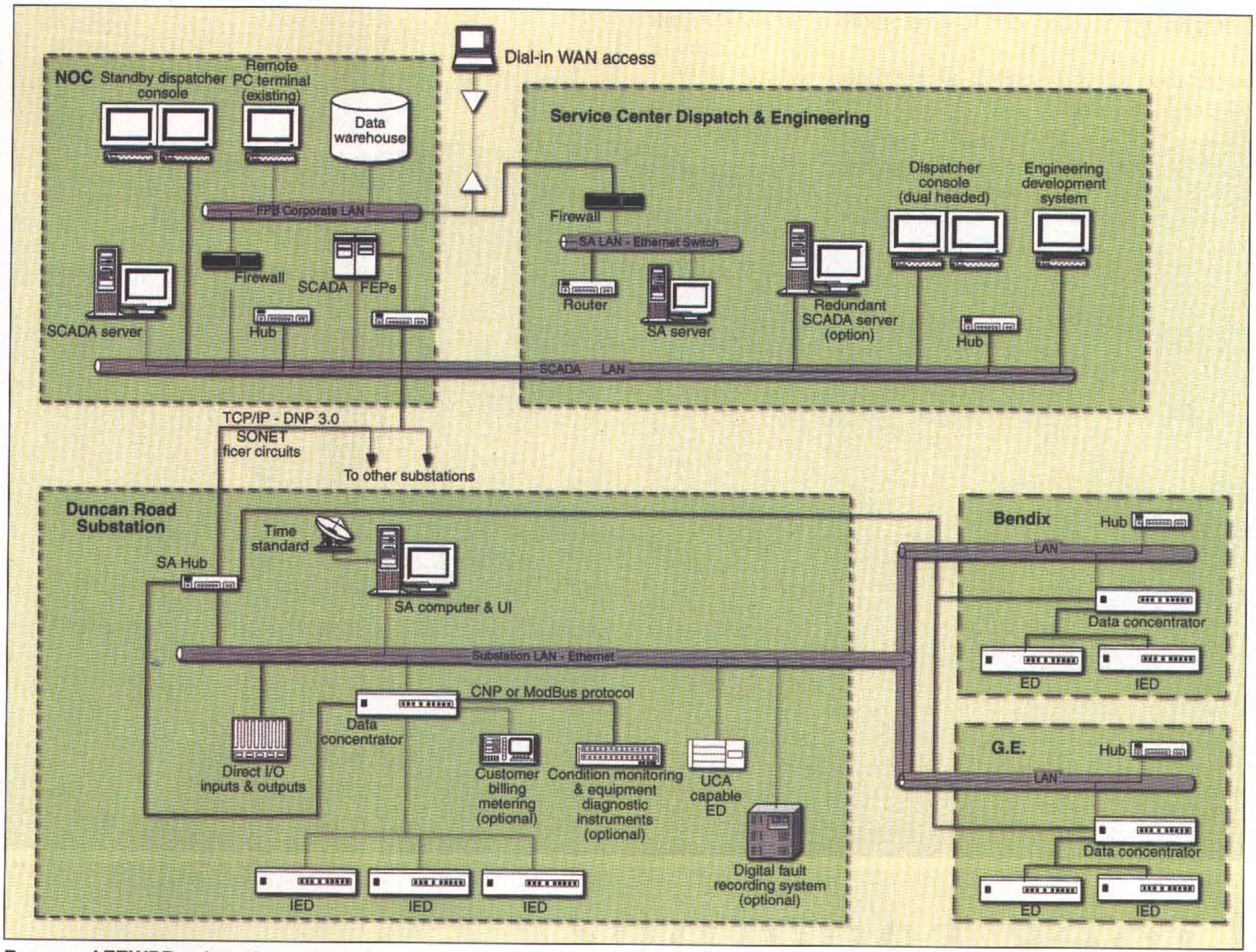
integrated substation automation (SA) could provide the utility, which had no remote monitoring or control of its 19 substations. As long as a decade before the catastrophe, the utility had recognized that these technologies would enable its personnel to know when individual substation peaks happened, where outages had originated and what sequence of events led to a fault. Unfortunately, budgetary issues kept the SCADA plans on the back burner until the fire reignited interest.

With funding approved in 2000, FEWPB resurrected plans to implement its first SCADA system and a substation automation and integration program. Until then, automation had been limited to installation of a variety of microprocessor relays. The utility launched the dual implementation with expectations of improving system reliability and accelerating outage restoration, as well as reducing operations and maintenance costs.

The problems experienced by FEWPB as a result of not having a SCADA system are likely similar to most other utilities. However, the Frankfort project, now more than halfway complete, forged a unique path because it is one of the few utilities in recent years to implement modern SCADA and SA technology where none existed before. This "clean slate" offered interesting advantages and challenges.

Focusing on Tech Ed

Incompatibility is possibly the most daunting challenge of installing new SCADA and SA technology where previous systems already exist. Typically, a utility faces constraints as to which vendor can be selected or how system architecture can be designed based on components already in place. For example, a new SCADA master often must be chosen or configured to integrate with remote terminal units (RTU) that were installed with the old system. Likewise, a new SA system must be selected for compatibility with the existing SCADA system.



Proposed FEWPB substation automation scheme.

With the exception of the random microprocessor relays already installed, FEWPB had neither technology in place and viewed this as an opportunity to consider all available products before purchasing the systems that best suited its needs. In addition, the utility could develop an architecture that completely networked and seamlessly integrated the SCADA master and the substations. FEWPB envisioned a SCADA/SA solution provided by one vendor, or at the very least, two companies working together as a team in joint implementation—a rare occurrence in the industry.

Realizing its lack of experience with current technology, FEWPB hired KEMA Inc. (Burlington, Massachusetts, U.S.) to help with the request for proposal (RFP) and vendor selection processes. KEMA made enterprise-wide education a priority and held a one-day seminar in March 2001 to introduce nearly all utility personnel to SCADA and automation technology.

Looking back, FEWPB believes this educational process played a major role in the success and satisfaction the utility has experienced with the project. As personnel became familiar with the new technology, they understood how it could help them do their jobs more effectively. In follow-up meetings with each department, these people shared ideas and recommendations that ultimately determined many of the capabilities that would be sought and implemented. (See "Required Functionality and Capabilities" for a listing of SCADA/SA functions included in the final proposal.)

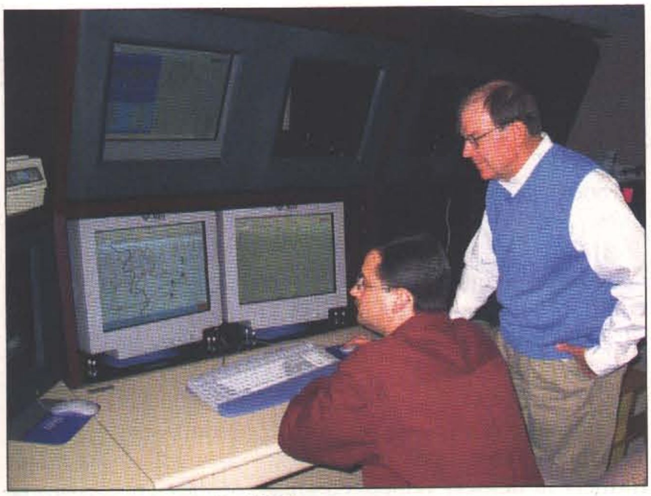
Required Functionality and Capabilities

Input from FEWPB personnel in several departments outlined the following capabilities and functions required of the SCADA/SA systems:

- Data acquisition
- Supervisory control
- Equipment condition monitoring
- Corporate data warehousing
- Automatic load restoration
- Adaptive relay settings
- Power system disturbance and power-quality data
- Sequence of events
- Power-quality monitoring
- Feeder automation support
- Dynamic transformer ratings
- Expert alarm processing
- Access to substation metering data
- Access to utility documentation and systems
- Historical data recording
- Additional SCADA dispatch centers.

Developing an Integrated Architecture

In addition to deciding on the functionality required to achieve the stated company goals, this seminar and subse-



SCADA interface at the NOC.

quent discussions shaped the overall implementation architecture. FEWPB operations personnel realized the "clean-slate" status of their situation gave them an opportunity to configure the SCADA/SA user interfaces in an efficient and convenient manner that possibly no utility had done before.

Rather than have separate interfaces for the two systems, FEWPB decided to ask the vendor to create a single interface incorporating both SCADA and SA functions and control. This interface would be duplicated and installed at several locations, including the primary dispatch center at the Frankfort Service Center, which houses the utility's Engineering, Operations and Support Services divisions. Identical interfaces would be put in place at the Network

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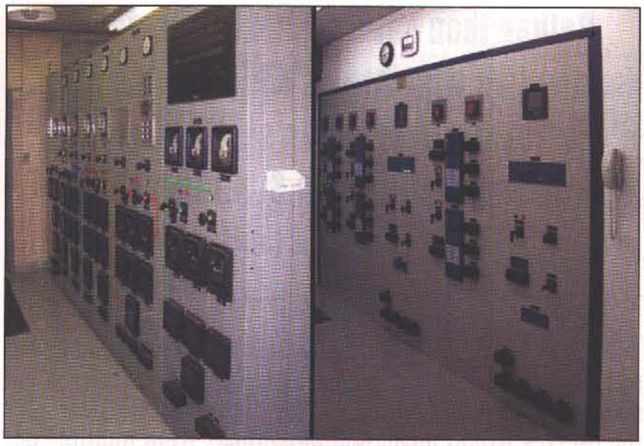
Operations Center (NOC) as a backup dispatch site and at larger substations.

If necessary, these substation interfaces would enable the utility to dispatch the entire SCADA from remote locations. Furthermore, the universal nature of the interfaces themselves would mean that individuals from multiple departments could operate the systems, eliminating the need for a dedicated SCADA dispatcher. Training also would be simplified because personnel would only learn one system.

Another implementation issue that surfaced during this discussion phase was what to do with the existing relays. Over the previous decade, FEWPB had purchased electromechanical and microprocessor-based relays from different sources. None met the communications requirements needed for integration with a substation automation system. Technically, it would have been possible to use the existing devices by purchasing a conventional SCADA system using transducers, but FEWPB opted to spend the extra money and replace all of them with new IEDs.

This decision was not as difficult as it sounds because new IEDs collect larger volumes of data from the substation and provide better power system protection for less money



Substation before and after SCADA.

than similar devices purchased just a few years ago. After extensive research, the utility also decided to standardize on one manufacturer's products for the sake of uniformity and compatibility.

Three types of relays, all from Schweitzer Engineering Laboratories (SEL; Pullman, Washington, U.S.), were chosen and installed in the substations. These were the Schweitzer 351S for overcurrent protection on feeder breakers, the 387 for differential protection in larger substations, and the 501 as backup overcurrent protection. This uniformity also allowed personnel to develop a standardized plan for the type of information that would be collected from each IED so that the process could be duplicated in each substation.

Leveraging Communications Technology

Another critical decision that had to be made before writing the RFP was what type of communications technology would be used to integrate the substation automation components, and to carry data and control commands between dispatch and the substations using the DNP3 protocol. To take full advantage of SCADA and SA technology, a high-speed, high-capacity communications network would be necessary.

Fortunately, FEWPB provides cable, phone, security and Internet services, as well as water and electric, to customers in the Frankfort area. This meant the utility already operated a Synchronous Optical Network (SONET) ring throughout the area. This fiber-optic ring is considered ideal for SCADA communications because of its capacity and reliability. A break in the cable does not disrupt communications because the data flow direction can be reversed around the ring at a moment's notice. Although ideal for SCADA communications, SONET is not suitable for protection communications and is not used for that.

The FEWPB SONET backbone is an Alcatel OC-12 system providing 100 Mbps transmission capacity at the substations, more than enough to transmit large operational and non-operational data files. The OC-12 lines already connected the NOC to the Service Center. Located throughout the ring were SONET hubs where lower capacity cable lines run TV, phone and Internet service to individual neighborhoods. Substations could be linked conveniently to these hubs.

At KEMA's suggestion, FEWPB viewed this existing network as an integral component of the overall project that could be leveraged to further streamline the planned SCADA/SA architecture. After careful study, team members proposed using the SONET system to reduce costs in the SA portion of the project. The plan called for categorizing substations as either primary or secondary facilities.

Primary substations generally are ones with large transformers in densely populated areas, or they are the newer facilities with room for future expansion. They have a high bandwidth connection to the utility enterprise. The utility determined that it could save a significant amount of money by installing the full suite of components in only the primary substations. These would be equipped with IEDs, personal computers or workstations, and all SCADA/SA interface components. By comparison, the secondary stations would have only the IEDs and would be integrated with the SA system Data Concentrator. However, they would not have a personal computer or SCADA/SA user interface.

A fiber link would be established between each primary and the secondary stations that it supported. This link would carry data collected from the IEDs and data concentrator in the secondary facilities to the primary station where it could be analyzed at the SCADA/SA interface. This data, along with the primary station's data, would then be forwarded to the SCADA master via the SONET.

Ultimately, six substations were designated primary and 10 were secondary. The secondary substations would be linked to primary stations using all dielectric self-supporting (ADSS) 24-count fiber using corning glass from Alcoa Fujikura Ltd. This fiber would be lit with Omnitron transceivers, which provide 100 Mbps transmission. FEWPB field crews could string ADSS on existing utility poles, in the National Electric Safety Code's designated power space, eliminating clearance issues and providing another cost savings. This same type of fiber was used to connect primary stations to the SONET at neighborhood hubs.

Selecting a Vendor

Rather than plunge directly into the RFP process once the project goals, system capabilities and integration architecture had been outlined, FEWPB took a different approach with assistance from KEMA. The utility drew up a request for information (RFI) describing its SCADA/

Typical distribution breaker before and after SCADA.

SA plans and its desire for an open system, using commercial off-the-shelf hardware and software. FEWPB also wanted a maintenance contract and an SA training simulator. The RFI requested that vendors supply Frankfort with detailed technical information and budgetary pricing for their products.

The RFI was sent to 25 vendors with the objective of generating interest among the industry and garnering a larger number of replies with competitive pricing favorable to FEWPB. The utility also hoped this would encourage vendors to form bid teams to provide the SCADA and SA components. Ten vendors responded, out of which four were sent the final RFP, a modified version of the RFI.

After a multistep evaluation process managed by the consulting firm, FEWPB awarded the SCADA/SA contract to a single vendor, Hathaway Industrial Automation (Baltimore, Maryland, U.S.). Not long after the contract award in early 2002, this vendor was purchased by Danaher Corp. (Washington, D.C.) and integrated into its Qualitrol group. This transaction did not significantly impact the project.

FEWPB had anticipated using its own personnel to perform all of the make-ready work at each substation to prepare the facilities for installation of the SCADA/SA equipment, but limited staff size made this impractical. The utility hired R.W. Beck (Nashville, Tennessee, U.S.), an engineering firm that had done previous substation work for Frankfort, to handle some of the make-ready. R.W. Beck also assisted with the installation of the IED replacements in all substations as part of the contract.

Qualitrol delivered the first components of SCADA and SA systems in the third quarter of 2002. Implementation began immediately, starting with installation of the SCADA master at the Service Center and integration of the SA system in FEWPB's newest primary substation and its two secondary stations. Once completed, the second SCADA master was put into the NOC, and the SA training simulator was brought online.

Lessons are always learned in this type of project, especially when it is a utility's first one. The only modification FEWPB would make if it could be done again would be to install the training simulator first. This would have allowed personnel to determine how the IEDs should be integrated in a simulated environment, which would have saved time during actual SA implementation.

Additional substations have been integrated on a phased budgetary cycle, with two primary and seven secondary stations remaining over the next three years. The entire project should be completed by 2008 with an implementation cost of US$1.2 million for the SCADA and SA systems. The total project cost will reach $3 million when consulting, make-ready and new IEDs are included.

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