Dairyland Power Installs Multifunction High-End Meters and Expanded Wide Area I/P Communications for Metering and Real-Time Data Collection

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Abstract—**Dairyland Power Cooperative is installing a new distribution automation/telecommunications system that will provide secure collection of substation meter readings, load profile billing information, real-time meter data, local alarms, and a secure communications path for member Automatic Meter Reading (AMR) systems. Dairyland Power is a generation and transmission cooperative located in La Crosse, WI that provides wholesale power to 25-member cooperatives and 19-member municipal electric systems.**

Dairyland Power was experiencing diminished analog cellular service with limited bandwidth, minimal security, and no guarantee of service beyond February of 2008. As a result, a comprehensive distribution automation and telecommunications project was approved in December 2004. Expansion of the existing digital microwave network, installation of point-to-multipoint I/P-capable spread spectrum radios, and installation of custom-designed metering, communications, and automation cabinets provides secure serial and I/P connections for real-time and billing metering data, distribution SCADA, load management, and AMR traffic.

I. Communications Needs

Dairyland Power serves wholesale electric customers in 62 counties in four states (Wisconsin, Minnesota, Iowa, and Illinois). The existing public analog cellular network was providing dial-up communications to 348 substations across the Dairyland Power service area. These dial-up cellular connections were being used to read 15-minute interval billing information from load profile recording devices on a monthly basis.

On September 24, 2002, the Federal Communications Commission (FCC) published *Report and Order 02-229*, which established a five-year sunset period (February 18, 2003 through February 18, 2008) after which cellular carriers will no longer be required to provide analog service. In the mean time, analog cellular service has been diminishing in the Dairyland Power service area, and because of the many different vendors in the service area, Dairyland Power decided to search for a better solution.

The Dairyland Power staff reviewed the needs of a replacement system and identified a list of requirements for a secure communications network:

- A system that could support the needs of both the member utilities and Dairyland Power for secure, robust, wide area communications.
- A system that used off-the-shelf hardware and software that would be cost-efficient and supportable in the long term.
- A system that could securely transport the following:
  - Substation automation information from the substation to Dairyland Power
  - Real-time meter data for display on a secure system operations (SSO) website
  - Daily reads of delivery point load profile watt and VAR meter readings for billing
  - Communications to load management radio transmitters
  - Real-time distribution SCADA information from the delivery point substations to a shared SCADA master station
  - Engineering access to remote metering, automation, and facilities equipment
  - AMR data from the distribution substation to the member cooperative office

II. Existing Substation Equipment

The existing equipment at the distribution substations has been installed from many different vendors over a long period of time and has little consistency. It uses a variety of communications or in some cases has no communications capability at all.

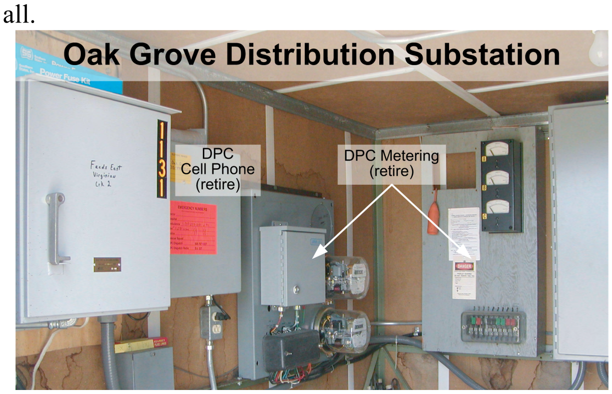

Fig. 1. View of Legacy Metering, Communications, and Control Equipment

A good example is the Oak Grove substation shown in Fig. 1. Metering was implemented using two electromechanical polyphase meters (one kWh and one kQh) equipped with pulse initiators. These pulses were fed into a solid-state recorder that accumulated the pulses and, every 15 minutes, wrote the number of pulses into memory. The recorder was read once per month over an analog cellular phone by the MV-90 meter data collection and processing application. Like many of the older substations, Oak Grove also had very limited load-monitoring equipment, just one thermal demand ammeter per phase. Operators had to drive to the substation to read these panel meters.

III. Flexible, Wide Area I/P-Based Communications

In order for Dairyland Power to implement new data collection, distribution automation, billing, and monitoring functions, they needed to reengineer the communications network. After an extensive study of a variety of options, the Dairyland Power staff developed a comprehensive plan that included expanding the existing digital microwave network. Four additional sites and five new microwave spurs were added in the northern part of the Dairyland Power system. The microwave system enhancements gave Dairyland Power a secure backbone for the wide area network.

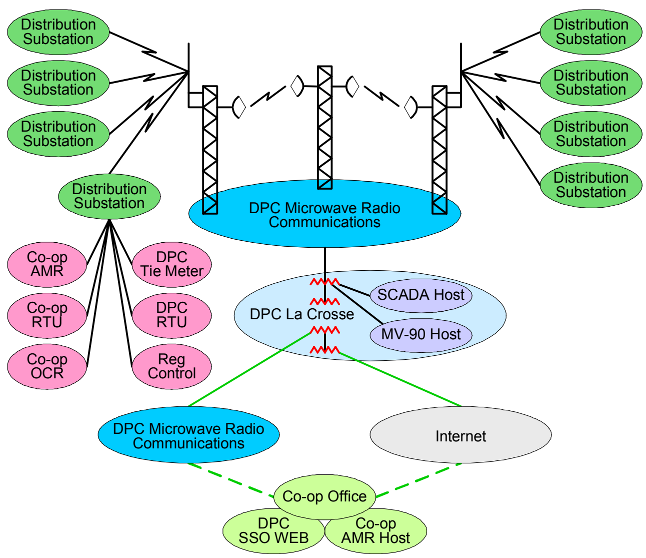

Fig. 2. One-Line Diagram of Dairyland Power Communications System

To complement the expanded microwave network, Dairyland Power is installing 900 MHz spread spectrum radios to link the distribution substations back to the microwave network backbone. These links are designed to handle multiple communications sessions simultaneously and are terminated in the new metering, communications, and automation cabinets with a network router and a communications gateway. Using the wide area network communications, Dairyland Power is providing a wide range of communications services for both real-time and continuously polled applications (SCADA and AMR). Dairyland Power uses these communications services for daily bulk data collection for billing and for engineering access to do configuration and diagnostics.

IV. Network Security

Security is a critical factor in the original network design and Dairyland Power implemented both physical security and cybersecurity into their new system.

Physical security for the distribution substations is implemented in layers. The first layer is the locked perimeter fence of the substation property. The second layer is the locked substation control house, and the third layer is the locked cabinet.

The new metering, communications, and automation cabinets are equipped with multiple security features. The first is a physical door sensor, which is continuously monitored by the Dairyland Power SCADA system. When the cabinet door is opened, Dairyland Power personnel have limited time to scan their employee badge with a permanently installed internal scanner. The SCADA master compares the employee ID with an approved list of IDs and approves access to the cabinet. The system is programmed to alert system operations staff if either no badge is scanned or if the ID is not on the approved list. This interactive security application creates an electronic audit trail for Dairyland Power historical records.

Dairyland Power communications staff developed the I/P network security design. All communications in the network originate from the master or secured side. Because the distribution substations are often in very remote areas, unsolicited communications originating from the substations are automatically blocked. Provisions have been made in the system to reject and shut down any unauthorized communications, and alarms are sent immediately to the network administrators.

Future security measures being investigated include motion detection and frame-capture video monitoring to document activities inside the substation perimeter.

V. Substation Metering, Communications, and Automation Cabinets

In order to simplify the installation of all of the new equipment in each of the distribution substations, the design team developed goals early in the design process:

- Design and specify a "standard" set of devices for all the distribution substations.
- Purchase a custom-designed cabinet, and assemble the components in the Dairyland Power La Crosse Telecommunications Fabrication shop.
- Develop a complete test facility in the Dairyland Power communications lab to validate the specific configuration built for each distribution substation.
- Assemble, integrate, and test the spread spectrum radio, router, communications and protocol interface device, high-end multifunction meter, and facilities interface in the Dairyland Power meter lab.
- Provide remote facility monitoring and both physical security and cybersecurity.
- Include a 48 Vdc battery-backed redundant power supply for all the equipment at each substation.
- Allow the cabinet to be modularly expanded to meet the needs of each specific substation.

- Minimize installation time by preconfiguring and testing the cabinet; field verify the completed cabinet once installed.

The new metering, communications, and automation cabinets consolidate communications, security, real-time meter data monitoring, load profile billing data collection, facilities monitoring, and substation automation, such as regulators and oil circuit reclosers (OCRs).

Dairyland Power is also developing the infrastructure to provide their members with remote control of OCRs, regulators, capacitor banks, and other substation equipment. These additional services will be implemented on an optional, additional-cost basis.

Fig. 3. Front View of New Dairyland Power Metering, Communications, and Automation Cabinet

VI. Metering Applications

The Dairyland Power staff began the project and decided to evaluate a number of different manufacturers' high-end meters. The list of requirements includes the following:

- Provide flexible communications capability, with simultaneous Ethernet, serial, and modem communications capability
- Support DNP3, Modbus®, and MV-90xi protocols
- Collect load profile data for Dairyland Power billing
- Provide more accurate real-time substation operating data including:
  - Reading kW, kVAR, kVA, and PF data
  - Monitoring local alarms
  - Measuring primary voltage by phase
  - Measuring primary current by phase
- Provide future capability to monitor power quality including:
  - Voltage sag, swell, interruption logging
  - Event recorder with programmable triggers
  - Oscillographic event recording
  - Harmonic monitoring

Dairyland Power selected a high-end revenue metering system for this metering project that offers very high accuracy, bidirectional metering, four-quadrant VAR measurements, a 12-channel load profile recorder, flexible communications, power quality monitoring, and time-of-use capability for future implementation.

The selected meter is panel mounted, making it easy to install in the 19" rack of the custom Dairyland Power cabinet. Standard test switches are mounted adjacent to the meter, one for the CT/VT connections and one for the I/O connections. This new meter operates on 48 Vdc auxiliary power, has an Ethernet port, an optical port, and two serial ports. Billing data and engineering access use the Ethernet port, and real-time SCADA occupies one of the serial ports.

Fig. 4. Meter and Test Switches

The high-end meter replaces a number of pieces of equipment in the distribution substation, including the two electromechanical meters, the solid-state load profile recorder, the thermal demand meters, and in some cases, transducers and RTU metering functions. Combining all of these functions into this single multifunctional device reduces the complexity of the installation, while increasing the amount of information available to the system users.

VII. Distribution SCADA

Dairyland Power has installed distribution level SCADA servers at the central Dairyland Power control center in La Crosse. These servers poll the new high-end meters, regulators, OCR controls, and other substation equipment to collect real-time information about the operation of the substation using DNP3 protocol. This operating information is posted on a secure website that is accessible by Dairyland Power member cooperatives. Fig. 5 shows a typical substation page containing both metering and regulator information.

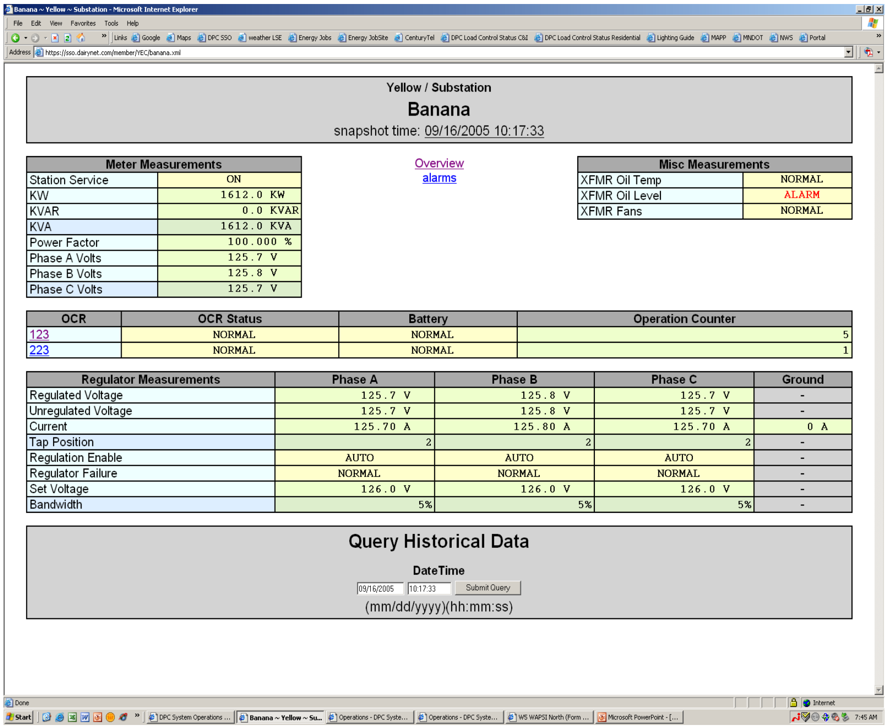

Fig. 5. Web Page of Banana Substation Information Summary

A Technical Standards Committee, made up of member cooperative and Dairyland Power staff, developed a standardized design for the web pages. They are also developing web-enabled historical reports for each distribution substation.

These distribution substation displays give the operations staff at the member cooperatives the ability to continually monitor load and voltage information on each of their substations. This is particularly helpful during very high load periods or when another piece of equipment is out of service for maintenance or repairs. Often the information available on these displays allows operations personnel to make switching or system restoration decisions more quickly and gives them immediate feedback.

The new meters replace traditional transducers and RTU analog inputs, provide higher accuracy, and do not need annual calibration. Because the new meters have DNP3 protocol, the SCADA master polls them directly, gathering kW, kVAR, kVA, PF, and per-phase voltages and currents. Direct communications with the meters eliminates multiple levels of signal conditioning and scaling and improves overall accuracy.

Dairyland Power now collects historical data at the SCADA master station, which has reduced the amount of data collected through the billing system. The information is archived on the central system and can be accessed by member cooperative operating and engineering personnel via secure web access.

VIII. Billing Information

One of the primary functions of the new metering system is to collect load profile watt and VAR billing data at each delivery point. Each meter collects kW and kVAR in and out readings every 15 minutes and stores this information in nonvolatile memory. Dairyland Power upgraded their meter data collection system, enabling the system to gather this interval billing information across the I/P wide area network. Retrieving the interval data at the end of every day provides Dairyland Power additional billing flexibility and reduces the impact of hardware or communications outages. The meters also keep months of backup data in their nonvolatile memory should the data be needed.

IX. Project Progress

Dairyland Power continues to install the substation metering, communications, and automation cabinets. The following segments of this large project have been completed:

- Communications network design
  - Real-time SCADA polling
  - Daily load profile data collection
  - Communications path for member AMR systems
  - Site and enclosure security monitoring
  - Future power quality data collection
- Physical and cybersecurity design
- Installation of the additional microwave sites in the northern Dairyland Power area
- Installation of 900 MHz spread spectrum radios and antenna systems
- Upgrade of the MV-90 meter data collection system to MV-90xi
- Installation of the web-enabled distribution SCADA servers at Dairyland Power
- Configuration of the SCADA databases—display development continues as the system expands
- Installation of the first 60 metering, communications, and automation cabinets in the substations

X. Currently Under Development

The next phase of the project is to securely connect member cooperative AMR computers to the AMR equipment in their distribution substations. Because the member cooperatives use a number of different AMR vendors, the Dairyland Power staff installed AMR master systems in the Dairyland Power test facility. In some cases, the AMR vendors have been updating their systems to allow them to operate across the Dairyland Power secure wide area network. Dairyland Power is providing a secure communications tunnel between the member cooperative office and their remote distribution substations.

Another project under development is the installation of SCADA remote consoles at the member cooperative offices. These consoles would allow member cooperative operations personnel direct monitoring and control of equipment in their distribution substations via the Dairyland Power SCADA and the secure wide area network.

XI. Summary

Dairyland Power's distribution and automation solution provides reliable real-time visibility of the substation meters, breakers, regulators, capacitor banks, as well as communications for AMR to Dairyland Power and its member cooperatives. This solution provides both physical security and cybersecurity of the substation communications equipment and data circuits. The complete solution will pay for itself through a reduction in telecommunications costs and improved reliability.

XII. Biographies

Ed West graduated from California State University at Chico with a BA in Industrial Technology in 1978. After working at the California Energy Commission, Pacific Gas and Electric, and Chugach Electric Cooperative, Ed joined Dairyland Power in 1989. Over the past 17 years, Ed has worked as a programmer/analyst, then as a supervisor in Load Management, and now as the director of Telecommunications and Control Systems. Ed is now responsible for the distribution and automation at Dairyland Power that will upgrade and automate 450 substations for their 25 distribution cooperatives.

Ken Graves has over 35 years of experience in the telecommunications industry. For the last 25 years he has worked in telecommunications and SCADA applications at Dairyland Power and is currently the manager of Telecommunications Services.

Dick Martin graduated from Iowa State University in 1972 with a BSEE degree, specializing in power engineering. He worked in sales and marketing for a number of leading power industry organizations, including Westinghouse Electric, ESCA (now Areva T&D), T&D Technologies, and Telemetric Corporation. Dick joined Schweitzer Engineering Laboratories, Inc. in 2004 and is the product manager for the Meter Systems Division.