

CASE STUDY

Westar Energy, Inc.—Lawrence, Kansas

Improving System Performance Using SEL's Distribution Network Automation (DNA™)

Economically adding fully automated fault location, isolation, and service restoration (FLISR) as well as voltage and reactive power (volt/VAR) control improved reliability and reduced system losses—delivering a win-win project for Westar Energy and its customers.

Lawrence, Kansas—In 2010, Westar Energy was awarded a Department of Energy (DOE) cofunded Smart Grid Investment Grant for the SmartStar Lawrence project. The three-year project consisted of installing advanced metering infrastructure, a meter data management system, and distribution automation (DA). Westar Energy is an investor-owned electric utility founded in 1910 that serves approximately 690,000 customers in the eastern portion of Kansas. The company chose the city of Lawrence as the initial location for implementing this technology due to its average size and diverse customer base, which includes many student residents, commercial and industrial customers, and educational institutions. While Lawrence customers will be the first to benefit from these new capabilities, the company plans to continue to install similar equipment throughout its service territory. The focus of this case study is the DA system that was implemented.

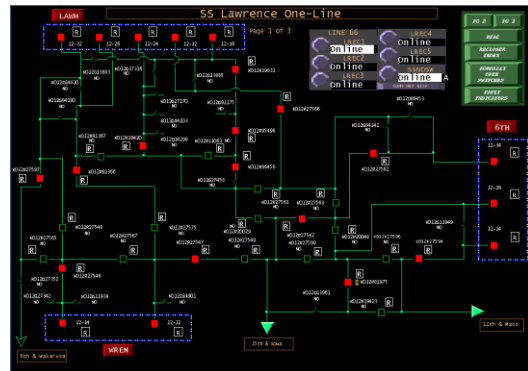


Figure 1—SmartStar DA EMS One-Line

Westar Energy identified the following objectives that it wanted to achieve by implementing a pilot distribution automation system.

- Increased system reliability
- Reduced outage restoration times
- Minimized distribution system losses
- Reduced system loadings during peak conditions
- Improved system operation and understanding
- Improved service to customers

To minimize the impact on the distribution system operators, Westar Energy also wanted to pass information from the DA system to the existing energy management system (EMS)/SCADA system so that a

separate interface would not be needed. Instead, the operators could use the same system they were already intimately familiar with operating.

DA System

The DA system was implemented on 20 of the 1,338 circuits across the Westar Energy distribution network. The feeder circuits used reclosers at normally open tie points to interconnect two or more power sources. Additional reclosers were installed throughout the feeder circuits to allow sectionalizing capabilities in the event of permanent faults occurring on a line section.

Equipment used in the system included the following:

- 33 new SEL-651R Advanced Recloser Controls and SEL-2401 Satellite-Synchronized Clocks paired with G&W reclosers
- One legacy Cooper recloser with Form 6 controls
- 53 S&C capacitor bank controls retrofitted to existing capacitor banks
- 10 substation transformer load tap changer (LTC) controls (6 of which needed to be upgraded)
- 39 existing nontelemetered switches
- 87 Sierra Wireless 3G and 4G cellular modems for feeder intelligent electronic device (IED) communications and control
- One SEL-3530 Real-Time Automation Controller (RTAC) as a distribution automation controller (DAC), providing centralized system intelligence
- One SEL-3620 Ethernet Security Gateway, providing comprehensive security measures and automated event collection capabilities from IEDs

The SEL DAC communicates with the substation transformer LTCs and protective relays via messages relayed through the

EMS/SCADA system to the substation remote terminal units (RTUs). In order to maintain an awareness of system configuration, a server-based software solution monitors the company's outage management system and provides the status of the nontelemetered switches in the system back to the DAC, thus maintaining awareness of abnormal operating system conditions.

At the foundation of the system, several communications protocols were implemented across the system, including DNP3, SEL, and Modbus®. The protocols were selected either due to legacy equipment limitations or to provide desired IED functionality. In turn, the DAC acts as a protocol converter, allowing the various IEDs in the DA scheme to communicate and operate together as a holistic system. Additionally, the DAC provides port-routing functionality for remote-access capabilities using various proprietary vendor software interfaces. This allows a mix of new and legacy IEDs as well as controllers from different equipment manufacturers to be used, thus minimizing the installation time and cost in implementing the system.

Since the automation system was being deployed primarily for system restoration and voltage control, high-speed communications were not required. All protective functions are performed locally within the IEDs, so the loss of communications would be acceptable, although not desirable. It was also recognized that design, deployment, and maintainability of a company-owned communications system would require a significant capital investment and would result in long-term operation and maintenance expenses, although there would be an advantage of no recurring carrier charges. This type of deployment would have also stressed the existing technical workforce at Westar, both in the present and in the future. Planned obsolescence would also need to be factored into the system, which would have required another future capital-intense system upgrade of the communications network. It was for these reasons that Westar

chose to leverage existing cellular technology.

Cellular communications allowed Westar to minimize deployment times since there was no back-end infrastructure to build and maintain. Although there were ongoing data charges, data rate plans were negotiated with the cellular provider(s), which offset the costs that would have been associated with a company-owned system. Additionally, the cellular network is continually being built to incorporate new technologies with increasing data throughput rates and decreasing costs of data plans. With the development of new cellular chipsets coupled with embedded microprocessors, IED vendors are beginning to deploy IEDs with integrated cellular modems as an option, some which even harvest power from the very lines they are monitoring, thus minimizing installation time and costs. It is for these reasons that Westar is confident that the move to cellular was the correct decision.



Figure 2—SEL-651R Advanced Recloser Control, SEL-2401 Satellite-Synchronized Clock, and 3G Cellular Modem

Implementation of the System

Westar Energy and SEL Engineering Services implemented the DNA system in two phases, starting with the fault location, isolation, and service restoration (FLISR) capability (Phase One) and then adding volt/VAR control capability (Phase Two). This allowed the reclosers to be installed initially, followed by the replacement of capacitor bank controls and LTC integration at a later time. SEL provided the initial FLISR and volt/VAR programming by creating a system model and configuring standard DNA libraries for the Westar Energy distribution system. Human-machine interface (HMI) displays were also developed for use during commissioning and testing.

Additionally, SEL provided remote interactive training so that engineers at Westar Energy would be proficient at maintaining and implementing changes to the system to accommodate additional IEDs or feeder circuits in the future. Westar engineers further developed and implemented features in the system, including the deployment of automated password management, remote IED management capabilities, automated SMS/email routines, and additional HMIs, to aid with routine system monitoring and operations.

It was through a concerted effort by both the SEL Engineering Services and Westar teams that the implementation of a comprehensive distribution automation system was a success.

DNA System Capabilities

The Phase One portion of the Westar Energy system provided centralized automated controls that perform autonomous fault location, isolation, and service restoration activities. The SEL solution included the following features as part of the FLISR functionality:

- Loss-of-source detection
- Open-phase detection

- Miscoordination detection and mitigation (provides operator notification and sectionalizes the correct portion of the system with the fault)
- Overload mitigation and load shedding, (smartly selects an alternate source with available capacity, shifts sources if loading increases beyond limits, or sheds load if no alternate sources with capacity are available)

In Phase Two, automation and control for voltage and reactive power flow were implemented. The implementation used the same centralized system DAC and feeder information but added control of voltage regulators, capacitor banks, and substation transformer LTCs to the system model. This simplified the effort to add volt/VAR control while allowing both systems to operate as an integrated system. A benefit of implementing the system in this manner was that even after system reconfiguration, volt/VAR capabilities could still be performed on the reconfigured system.

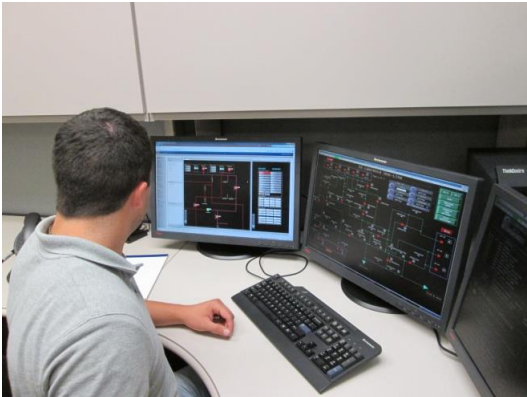


Figure 3—RTAC HMIs and Distribution Automation EMS Screens

Additional features that were part of the SEL volt/VAR capabilities included:

- Minimizing VAR flow (i.e., system losses)
- Voltage operating limits flattened across feeders, allowing for feeder voltage reductions while not exceeding the minimum voltage limits to end-use customers

- Feeder voltage reductions that resulted in reduced energy consumption during peak demand (dependent on load characteristics), also known as conservation voltage reduction (CVR)
- Flexible operator control modes to:
 - Optimize voltage on the feeder
 - Optimize power factor (PF) on the feeder
 - Optimize PF on the station bus
 - Demand response for peak load reduction
 - Optimize VAR set point on the primary side of the transformer for transmission VAR support

Additional System Features

A benefit of having secure communications to substation and feeder devices is that it enables remote engineering access. Engineers are now able to retrieve and change IED settings as well as pull event data (Sequential Event Records [SERs] and oscillography) from all devices on a feeder circuit, facilitating faster event analysis as well as helping to refine settings for improved system operation and protection. Westar has also implemented automated password management and automated SMS text and email messaging routines for configured alarms and events.

System in Action

Although the system has been tested with system events occurring on a routine basis, to date there have been no incidents that would have allowed for an automated restoration. However, the system has been used to identify sympathetic faults on feeders in the automation scheme. As a result of remote data collection capabilities provided by the system, the engineers were able to identify a location upstream of a faulted line section in which conductors were “slapping” together due to magnetic fields associated with high fault current

levels. It is believed that similar intelligence can be designed into the system such that this process of fault identification can be automated in coming years.

Another benefit that has been realized by the addition of reclosers and recloser controls to the system is the reduction in customer interruptions, even without FLISR system interaction. To date, the reclosers have eliminated approximately 173,000 customer minutes interrupted (CMIs).

Lessons Learned

As with any project, Westar Energy learned some valuable lessons as part of the project that will be incorporated in future projects. These lessons included:

- Building relationships with IT groups and personnel involvement, including IT security, was instrumental in successfully designing and securing the system.
- Cross-functional communication between the various interacting groups was key, beginning in the early stages of the project.
- New devices deployed en masse, in contrast to a small trial installation, resulted in some challenges with wildlife protection (faults experienced which required rework).
- The use of cellular modems required some communications handshaking and latency issues to be overcome, some requiring vendor firmware modifications to resolve.
- Autonomous (closed-loop) system acceptance by operating groups was aided by education and training, and was a key part of the implementation.
- “Fault bit” logic in recloser controls and protective relays is useful for identifying fault locations and miscoordination events. This technology could be used as

an early warning system for problem areas.

Summary

The Lawrence Area is already realizing the benefit of improved system reliability, which includes fewer outages and in the future will result in a reduction in outage durations due to faster restoration to unfaulted line sections. This benefits both the customers and Westar Energy, thus creating a win-win project.

Westar Energy implemented a very economical and cost-effective distribution automation system that is providing a very capable and fully automated FLISR and volt/VAR distribution solution. The system has the ability to translate between various communications protocols and seamlessly interfaces with Westar’s existing EMS system. The implemented system leverages some of Westar’s existing legacy equipment as well as positions the company for future deployments.

Deployment of the SEL DAC and Security Gateway hardware at Westar has opened the door to a system-wide deployment of communications devices across their entire company territory. The systems have been designed to maximize system effectiveness, allow improved system awareness, and increase work efficiencies across the company, primarily due to the new remote access capabilities. Through collaboration between SEL and Westar Energy, the Lawrence SmartStar Distribution Automation project was a key success and has provided valuable experience that will be leveraged as Westar continues to expand distribution automation to other parts of their system.

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About Westar Energy

Westar Energy is the largest electric energy provider in Kansas and provides generation, transmission, and distribution to nearly 700,000 customers in much of east and east-central Kansas. Westar Energy is dedicated to operating the best electric utility in the Midwest and providing quality service at below-average prices. The company is headquartered in Topeka and employs about 2,400 people in Kansas. Energy centers in 11 Kansas communities generate more than 7,000 megawatts of electricity, and Westar Energy operates and coordinates 34,000 miles of transmission and distribution lines.

About SEL

Schweitzer Engineering Laboratories, Inc. (SEL) designs, manufactures, and supports a complete line of products and services for the protection, monitoring, control, automation, and metering of electric power systems for utility and industrial customers. SEL's mission is to make electric power safer, more reliable, and more economical.

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