TRANSMISSION & DISTRIBUTION WORLD

One of the antennae for the powerful 700-MHz system is shown at left, mounted on top of the switch structure at Energy Park Substation near Elk River, Minnesota.

Wireless Communication Across 10,000 Lakes

Deployment of a broadband Internet protocol communications network provides Minnesota cooperatives with a Smart Grid foundation.

By **Jim Goodin**, *Great River Energy, and* **Ed Budde**, *Connexus Energy*

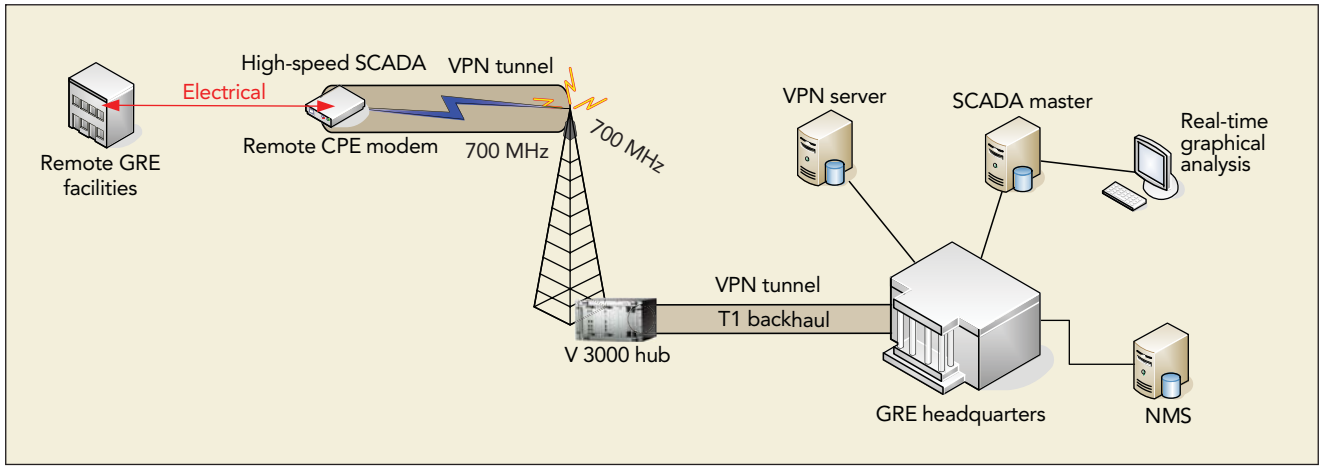
A GROUP OF MORE THAN A DOZEN DISTRIBUTION COOPERATIVES ACROSS MINNESOTA are now connected to a private, licensed 700-MHz wireless broadband IP communications network. The system has been deployed across most of Minnesota, the "Land of 10,000 Lakes" (the state's nickname), a 55,000-sq mile (142,449-sq km) service territory. This network supports field automation and will be key to advancing Smart Grid applications.

ADVANCING THE SMART GRID

Since going live in 2006, Great River Energy (GRE; Maple Grove, Minnesota, U.S.), the leader of this initiative, and a growing group of its member distribution cooperatives, including Connexus Energy (Ramsey, Minnesota, U.S.), have already used the standards-based communications network for a wide range of applications, including demand-response and voltage-management programs, distributed-generation dispatch and control, advanced metering communications, substation automation, and T&D supervisory control and data acquisition (SCADA).

Smart Grid prospects are on our industry horizon, and the speed of change can induce a full-blown attack of future shock, a paralyzing fear when confronted by too much change in too short of a time. With this deployment, GRE has laid a communications foundation that effectively short circuits the Smart Grid-related future shock that is hitting much of the utility industry. As new applications and new substations are tied into the network weekly, GRE and its member cooperatives consider ways in which the network can support the future Smart Grid, while helping them work together today to lower costs and improve service.

Connexus Energy has engaged the network in support of distribution substation communications at more than 20 locations with applications for distributed-generation control programs and a voltage-management demand-response program that saves members more than US$250,000 on the hottest days of summer.

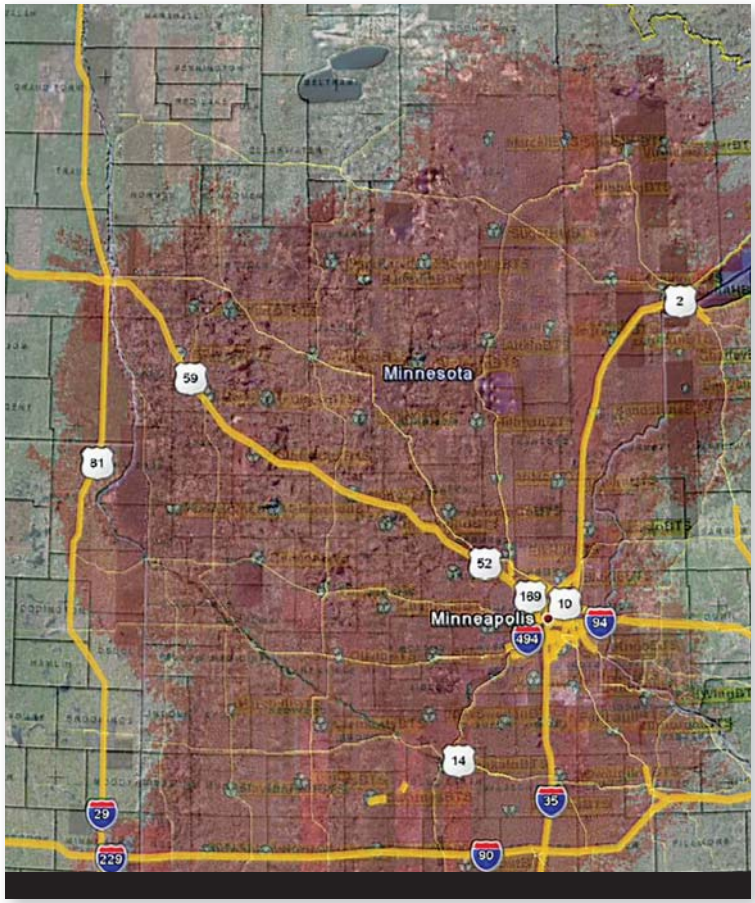


Great River Energy's broadband network configuration leverages 700-MHz radio and virtual private network.

PROJECT OVERVIEW

GRE is the fifth-largest generation and transmission cooperative in the United States, with $1.7 billion in assets. Its 28 member cooperatives in Minnesota and Wisconsin distribute electricity to approximately 650,000 homes, businesses and farms. Not only does GRE serve an extensive customer base, but its network also covers more than 60% of Minnesota.

Collectively, GRE's member cooperatives have 100 transmission substations, more than 4500 miles (7242 km) of transmission lines and more than 480 distribution substations. This large, rural territory frequently faces floods, snowstorms and searing summer heat. Therefore, to effectively serve customers across the large service territory, while continuing to build a user network, the communications network needed to be secure, efficient and in real time.



GRE's deployed communications network coverage area (in red).

THE BUSINESS CASE

Several years ago, GRE defined requirements for an integrated communications network that could replace its aging telecommunications infrastructure. The previous communications links, implemented over a couple of decades, were usually implemented for individual application purposes, and they were engineered with whatever technology fit best for that particular situation. In addition, GRE faced rapidly increasing demand on its generation resources. Potential solutions needed to address the growing concerns of all utilities for greater operating efficiencies, reliability and security.

In this case, GRE decided that investing in an integrated IP communications infrastructure would most directly meet the long-term needs of the utility and its distribution cooperative members. GRE sought a project that would mitigate its vulnerability to technology obsolescence. While technology innovations come fast and sometimes end abruptly, the ongoing partnership GRE formed with Arcadian Networks (Valhalla, New York, U.S.) as a managed service broadband IP network provider has paid dividends. Arcadian has continued to make ongoing investments in the network since the original deployment started in 2006.

PROJECT RISK MANAGEMENT

GRE faced two major risks in deploying a wireless network: the spectrum license and the radio technology equipment. Through their partnership, GRE and Arcadian Networks established a shared network model, which allows both parties to share the network capability, as well as the cost and risk of

deployment and operations. Acting as the "anchor tenant" and network manager, GRE moved to a standards-based converged IP communications network, which allows for use by each of its member cooperatives and enables gradual migration to fit the members' individual communications needs. To date, 15 of the 28 distribution cooperatives GRE serves have deployed, with additional deployments underway. Through its licensed spectrum, Arcadian was able to provide GRE and its members a completely integrated wireless broadband network to accommodate standards-based SCADA applications and a range of additional ensuing applications.

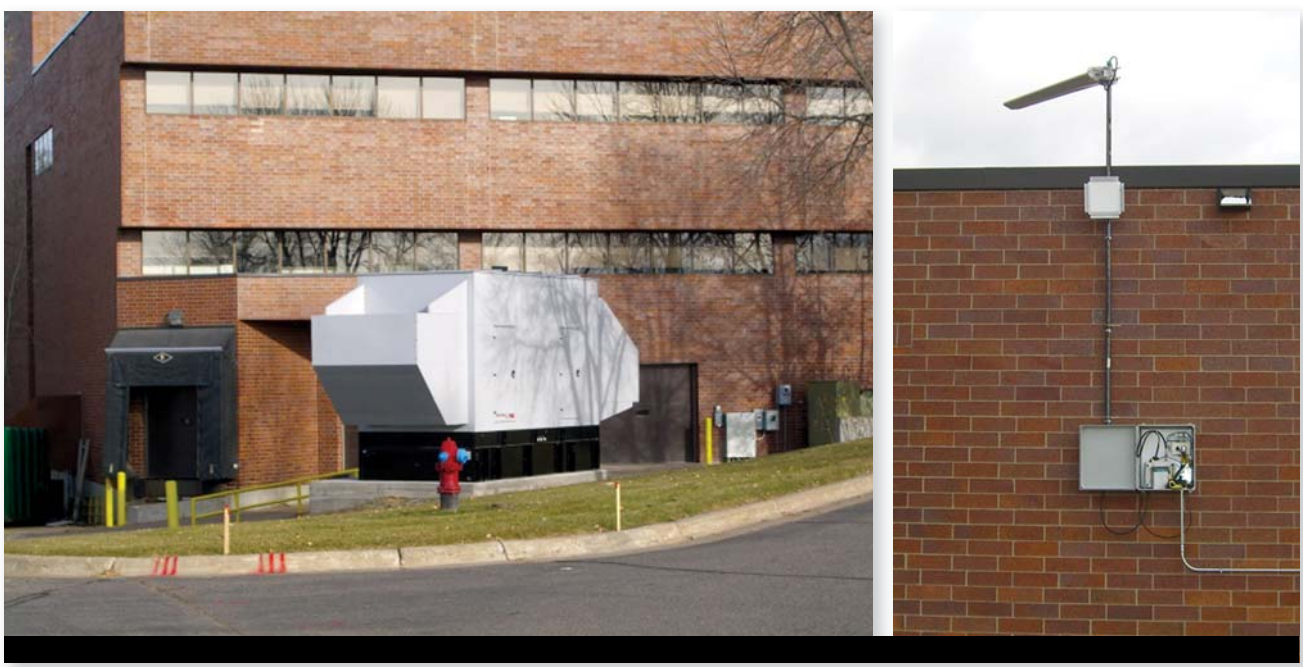
SYSTEM DESIGN

How many towers do I need? What coverage can I expect? Proper and complete answers to such questions would require a detailed radio frequency (RF) study based on specific requirements and the availability of tower and installed fiber assets in the service territory. GRE deployed an integrated long-term solution that incorporates its fiber backbone network across approximately 60 communications sites. These are complemented with endpoint RF network substation sites provisioned with remote access points served by the 700-MHz wireless network coverage from 67 tower sites across the territory. The Network Operations Center at GRE provides firewall-secure service for the network that is controlled and managed by GRE. The Arcadian 24/7 network operations center in New York provides second-level support.

NETWORK APPLICATIONS

The network provides a wide-area, secure IP network that member utilities can use to connect remote assets that typically use nonroutable protocols such as DNP3 through standards-based Ethernet or serial interfaces. Users can connect one or many devices to an endpoint, reducing the number of discrete communication links they need to manage. The converged IP communications platform provides great flexibility with support for a wide variety of applications; however, one lesson that has been learned is that bandwidth could become a limiting factor. Network design and management strategies should be deployed upfront to optimize the network for priority traffic and data flows. Examples of applications the GRE network can handle using this approach include SCADA remote terminal units (RTUs), advanced metering, automated meter reading (AMR) backhaul, VoIP phone calls, Wi-Fi access to network applications, downloading engineering drawings and video/security surveillance.

- *SCADA communications performance.* SCADA is a high-transaction yet low-data-rate communications that often drives mission-critical requirements. In a recent GRE study of 27 of its endpoint locations, the energy management system poll data rate was 254 bps. The average RTU response was 192 bps, and the SCADA response payload was 30 bytes, ranging from 0 bytes to 187 bytes. The largest RTU, in terms of analog and status points, sent and received 317 kb over a one-hour period.
- *Direct meter-reading performance.* Substation-based meters are also a critical monitoring element for GRE and its members. In the 27 locations study, the average number of bytes sent and received during meter reading was 24 kbytes, with an average meter poll data rate of 1019 bps. The average meter response data rate was 3916 bps, with a response duration of 38 seconds.
- *Advanced metering infrastructure (AMI) applications.* AMR and AMI deployments and the network use cases vary widely across GRE members because of the number of meter connections per concentrator, the meter-reading frequency and the wide variety of AMI systems deployed by the various distribution cooperative members. But many AMR configurations can be supported on low-data-rate communications with less than 50-kbps capability.



At left is a generator set and the building it serves. The 700-MHz antenna at right is mounted on the building.

A Connexus distributed-generation installation controlled by 700-MHz wireless communications.

● *Video substation monitoring, VoIP and network hot spots.* MPEG4 video technology is a highly efficient video standard that is suitable for surveillance applications in remote locations. The network also can be leveraged to enable capacity for VoIP extensions of IP-capable PBX and remote workforce applications such as Wi-Fi.

● *Distributed generation control.* Connexus, with more than 130,000 customers, used the communications network to expand its distributed-generation program across its service territory. To make efficient use of its existing radio assets, Connexus redeployed many of its 900-MHz radio assets from substations to use on distributed generators, and then replaced communications to those substations with the 700-MHz network. The 700-MHz network is also deployed to four distributed generators in the field.

● *Distribution voltage-management program.* When GRE notifies Connexus Energy of the need to reduce demand on the network during demand-response events, Connexus implements a voltage-management program using the communications network and SCADA controls deployed to more than 20 urban substations. Connexus is able to achieve an approximately 50% effective decrease in demand from its voltage-management efforts, where generally a 3% decrease in voltage affects approximately a 1.5% decrease in system demand with no noted adverse effects on overall customer service. Connexus is able to achieve this through urban network conditions, using the Arcadian communications network and its SCADA platform and voltage regulators from Beckwith (Largo, Florida, U.S.), Siemens (New York, New York) and Schweitzer Engineering Laboratories (Pullman, Washington, U.S.).

FUTURE PROSPECTS

As GRE, Connexus and other member distribution cooperatives continue to add to the communications network and consider the many ways they can leverage the network covering their service territory, opportunities to deliver increasing value through Smart Grid programs will continue to grow. TDW

James L. Goodin is the technology consultant at GRE, where, for the past 31 years, he has worked in various capacities in system operations, electrical engineering, SCADA and information technology. He was previously in cryptographic communication in the United States Army and has worked in various aspects of long-distance switching, data networking and telephone transmission with the Bell System. Goodin has 41 years experience in automation and telecommunications and is a graduate of St. Cloud State University. He has authored papers on radio systems, HVDC inductive coordination, distribution automation and network technologies.
jgoodin@grenergy.com

Ed Budde is the systems engineer at Connexus Energy in charge of the SCADA front-end system, substation automation, customer generation and the communications infrastructure. He is a registered professional engineer.
Ed.Budde@connexusenergy.com