GREAT RIVER ENERGY™

12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
763-445-5000
greatriverenergy.com

June 21, 2017 **—Via Electronic Filing—**

Mr. Daniel P. Wolf
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

RE: **In the Matter of the Commission Investigation into Grid Modernization: Focus on Distribution System Planning**
MPUC Docket No. E999/CI-15-556

Dear Mr. Wolf:

Great River Energy (GRE) hereby submits, via electronic filing, its comments on Distribution System Planning Efforts and Considerations in response to the Minnesota Public Utilities Commission's (the Commission) April 21, 2017 Notice (Notice) in the above-referenced Docket.

GRE is pleased to submit these comments as part of the Commission's continuing inquiry into Grid Modernization and distribution system planning. We wish to clarify that as a generation and transmission cooperative, we do not own distribution assets or infrastructure, nor do we engage in cooperative distribution planning. We are, however, very engaged with our members in developing and implementing a common vision of the future of the integrated, or modernized, grid, through our GRE and member driven Grid Modernization Initiative (Initiative). Through this Initiative, we have evaluated where we are today, where the industry is headed, and the benefits and opportunities of new technologies. We are in the discovery process of the Initiative, and have begun implementing new technology applications and innovative pilot programs with our membership. We are using the Initiative to hold ongoing discussions with our members, experts, and stakeholders to ensure a successful grid transformation.

GRE and our members understand that the future of the utility business model is likely to look very different than it does today. The energy industry is changing quickly, and dynamic technological shifts are occurring that will transform the way that we think about, evaluate, and conduct business in the integrated grid of the future. GRE and our members are excited about the challenges that the changing industry is providing and we continue to seek opportunities to work together for the benefit of all of our members.

These comments do not provide an itemized response to the questions raised by the Commission in its April 26, 2017 Notice, but instead provide an overview of our Grid Modernization Initiative, a discussion of its goals, pilot program, and the direction in which this innovative work with our members is headed.

GRE and Member Grid Modernization Initiative

GRE established a Grid Modernization Initiative in 2014 that brought together members and GRE leaders to collaborate and develop a shared vision of the future. Phase One of the Initiative focused on two primary objectives:

1. Develop a shared vision of the future among Great River Energy and our members, and
2. Move toward shared technology platforms.

These objectives were met through assessing the current systems and framework and envisioning what new technologies and systems might provide to us and to our members. The discussions resulted in a movement toward a shared technology platform that will provide benefits to GRE and our members.

The first phase of the Initiative included the following actions:

- Facilitated a future grid strategy session for GRE's board of directors and member managers
- Visited leading utilities around the country with more advanced progress of implementing new grid technologies as a means to gather information and practical advice
- Participating in the Minnesota Public Utilities Commission's grid modernization process
- Progress toward shared technology platforms, including demand response management systems (DRMS), telecommunications, meter data management systems (MDMS) and advanced metering infrastructure (AMI)
- Hosted multiple GRE member forums to facilitate learning and collaboration.

Phase One of the initiative is now complete. GRE and our members are now beginning the second phase of the grid modernization initiative, which will include:

- Maximizing the value of the advanced grid technologies being implemented
- Providing forums to enable collaboration between GRE and our members
- Leveraging relationships with research and development organizations, such as the Electric Power Research Institute, to ensure the most current research and best practices are informing our decision making
- Continue to monitor industry trends.

The Initiative's Phase Two will continue the collaboration and help us to further pursue and realize the benefits of shared technology platforms.

New Technologies

A key aspect of the Phase Two is implementing, and maximizing value from two-way flows of information, such as our DRMS and MDMS. As the transmission and distribution system ages, we have an opportunity to invest in technologies that will allow a much more interactive grid experience, offering new capabilities that will make our system more responsive while creating value that will serve our members in new ways. We are using new technology to begin the transition to the future grid for us and for our members.

Our AMI system is an integrated system of meters, communication networks and data management systems that allows a flow of two-way communications between utilities and end-users. Our members have begun and are continuing to implement AMI rollout. By the end of 2017, we estimate that approximately 30 percent of the meters on our members' systems will be capable of advanced functionality. However, with AMI and many other technologies, our membership differs greatly in both size and capability, which varies the ability of our members to transition to the grid modernized future. GRE and its members seek to work together to bridge these gaps and push our Initiative forward.

As GRE's existing one-way demand response dispatch system reaches the end of its life, we are in the process of deploying a new DRMS, Open Access Technology International Inc.'s webDistribute system. The new system will provide more value from Demand Response (DR) resources than previously possible. The system will allow more precise control and allow for interconnection with growing load control technologies, such as smart thermostats and Wi-Fi-enabled devices.

DR programs intentionally change end users electric usage patterns in response to changes in the price of electricity or incentive payments. The programs are largely designed to induce lower electricity use at times of high wholesale market prices, and shift the electricity use to times when wholesale market prices are at their lowest. GRE and our members currently have almost 400 MW under DR control through the end uses of peak shave water heating, irrigation, cycled air conditioning, and commercial and industrial interruptible load. 400 MW is over 15% of our summer coincident peak.

2017 Grid Modernization Summit

On March 28 and 29 of 2017, GRE hosted a two day summit focused on research, new technology, and best practices that included national experts and leaders in the advanced grid arena of the electric utility industry. The summit was attended by GRE and member leaders, key staff, external stakeholders, and invited guests. The summit focused on our Grid Modernization Initiative, updated members on the progress being made, and introduced Phase Two of the initiative. Panel topics included:

- Utility of the Future – A discussion of a future vision of the utility world in 2030, with insights into technology roadmaps and research and development activities that can enable business changes. Changes to the customer experience were discussed, as well as the value of electricity and sharing of examples of business cases from across the country.
- Encouraging Beneficial Electrification – A discussion on the value of beneficial electrification as a means for supporting decarbonization efforts by tying demand side resources like water heaters, heat pumps, and electric vehicles to an increasingly renewable energy supply. Discussions also addressed pilot and demonstration projects, and partnerships and funding mechanisms for electrification in rural areas.

- Planning for Distributed Energy Resources – As a future rich in distributed energy resources moves nearer, this panel discussed strategies, achievements, and obstacles to planning and integrating distributed generation on systems. The interface with the transmission system, and how data analytics play a role were also discussed, in addition to insights on how storage and microgrids are changing the configurations of systems and planning.
- Advanced Distribution Management – This panel discussed the need for a distribution system of the future, and the necessity for a more automated, transactive, and data driven system than those of today. The panel discussion addressed how different entities were responding to the Information Technology/Operational Technology convergence and the operational benefits and challenges related to distribution automation and conservation voltage reduction. Specific business examples and cases were discussed.

Grid Modernization Pilot Programs

As part of our Grid Modernization Initiative, GRE and our members have several new pilot projects focused on new technology and associated benefits. The goals of the pilot program are to encourage development and implementation of small scale test projects, create a mechanism that fosters collaboration, and ensure consistent communication internally and with our members. The generation and application of new ideas is a large part of what makes the GRE grid modernization pilot program productive for both GRE and our members.

Our pilot projects are documented through short project summaries that provide an overview of the project, the description, and why the pilot project matters to GRE and our members. An example of a Grid Modernization pilot project that illustrates the collaboration and innovation between GRE and our members is described below.

Pilot Program Example: Conservation Voltage Reduction (CVR) Project with East Central Energy

GRE and East Central Energy (ECE) are researching how CVR can decrease energy use, lessen peak load, and reduce demand charges while continuing to serve members within established voltage parameters. CVR is a term sometimes used interchangeably with demand voltage reduction (DVR). We are working with ECE to retrieve end-of feeder data from ECE's AMI system to automate and enhance the performance of the CVR/DVR control. The initial phase includes two sites with four distribution substation transformers.

GRE's Information Technology and Transmission employees are setting up the pilot project. Involvement is required from a number of external parties to achieve the equipment installation, data integrations and software installation required to enable the capability. If successful, this pilot will allow other members the opportunity to learn about CVR and how it could be used around their peak loads.

Grid Modernization Catalog

Attached to these comments as Attachment A is GRE's Grid Modernization catalog. The catalog presents our view of the grid modernized future, our progress to this point, and a summary of the pilot projects and progress underway with our members.

Conclusion

GRE and our members understand that the future of the utility business model is likely to look very different than it does today. The energy industry is changing quickly, and dynamic shifts are occurring in technology that are, and will, transform the way that we think about, evaluate, and conduct business in the integrated grid of the future. GRE and our members are excited about the challenges that the changing industry is providing and we continue to seek opportunities to work together for the benefit of all of our members.

These comments provide an overview of our Grid Modernization Initiative, a discussion of its goals, pilot programs, and the direction in which this innovative work with our members is headed. We appreciate the opportunity to submit these comments as part of the Commission's continuing inquiry into Grid Modernization and distribution system planning.

Pursuant to Minn. Stat. §216.17, subd. 3, we have electronically filed this document with the Minnesota Public Utilities Commission. GRE appreciates the opportunity to share its progress on grid modernization with the Commission, and looks forward to continued participation in stakeholder meetings.

Sincerely,

/s/

KRISTA BENJAMIN
GRID MODERNIZATION PROGRAM MANAGER
kbenjamin@grenergy.com
763-445-5900

ZACHARY RUZYCKI
SENIOR RESOURCE STRATEGIST
zruzycki@grenergy.com
763-445-6116

ATTACHMENT A

SHAPING OUR FUTURE

GREAT RIVER ENERGY™

GREAT RIVER ENERGY™

Shaping our future

The future grid initiative

Great River Energy and its members are excited about the opportunities that lie ahead for the cooperative members of tomorrow. No one could be fully prepared for the speed of change we are experiencing in our industry, but with thoughtful planning, an innovative workforce and strong relationships among us, we are shaping our future in a way that only cooperatives can.

Future grid initiative

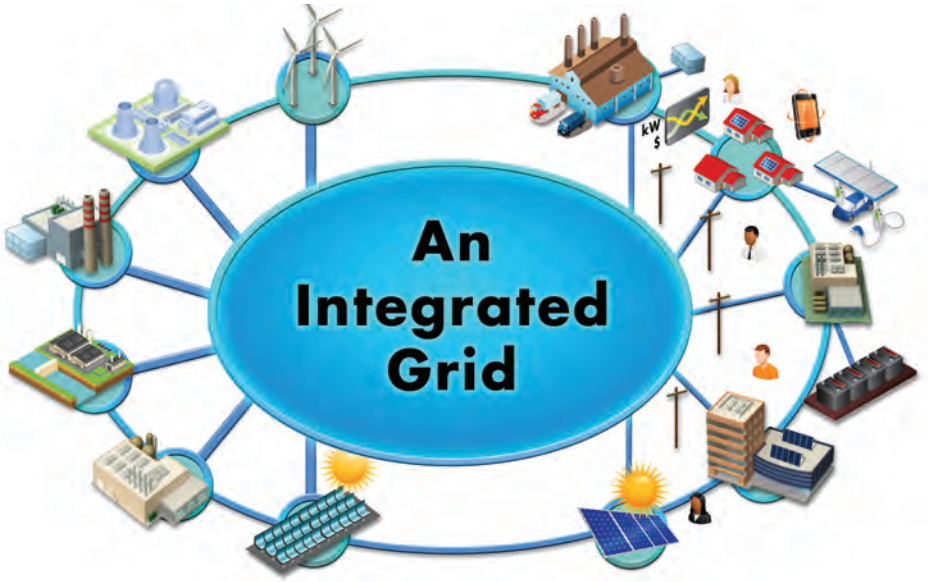
In 2014, a Great River Energy-member group called the Future Grid Committee was formed to facilitate collaboration among us and develop a common vision of the future. Through our future grid initiative, we are planning, evaluating new technologies, learning from industry peers and leading conversations with other innovators to ensure the best future for our members, our employees and the industry.

The future grid initiative complements grid modernization efforts underway at other electric utilities and in states around the country, including in Minnesota. Each process is unique, but the common thread is a commitment to assess all that is in play in today's energy environment and rethink "what always has been" in terms of how the grid operates, what customers want from their electric utilities, what role regulators should play in grid planning and how electric utilities operate their businesses. Distributed energy resources and the transition from a centralized electric system to one that is far more integrated are central in these discussions.

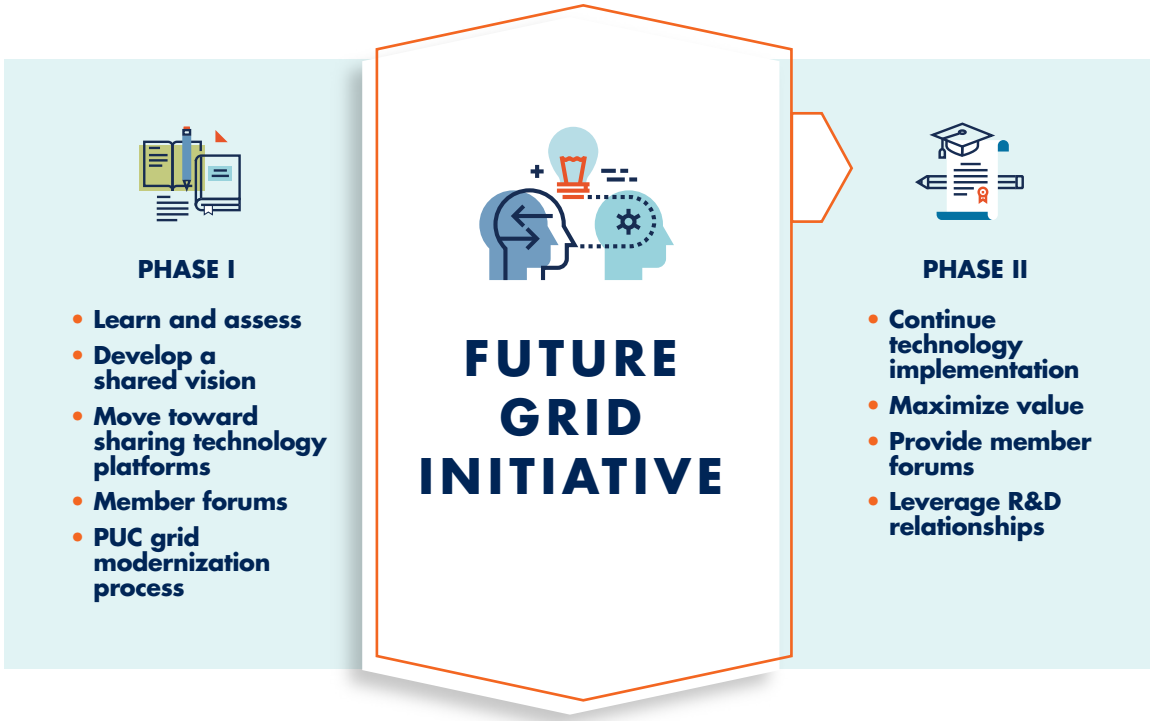
The first phase

The first phase of the future grid initiative focused on two primary objectives: 1) developing a shared vision of the future among Great River Energy and its members, and 2) moving toward shared technology platforms. Steps Great River Energy and its members took in the first phase:

- Facilitated a future grid strategy session for Great River Energy's board of directors and member managers



Distributed energy resources and the transition from a centralized electric system to one that is far more integrated are central to discussions about the evolving electric utility industry. Graphic courtesy of EPRI.



- Visited leading utilities around the country who are further down the path of implementing advanced grid technologies
- Participated in the Minnesota Public Utilities Commission's grid modernization process, establishing a leadership position
- Progressed toward sharing technology platforms such as demand response management systems (DRMS), telecommunications, meter data management systems (MDMS) and advanced metering infrastructure (AMI)
- Hosted multiple Great River Energy-member forums to facilitate learning and collaboration

The next phase

Activities in the second phase of the future grid initiative will include:

- Maximizing the value of the advanced grid technologies being implemented
- Providing forums that make it easy for Great River Energy and its members to collaborate
- Leveraging research & development relationships, such as with the Electric Power Research Institute
- Continuing to monitor industry trends

Pillars of technology

Great River Energy and its members are well into updating critical systems and implementing advanced grid technologies. Over the last several years, we have made significant progress toward updating and implementing these key technology "pillars":

- **AMI:** Great River Energy's members continue down the path toward installing advanced metering infrastructure (AMI). AMI is an integrated system of meters, communication networks and data management systems that enables two-way communication between utilities and customers. By the end of 2017, approximately 30 percent of the meters on Great River Energy's members' systems are expected to have advanced functionality.
- **DRMS:** Great River Energy is deploying a demand response management system because its one-way load management system is reaching end of life. The new system will allow Great River Energy's members to adopt many new demand response technologies while still providing Great River Energy the simplicity of operating a single system. The DRMS brings enhanced analytics to demand response, creating an opportunity to secure and increase the programs' value via the wholesale power market.

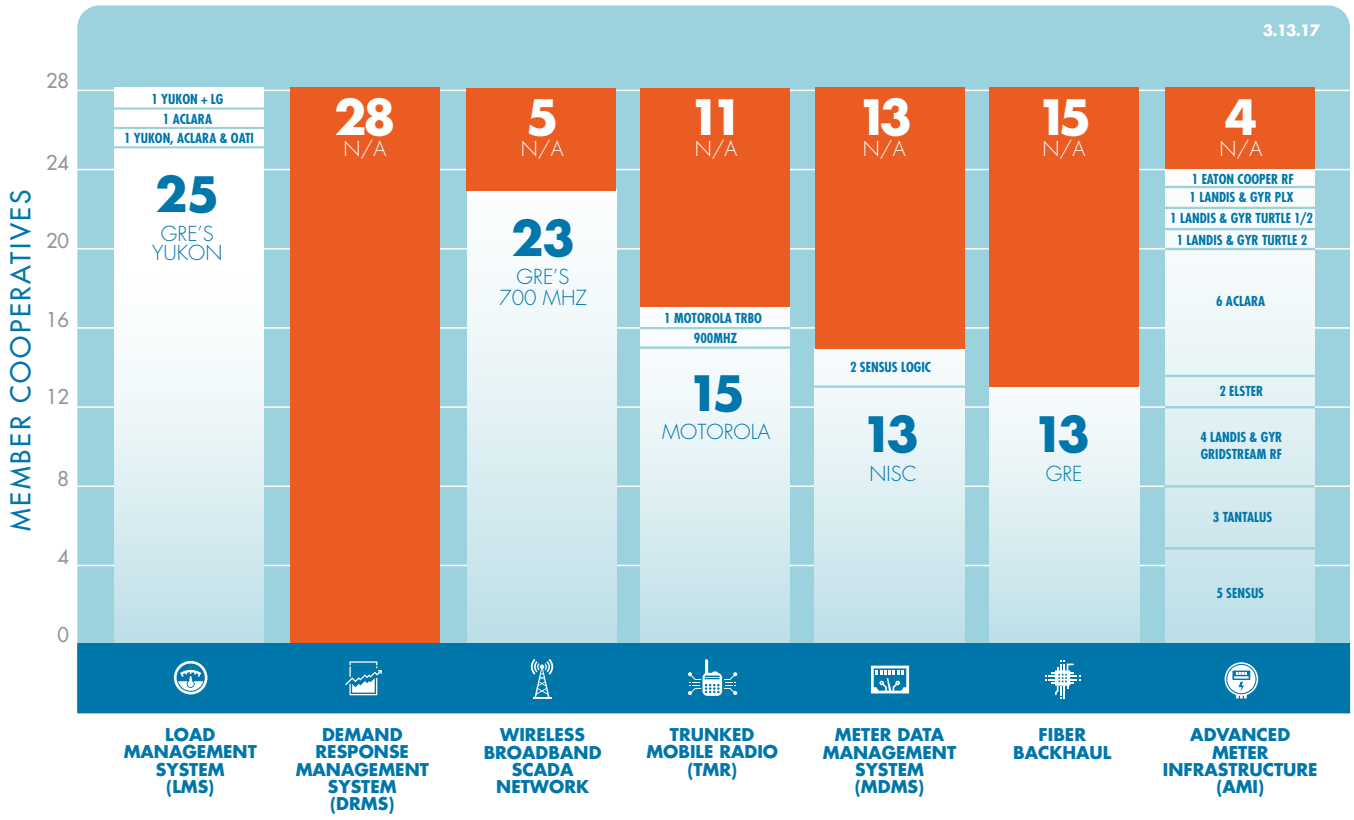
- **Telecommunications:** The fiber backhaul network, 700 MHz wireless broadband and trunked mobile radio (TMR) systems are the three critical components of Great River Energy's telecommunications system. Employees completed an upgrade of the critical TMR radio system from analog to digital technology in early 2017. Fifteen members use the system. Employees also worked to update the fiber backhaul and 700 MHz wireless broadband systems which are used by 13 and 23 of Great River Energy's members, respectively.
- **MDMS:** Great River Energy implemented a new MDMS system in November of 2015. In August of 2016, we began to see savings as a result of more accurate data reported to MISO. Members continue to adopt MDMS systems. Fifteen members have or are installing MDMS systems. Thirteen of those are using the same vendor as Great River Energy (NISC).

Getting value from new technologies

Now that Great River Energy and its members are working more closely together to share technology platforms, the potential value of the technologies is growing exponentially. A significant focus will be on getting the most value out of the technologies. A few examples:

- Currently 15 of Great River Energy's members use our two-way radio system (TMR) to communicate between system operators and field staff. At a small cost, other members could use it as well, rather than managing their own systems. A common radio system enables greater field coordination and mutual assistance, as well.
- Great River Energy now has data analytics resources available to help members who have AMI and MDMS get the most from the data their systems are collecting. For example, Great River Energy worked with Minnesota Valley Electric Cooperative and LREC on a study related to its cycled air conditioning program. The study revealed an opportunity for members to target their marketing efforts more effectively.

SHARED TECHNOLOGY PLATFORMS

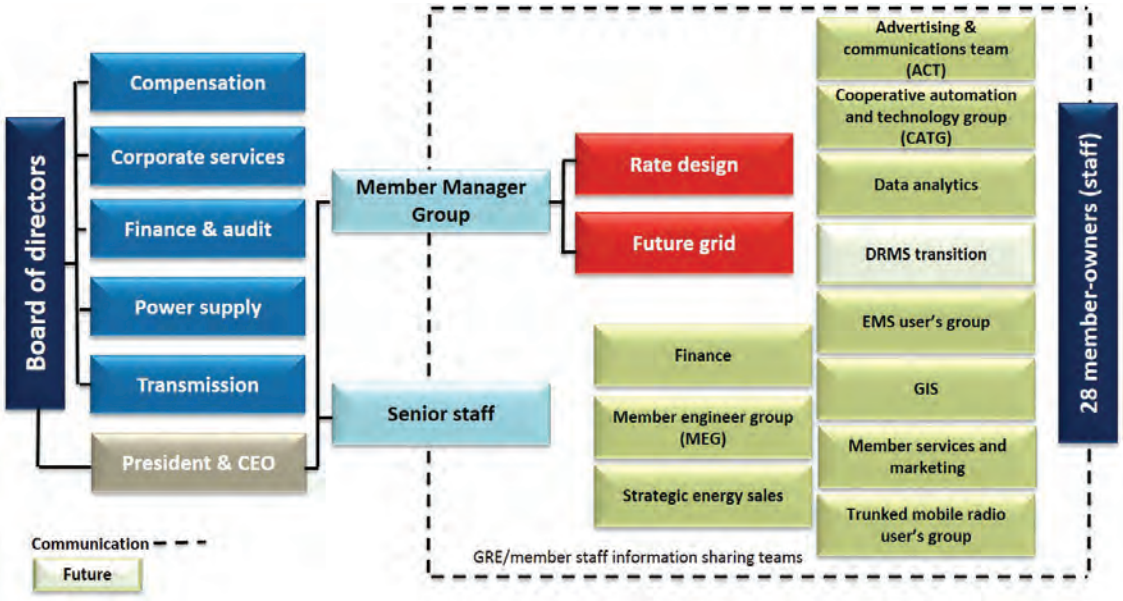


Great River Energy and its members have made significant progress in installing and implementing advanced grid technologies. For example, 15 members are either using or installing meter data management systems, which collect meter data and help co-ops be able to use the data to improve their operations.

- Great River Energy plans to separate a major combined operating system, the energy management system (EMS) and the distribution management system (DMS). All of Great River Energy's members use the DMS on some level. Separating the systems may open up a growing number of opportunities for new distribution automation capabilities in the future.

Making it easy to collaborate

Great River Energy facilitates collaboration with and among its members through information-sharing teams, member workshops and other forums. Some groups include: Member Services and Marketing Team, Advertising and Communications Team (ACT), Member Engineering Group (MEG), Cooperative Automation & Technology Group (CATG), Energy Management System Users Group and a Geographic Information Systems Group. As a result of the future grid initiative, new teams for data analytics, meter data management and AMI users also have been formed.



Future Grid Committee members

Member systems/MREA

Greg Miller (co-chair), Dakota Electric Association
Syd Briggs, Steele-Waseca Cooperative Electric
Ryan Hentges, Minnesota Valley Electric Cooperative
Jim Horan, Minnesota Rural Electric Association
Greg Ridderbusch, Connexus Energy
Steve Shurts, East Central Energy
Tim Sullivan, Wright-Hennepin Cooperative Electric Association
Tim Thompson, Lake Region Electric Cooperative
Adam Tromblay, Nobles Cooperative Electric
Steve Wattnem, Cooperative Light & Power Association

Great River Energy

Will Kaul (co-chair), vice president and chief transmission officer
Krista Benjamin, transmission strategic project specialist
Jon Brekke, vice president and chief market officer
Gary Connett, director, member services and marketing
Mark Fagan, vice president and chief business development officer
Tessa Haagenson, principal planning analyst
Jim Jones, vice president and chief information officer
Therese LaCanne, manager, corporate communications
Laureen Ross McCalib, director, resource planning
Louy Theeuwen, director, executive services

GREAT RIVER ENERGY™
Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369
763-445-5000

greatriverenergy.com

KEY TECHNOLOGIES

Future grid technologies

Technological advances are a key driver in the evolution of the electric utility industry. Great River Energy and its member cooperatives are laying the technological groundwork that will enable cooperatives to offer members more options allowing them to further customize their service.

Great River Energy describes the technology roadmap below as the five pillars.

Telecommunications infrastructure

Great River Energy's telecommunications system includes three critical components: the fiber backhaul system, the 700 MHz wireless broadband (SCADA) network and the trunked mobile radio system. In partnership with member cooperatives, Great River Energy plans to build a foundation for smarter energy and deliver solutions and services.

Advanced metering infrastructure (AMI)

Modern meters fulfill an integral role in providing data to members and cooperatives. AMI automates metering functions using communication networks and eliminates the need for field collection and on-demand polling of meters to verify an outage or restoration. Data collected through AMI can be used to identify customer consumption patterns and identify maintenance needs.

Meter data management system (MDMS)

An MDMS can help monitor line losses, transformer losses and power theft, and help accurately bill accounts with intermittent generation, such as solar.

Demand response management system (DRMS)

A modern DRMS will allow Great River Energy and its member cooperatives to better adapt to changes in technology, consumer expectations and market forces. A DRMS is the analytics engine for demand response. It will help cooperatives better understand the impact of demand response, control electric loads at a more granular level and interconnect with other load control technologies.

Energy management system (EMS) and distribution management system (DMS)

An EMS is a system of computer-aided tools to monitor, control and optimize the performance of the generation and/or transmission system. A DMS is a collection of applications designed to operate the distribution network efficiently and reliably. Great River Energy and its member cooperatives use both systems to collect data and remotely operate the transmission and distribution systems.

Advanced metering infrastructure (AMI)

Overview

Cooperatives have long depended on meters to monitor the electric system and measure the electricity being consumed at homes and businesses. Technological advancements in metering now allow the devices to do more than just measure energy, fulfilling an integral role in providing data to members and cooperatives.

Most digital meters contain chips that enable them to send kilowatt-hour (kWh) use readings and other data to electric cooperatives – what's called automated meter reading, or AMR. Some units go a step further and can send and receive signals from a co-op, opening up a world of possibilities. This allows co-ops to install AMI, or advanced meter infrastructure systems.

AMI is an integrated system of meters, communication networks and data management systems that enables two-way communication between utilities and customers.

AMI is a foundational technology for the future grid enhancements planned by Great River Energy and its member cooperatives.

Measurements

Historically, electric meters' primary function was to measure power consumed over time. With advances in metering, many other measurements are now available. Collecting additional units of measure (UOM) from smart meters enables business improvements and new opportunities. Some units of measure to consider beyond energy are:

- Current – used to analyze losses, etc.
- Voltage – used to analyze losses, outages and health of electric grid, etc.
- Events – used to determine when electrical or physical meters issues occur.

Frequency of data capture

Today's meters are capable of capturing data at intervals not available in the past.

Hourly meter readings provide a 60-minute view of consumption measures (e.g., energy) and hourly snapshots of instantaneous measures (e.g., voltage). About 8,800 measurements are collected for a single meter in a year.

Fifteen-minute readings provide four times more granularity than hourly meter readings, which is useful in understanding changes in consumption and demand response. Nearly 35,000 measurements are collected for a single meter in a year.

Benefits of AMI

The primary function of AMI is to automate metering functions using communication networks. AMI also eliminates the need for field collection and on-demand polling of meters to verify an outage or restoration.

Data collected through AMI can identify customer consumption patterns, identify maintenance needs, drive demand response strategies and much more.

The two-way nature of AMI systems also makes them a platform for executing demand response. This enables the electric utility to deploy demand response with an incremental investment (load control devices) versus having to install a separate communications network and load control devices.

To participate in Great River Energy's demand response programs, AMI systems should have the capability to control loads across the AMI system's communication network by Jan. 1, 2026.

Other AMI use cases

- Better educating members about energy use
- Providing more information for customer service representatives
- Identifying and tracking losses
- Monitoring and improving distribution line voltages
- Improving load forecasting accuracy
- Enabling rate and billing plan options
- Improving outage identification and response

Contact information

John Aiton, leader, energy data and metering infrastructure
Great River Energy
jaiton@grenergy.com

A field guide to meters

Electromechanical meter

Invented in 1888, this meter tracks electricity use with spinning dials. It can only be used to measure kWh consumed.

Solid-state electronic meter

An LED screen displays electricity use on this digital meter, which is accurate and inexpensive, but lacks advanced features.

AMR smart meter

This meter sends information to a centralized database, and can record and analyze electricity use.

AMI meter

This meter allows for two-way communication with the cooperative and offers enhanced options, such as time-of-use rates.

Demand response management system

Overview

Utilities have long understood that they can use the electric system efficiently and economically by reducing demand at certain times. Great River Energy and its member cooperatives are leaders in this discipline, known as demand response.

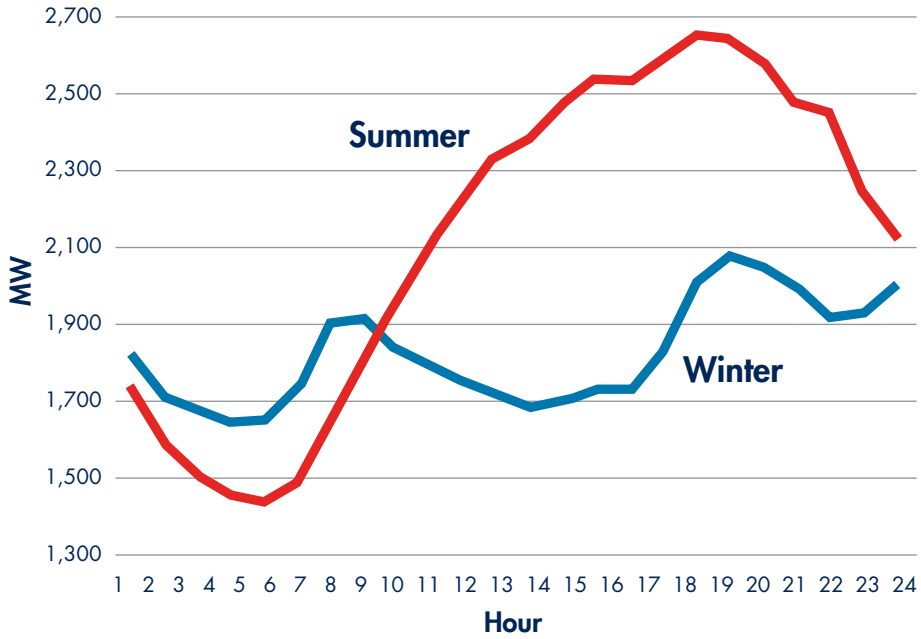
By controlling electric loads, Great River Energy can reduce the amount of electricity it must purchase during periods of high energy prices, which saves everyone money. This is particularly valuable for cooperatives, which provide electricity at cost.

New system, new possibilities

Great River Energy has established its demand response practice using a system that sends one-way signals to cycle certain devices off and on. As the technology nears the end of its useful life, Great River Energy has installed a modern demand response management system.

The new system will help Great River Energy better adapt to changes in technology, consumer expectations and market forces. It will allow more precise control and allow for interconnection with growing load control technologies, such as smart thermostats and Wi-Fi-enabled devices.

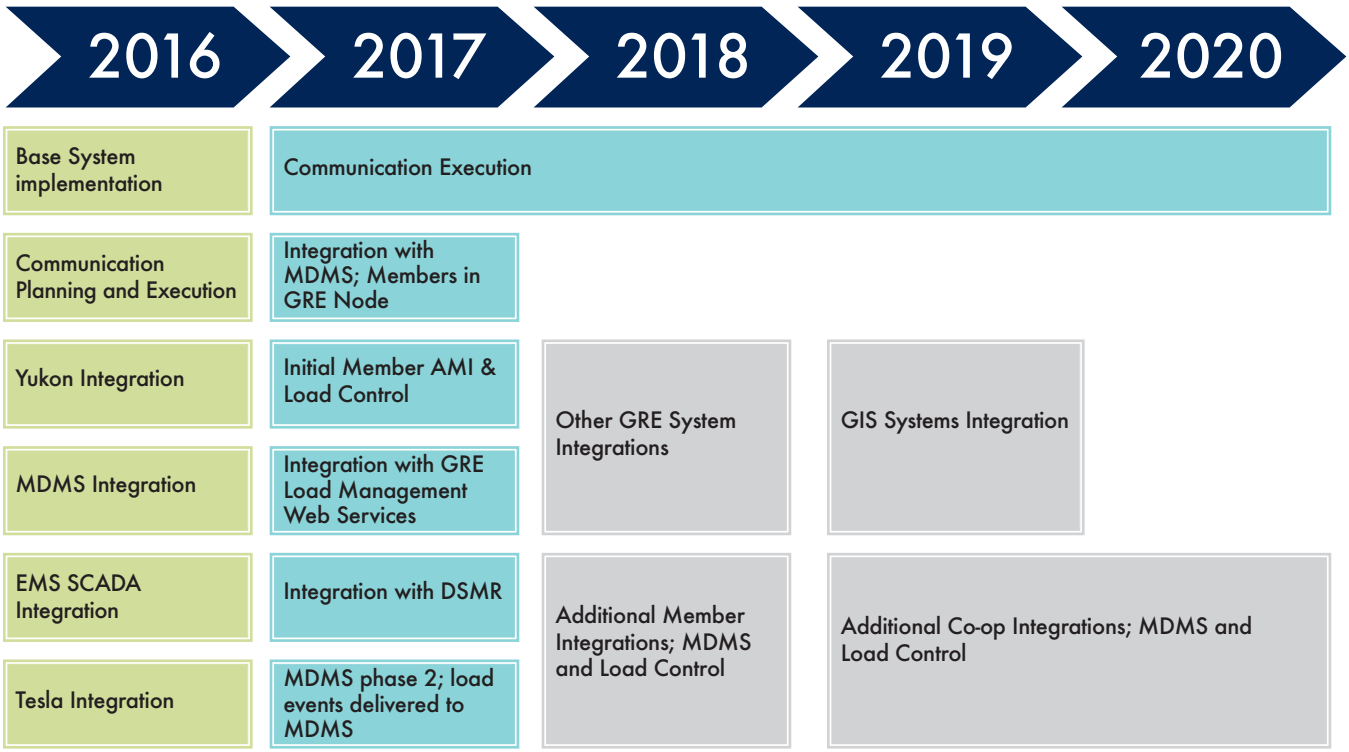
With two-way communication, Great River Energy will be able to accurately monitor the effectiveness of its demand response and analyze data to continually improve its programs.



Demand response allows Great River Energy to avoid purchasing electricity when heightened demand drives up market prices, such as summer evenings.

Project road map

In 2017, Great River Energy will begin transitioning existing demand response programs to the new system. The system will then be made available to Great River Energy's member cooperatives, which can benefit from the system's additional capabilities.



Contact information

John Reinhart, demand response and technologies lead
Great River Energy
jreinhart@grenergy.com

Meter data management system

The decision to deploy advanced metering infrastructure brings about an increase in data coming into electric cooperatives.

Just how steep is the rise? Take, for instance, a cooperative with 10,000 members. With monthly meter readings, it would collect 10,000 meter readings per month. Meter data accumulates quickly when that cooperative begins collecting meter data hourly (7.3 million per month) or every 15 minutes (29 million per month).

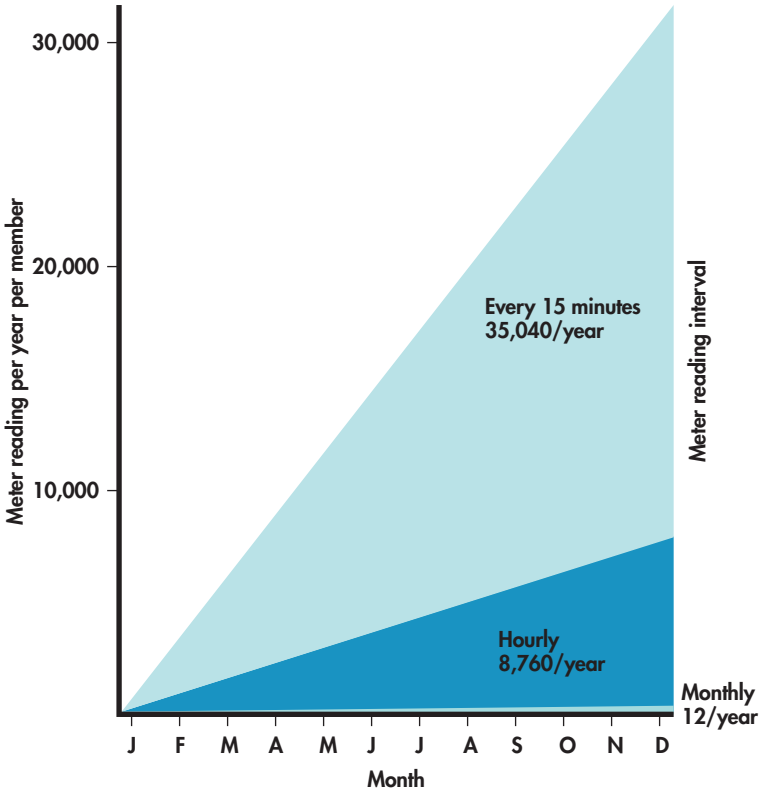
Establishing processes and systems early ensures cooperatives can keep up with growing data demands. The system designed to handle this avalanche of data is known as a meter data management system (MDMS).

An MDMS collects meter data and subjects it to a continuous set of parameters to ensure the data is complete and accurate. With an abundance of clean data, cooperatives can do many things.

Great River Energy and two member cooperatives conducted an MDMS demonstration project that uncovered a wide variety of business applications to both Great River Energy and distribution cooperatives:

- Monitoring line losses
- Monitoring transformer losses
- Identifying power theft
- Billing accounts with intermittent generation, such as solar.
- Analyzing energy data

These applications deliver substantial monetary value to utilities and reap a return on the MDMS investment.



Contact information

John Aiton, leader, energy data and metering infrastructure
Great River Energy
jaiton@grenergy.com

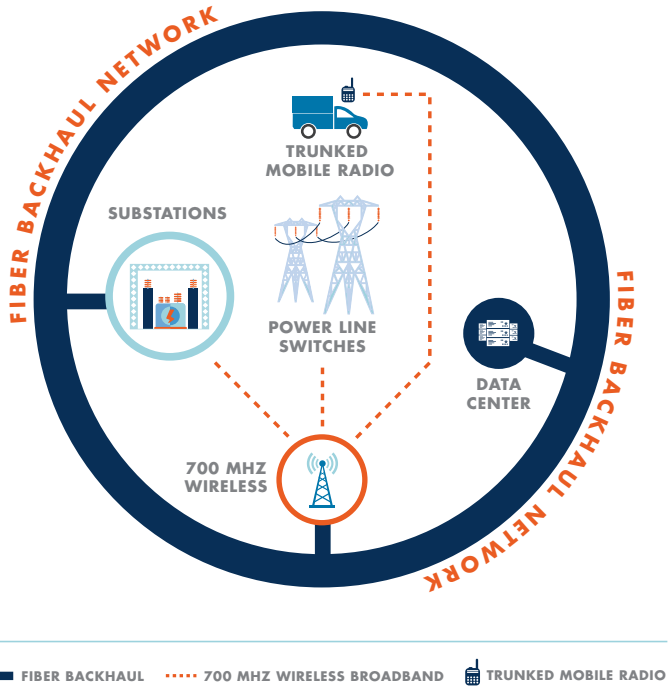
Fiber backhaul network

Overview

Great River Energy's fiber backhaul network connects its communication towers to the organization's headquarters building to transport or backhaul data from the field to its data centers. This system carries data from Great River Energy's trunked mobile radio system, 700 MHz wireless broadband (SCADA) network, load management system and member cooperative owned communication systems. The backhaul network is a critical component for Great River Energy and its member cooperatives to support important communication needs. The network is a combination of telephone company leased circuits, Great River Energy owned fiber and fiber shared with neighboring utilities.

A fiber backhaul network is the backbone that supports other systems such as advanced metering infrastructure, automated meter reading and distribution automation. This network consists of two main components – the fiber optic cable buried in the ground or hanging on Great River Energy's transmission lines and the electronics required to move the data over the fiber.

TELECOMMUNICATIONS SYSTEMS



Project update

Great River Energy is working to migrate the electronic equipment on its fiber backhaul network from SONET to multiprotocol layer switching (MPLS). This three-year project was started in conjunction with the trunked mobile radio system replacement, which was completed in early 2017, and the 700 MHz wireless broadband (SCADA) network replacement. The anticipated project completion date is March 2018.

In conjunction with the MPLS upgrade, Great River Energy has been building out fiber to both transmission and distribution substations. So far, 70 transmission substations have been connected with fiber in addition to 60 member cooperative distribution substations. While bringing fiber to transmission substations has been a strategic goal, distribution substations have been added when it makes economic sense.

Current state

Great River Energy is currently migrating the electronic equipment from SONET to MPLS on its fiber backhaul network. The fiber has an expected life span of 30-40 years, while the life span of the electronic components is only 7-10 years. Great River Energy's upgrade will only replace the electronics portion that is at end of life. This will prepare Great River Energy and others for future business needs in support of the future grid.

- Great River Energy's fiber backhaul is a combination of leased telecommunication circuits, Great River Energy owned fiber and shared fiber with neighboring utilities.
- The network was originally installed in 2006 to support the 700 MHz wireless broadband (SCADA) network deployed at the same time.
- It is a high-bandwidth fiber network extending across the majority of Great River Energy's service territory.
- Backhaul network transports 700 MHz wireless broadband (SCADA) network, trunked mobile radio, load management and business network traffic.
- Twenty-seven of Great River Energy's 28 member territories have an entry point or node available for use which offers them access to the network.
- Nearly all of Great River Energy's telecommunication sites are covered with backup power generators to ensure system reliability in the event of a power outage.
- Thirteen member cooperatives currently take advantage of the network for other uses.
- Great River Energy's lease for its fiber backhaul network is valid through 2021.

How we use it today

A number of Great River Energy member-owners are utilizing the network in various ways, including:

- Advanced metering infrastructure needs.
- Accessing offsite shared disk storage located at Great River Energy's headquarters. This enables Great River Energy to remotely support and troubleshoot issues on their networks.
- Accessing other members' networks to fulfill after-hours dispatch responsibilities.
- Connecting their mobile radio repeaters, distribution automation sites and Verizon downline automation devices.
- Connecting member outpost service centers to one another.

How we'll use it in the future

Great River Energy and its member-owners are excited about the opportunities new technology and the changing industry provide. Years of planning and preparation have put Great River Energy in an excellent position to serve members well into the future. The updated fiber backhaul system will:

- Continue to support Great River Energy's day-to-day business operations.
- Support the backhauling of data as member cooperatives expand deployment of future grid technologies like advanced metering infrastructure, automated meter reading and distribution automation.
- Allow Great River Energy to strategically add optical ground wire on all new transmission lines.
- Enable expansion of rural broadband in Great River Energy's member territories through strategic partnerships.
- Bring fiber connections to all 110 of Great River Energy's transmission substations, in preparation for future North American Electric Reliability Corporation (NERC) requirements.
- Assist in bringing fiber connections to distribution substations to support member requirements.

Contact information

Chris Leleux, manager, infrastructure services
Great River Energy
cleleux@grenergy.com

Michael Tate, telecommunications engineer II
Great River Energy
mtate@grenergy.com

700 MHz wireless broadband (SCADA) network

Overview

Great River Energy's 700 MHz wireless broadband (SCADA) network connects to about half of its transmission substations and most of its members' distribution substations, and automated switches. Great River Energy uses the broadband network primarily for SCADA communications, metering and network access including Wi-Fi and voice over internet protocol (VoIP) phones.

Project update

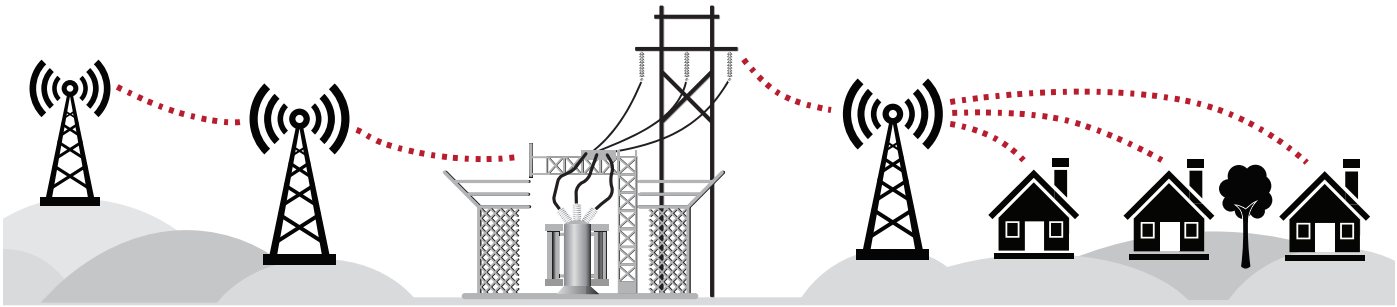
Currently underway, Great River Energy's multi-year 700 MHz wireless broadband (SCADA) network project will include the purchase of the spectrum license and the replacement of the aging electronics.

The project will be done in two phases. Phase one includes the installation of a Cisco router with cellular backup. This will allow SCADA traffic to failover to the cellular network during the cutover to the new system in phase two. Phase one is currently underway with approximately 30 sites being installed each month. The project is expected to be complete by the end of 2019.

Current state

Great River Energy's 700 MHz wireless broadband (SCADA) network was originally installed in 2006 and includes 550 remote locations. The network requires two components to operate: radio frequency spectrum and electronics. The expected life span of electronic components is typically 5-7 years. Great River Energy's network electronic components have reached their end of life. This multi-year network project will include the purchase of the spectrum license that is currently leased and the replacement of the aging electronics.

- The network consists of 64 tower locations throughout Great River Energy's service territory.
- Almost 75 percent of Great River Energy's telecommunication sites are covered with backup power generators to ensure system reliability in the event of a power outage.
- 471 member distribution substations are connected to this network.
- Great River Energy leases radio frequency spectrum from a third party to operate the network. This lease expires in 2019. The lease holder has approached Great River Energy about purchasing the spectrum for its territory after the lease expires.



Great River Energy's 700 MHz wireless broadband (SCADA) network will enable its member cooperatives to use AMI and meter data management technologies that may not be otherwise possible.

How we use it today

Great River Energy's 700 MHz wireless broadband (SCADA) network has become a critical component for Great River Energy and its member cooperatives.

- Great River Energy uses the broadband network primarily for SCADA communications, metering and network access including Wi-Fi and voice over internet protocol (VoIP) phones.
- Twenty-three of Great River Energy's member-owners use the network to connect to more than 400 devices for their own data communication needs.
- Great River Energy's member-owners primarily use the network for advanced metering infrastructure (AMI) and advanced meter reading (AMR) systems.

How we'll use it in the future

In planning for the future, Great River Energy sought to understand its member cooperatives' plans for advanced metering infrastructure (AMI) and meter data management (MDM), as well as other technologies they may be considering.

The new network will:

- Continue to support Great River Energy and participating member cooperatives' day-to-day business operations in transporting SCADA data communications.
- Enable member cooperatives to use AMI and MDM technologies that may not be otherwise possible.
- Leverage meter data for mutual benefits through the use of secure, shared systems.
- Broadband companies could utilize Great River Energy's towers to provide rural broadband to their customers.

Contact information

Chris Leleux, manager, infrastructure services
Great River Energy
cleleux@grenergy.com

Kathy Shaft, senior telecommunications engineer
Great River Energy
kshaft@grenergy.com

Trunked mobile radio system

Overview

Great River Energy and over half of its member cooperatives own and use the Motorola trunked mobile radio (TMR) system for important two-way communications.

When line crews are dispatched to remote locations or outage areas, they need to be able to talk to each other and to system operators so they can identify where faults are located and fix the problems. To do that, they rely on their TMR system.

In early 2017, Great River Energy and its members completed a major update to this system from analog to digital technology. The new digital technology is critical to grid evolution as Great River Energy works to shape its future and provide more options for its member cooperatives, as well as improve reliability and security.

Current state

Great River Energy currently has a fully manufacturer supported, mission critical digital mobile radio system. The system includes 81 communication tower sites across Great River Energy's service territory and areas of North Dakota where its field crews operate. The system supports approximately 700 mobile radios used by Great River Energy and includes more than 500 radios owned by its 15 participating member cooperatives. The upgraded system is fully redundant with automatic failover at Great River Energy's backup control center to ensure continued reliability and security.

How we use it today

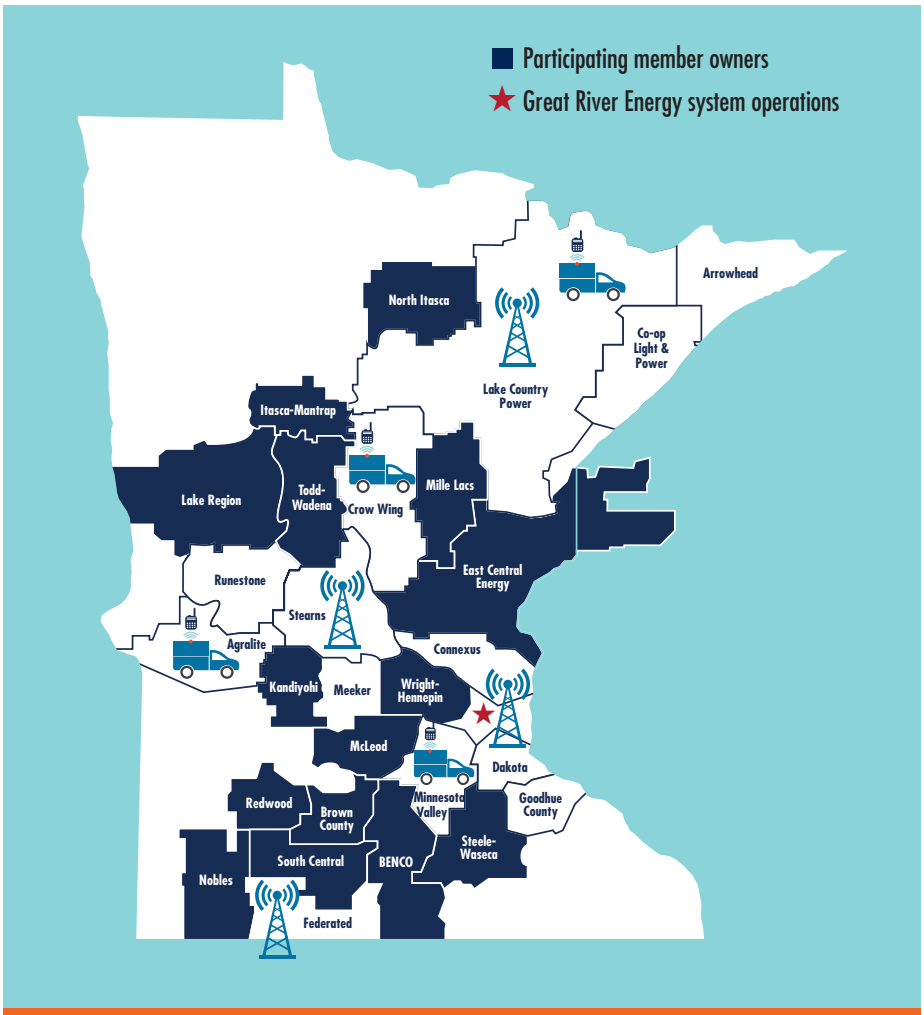
Great River Energy, its 15 participating member cooperatives and both groups of field crews use the TMR system for important two-way communications. The TMR is often used as a dispatching tool for those currently utilizing the system. The two-way radio system enables the Great River Energy system operations group to communicate critical information to the field services crews and with each other.

Great River Energy and its participating cooperatives communicate with each other on the joint system. The two-way radio system allows participating field crews to communicate with each other and system operators during storms, outages or after being dispatched to remote locations. They also rely on the system to notify Great River Energy's system operations when safe entrance is needed to secured locations in order to conduct work in a safe manner.

How we'll use it in the future

Technologies that allow information to flow back and forth support the grid of the future by providing critical two-way communications. The upgraded TMR system will continue to support Great River Energy's and its member cooperatives day-to-day business operations using a highly reliable digital mobile radio system. During critical times of need, Great River Energy's TMR system will continue to offer reliable communications when other tools, such as cell phones, may be unavailable.

During the recent TMR upgrade, Great River Energy on behalf of its membership, negotiated lower cost subscriber pricing making it more cost effective for the remaining member cooperatives to participate in the joint system in the future. Great River Energy encourages the use of the joint system by more member cooperatives as there's a benefit for all member cooperatives to be on the system for mutual aid and switching.



Trunked mobile radio system (TMR)

Contact information

Chris Leleux, manager, infrastructure services
Great River Energy
cleleux@grenergy.com

Kathy Nelson, principal telecommunications engineer
Great River Energy
knelson@grenergy.com

RESEARCH AND DEVELOPMENT

Upcoming projects

The process of researching, designing and implementing innovative new projects and programs to better serve Great River Energy members – and also prepare for the energy grid of the future – are an ongoing effort within every division at Great River Energy. The following are descriptions of pilot projects from Great River Energy's generation and member services divisions that are in various stages of this process.

Dickinson Solar Project storage and tracking

Great River Energy partnered with member Wright-Hennepin Cooperative Electric Association on a 2.25-megawatt solar array that directly serves the distribution cooperative's membership. The 8,000-plus panels, 464 racks and three inverters went into service Aug. 22, 2016, marking the end of the project's first phase.

The second phase, which would add tracking arrays, incorporate battery storage and include smart grid technologies, is currently in project development. Project leaders hope to learn and understand the cost and benefits of fixed versus tracking arrays with and without battery storage.

Contact information

Vince Herda, principal engineer, generation
Great River Energy
vherda@grenergy.com

Cole Funseth, engineer II, generation
Great River Energy
cfunseth@grenergy.com

EnergyWise MN Store

Great River Energy is partnering with Simple Energy, the No. 1 provider of utility-branded marketplaces, to launch a new EnergyWise MN Store. It will feature integrated instant rebates on smart home and energy efficiency products. With a few clicks of a mouse, members across the state can validate their eligibility and unlock significant savings on LED lighting, Wi-Fi thermostats, smart home products, and water saving products from popular brands like Nest, ecobee, Philips, GE and more.

Those involved in the project wanted to make it easy and affordable for cooperative members to make significant changes that can greatly increase their energy efficiency and comfort. The EnergyWise MN Store will be the first marketplace of its kind to serve customers of multiple energy cooperatives under a single platform and brand.

Contact information

Tara Collins, senior marketing specialist
Great River Energy
tcollins@grenergy.com

Zero-Net Energy dairy farm

Great River Energy has joined EPRI's Advanced Energy Communities Supplemental Project to evaluate the application of a Zero Net Energy (ZNE) dairy farm affiliated with the University of Minnesota-Morris, West Central Research and Outreach Center. EPRI has conducted extensive research into Advanced Energy Communities to better understand how customer-side systems enable utility customers as well as how they impact the electricity grid. Net Zero communities are typically envisioned as residential communities, but the same applies for commercial, industrial and agricultural institutions.

The project will evaluate how ZNE works in reality with the farm and focus on understanding the thermal energy flows and opportunities for heat recovery and energy efficiency. It will also identify additional opportunities for energy efficiency at the farm, including the potential conversion of thermal loads from fossil heating systems to electric heating systems. It will conduct measurements of energy usage and develop a load-shape model using the operating schedules and functioning of the dairy farm as well as look at how applications of renewables, both solar and wind generation (currently at the farm and planned for 2017 installation) will impact net-load shape and distribution system impacts.

Efforts on this project began in December 2016 and are estimated to continue through December 2018.

Contact information

Jeff Haase, strategic energy and efficiency program representative
Great River Energy
jhaase@grenergy.com

Battery electric school bus pilot

Overview

As part of Great River Energy's commitment to innovation and minimizing its impact on the environment through reducing emissions, as well as responding to member interest, it is seeking to demonstrate the performance of battery electric school buses (BESB) on our system.

The objectives of the BESB pilot are to showcase new energy-efficient technologies, demonstrate its performance in Minnesota's cold-weather climate and on longer, suburban and rural routes due to the unique service territories of Great River Energy's 28 member cooperatives. The team also would use the opportunity to document the regional economics of the addition of BESBs, including operation and maintenances cost savings and also quantify associated emissions reductions directly in the communities that the co-ops serve.

One model of BESB that is being evaluated is the "eLion" and is manufactured by the Lion Bus Company. It has a range of up to 100 miles with the optional fifth battery module and takes approximately six-and-a-half hours overnight to charge. Currently, 29 eLions are on routes across North America and the company plans to produce 70 more in 2017.

Project phases

While in the process of mapping out key participants for this pilot, the announcement came that Volkswagen would need to invest $2.7 billion in environmental mitigation efforts with eligible projects including replacing diesel vehicles with electric. Of this amount, approximately $43 million was initially allocated to Minnesota. This created the opportunity to develop a phase II pilot for buses two and three in areas requiring more significant grant funding.

Knowing the VW settlement funding would not be available for at least another year, the first phase is the purchase of one BESB that is being fully funded by the three major participants (Great River Energy, its local distribution cooperative and the student transportation provider). The current base price of a dedicated BESB is about $325,000, compared to $100,000 to $125,000 for a diesel-fueled school bus.

Phase II will rely on more significant grant funding for the purchase of two additional BESBs to help subsidize participation costs for smaller, rural member cooperatives and their transportation providers. In all, Great River Energy is seeking a 50 percent cost share for the overall $1.2 million BESB project, with $600,000 being cash from participants, and a goal of receiving $600,000 of the VW settlement funds. Having multiple BESBs on the system will demonstrate how this technology works in more extreme northern Minnesota climates as well as the southern Minnesota area and on suburban routes closer to the Twin Cities. Great River Energy believes funding a variety of emerging technologies across the state is the most prudent use of the VW settlement funding.

Schedule

BESB pilot program development began in third quarter of 2016 with business models, the cost/benefit and funding options following in the fourth quarter, continuing into the beginning of 2017. Site selection, and securing commitments from the participating member cooperative and student transportation service is slated to continue throughout second quarter. Following that, data gathering and analysis will carry on through until mid-2018 when state and federal grant application and award cycle begins. An evaluation report and recommendation is then planned to be presented in the second quarter of 2019.

Contact information

Sandra Broekema, director, corporate and business development
Great River Energy
sbroekema@grenergy.com

David Ranallo, leader, member services and marketing
Great River Energy
dranallo@grenergy.com

Conservation voltage reduction pilot project with ECE

Overview

Great River Energy and its members are researching how members can use conservation voltage reduction (CVR), a term sometimes used interchangeably with demand voltage reduction (DVR), to decrease energy use, lessen their peak loads and reduce demand charges while continuing to serve their members within established voltage parameters.

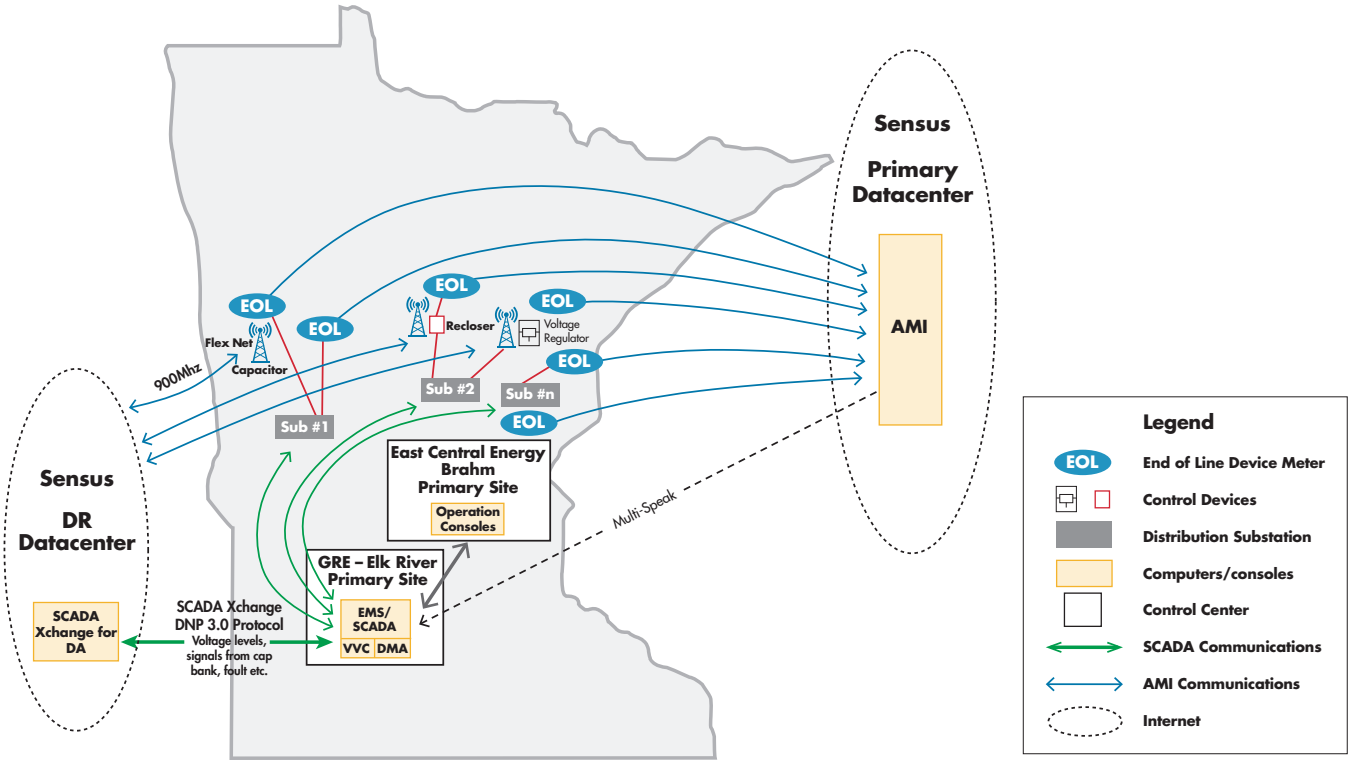
To that end, Great River Energy and East Central Energy (ECE) are conducting a pilot project to retrieve end-of-feeder data from the East Central AMI system to automate and enhance the performance of the CVR/DVR control. The initial phase includes two sites with four distribution substation transformers.

Description

Great River Energy and East Central Energy are working on a pilot project that will allow them to access the data in their AMI to assess whether they can identify opportunities to lessen their peak loads and reduce demand charges.

Why it matters

Great River Energy employees from IT and transmission are in the midst of setting up the pilot project. Involvement is required from a number of external parties to achieve the equipment installation, data integrations and software installation required to enable the capability. If successful, this pilot will allow other co-ops the opportunity to learn about CVR and how it might impact their bottom line.



Tentative Schedule – the goal date for pilot start is a June/July timeframe. The feasibility of the schedule is being confirmed with the software vendor and other parties involved in the pilot.

Work in progress:

- Execution of non-disclosure agreements and software contracts
- Set up work by Sensus
- ECE equipment installation

Next Steps

- Confirmation of schedule and execution of software contract
- Configuration and development activities
- Test planning and execution

Project cost

Great River Energy: Software license and implementation costs; Great River Energy internal labor and product user training.

East Central Energy: Software license and implementation costs; internal labor and product user training; field hardware and installation costs.

Contact information

Dick Pursley, manager, system operations
Great River Energy
dpursley@grenergy.com

Vern Johnson, vice president of operations and engineering
East Central Energy
vern.johnson@ecemn.com

Data analytics

As advanced metering infrastructure (AMI) and meter data management systems (MDMS) are deployed, utilities are left with exponentially greater amounts of data.

Translating mass amounts of raw data into actionable business intelligence is a challenge for cooperatives that may be unaccustomed to data analytics. With the proper resources and strategy, data analytics can improve operations, service to members and efficiency.

Data analysis is already shedding new light on some of the nagging questions utilities have long faced: Where should we prioritize our investments? What types of end-use members give us the shortest payback for an energy efficiency program?

Although this type of work is relatively new to utilities, it is common in other industries. When data becomes available in abundance, statistical methods are used to identify trends and opportunities.

Analysis by Accenture suggests that the potential value of analytics could approach $40 to $70 per electric meter per year, with benefits divided 60 percent to the consumer and 40 percent to the utility. A study conducted by the Electric Power Research Institute found that data analytics can spur improvements in many areas of utility operations.

- Load shapes constructed from AMI interval data contributed to better targeting of customers for utility programs.
- Analysis of distribution curves identified where energy efficiency and demand response programs would have the greatest impact to optimize distribution planning.
- Once accepted as a resource within an organization, data analytics aided in decision-making.

Completed projects

To help members get the value out of business intelligence and data collected through AMI and MDMS systems, a sub-team with three Great River Energy member cooperatives identified three data analytic projects of interest to their cooperatives to demonstrate how the use of data analytics could be used to improve the efficiency of their distribution system. These member-driven projects

were initiated with the condition they could be repeated and seamlessly integrated to other member cooperatives. Great River Energy, in collaboration with Lake Region Electric Cooperative, Minnesota Valley Electric Cooperative and Steele-Waseca Cooperative Electric have completed data analytics projects related to:

- KRTA data analytics*
- Residential cycled AC response*
- Substation losses*

** To learn more about these projects, see the individual fact sheets within this book.*

Projects under consideration

The following projects have been vetted and are under consideration as Great River Energy's member cooperatives determine if the projects are of interest and would add value to their cooperatives.

- **Distribution line loss measurement** – Develop a methodology that utilizes Great River Energy's AMI data and member owners' AMI data and SCADA – connected reclosers to verify that an aggregation of a substation's feeder data can be used to accurately measure substation losses.
- **Demand response program measurement** – Member distribution cooperatives have various retail programs that they use to aid in controlling peak load (e.g. cycled AC, peak shave water heating). Currently there are few methods in place to analyze the impact of the retail programs. To improve and aid in expansion of the program offerings, member distribution cooperatives need to better understand the kW impact of the programs in relation to system peak and energy sales, in addition to informing consumers of the potential impact and savings by participating in the retail programs.
- **Target marketing** – Member distribution cooperatives have various retail programs that they use to aid in either controlling peak load (e.g. cycled AC, peak shave water heating) or strategic energy growth (electric water heaters). Currently there are limited methods in place to target market these programs to (1) maximize the benefit of the program, (2) avoid "free riders," and (3) to ensure optimal program enrollment. To improve and aid in expansion of the program offerings, member distribution cooperatives need to better understand who are their customers who participate in their demand response program, identify potential new participants and ensure program marketing campaigns are targeting and enrolling the proper end-use customers.

Contact information

Nathan Grahl, principal data analyst
Great River Energy
ngrahl@grenergy.com

Member and community solar initiative

A variety of solar technologies and configurations are being tested at Great River Energy's headquarters site.

Background

Great River Energy began an effort in 2013 to develop and demonstrate distributed generation technologies – including solar and other non-traditional technologies – in collaboration with its member cooperatives across the state and as direct Great River Energy resources with a goal of advancing internal skills and overall knowledge around these technologies.

At this time, the state of Minnesota had enacted a solar energy standard for investor-owned utilities that would require a specific percentage of retail electricity sales to be generated from solar energy. Great River Energy decided to participate in the solar market in response to member interest and needs as a matter of importance to prepare for a future in which solar generation is part of the generation portfolio for both utilities and consumers.

Great River Energy developed two action plans to meet its initial solar goals.

Headquarters project

The first in the series of solar installations was completed at Great River Energy's Maple Grove, Minn., headquarters site in May 2014. The 250-kilowatt (kW) project has a research and demonstration component that tests the performance of solar panels from three different manufacturers (Sharp, tenKsolar, Suniva) and three inverter manufacturers (Solectria, tenKsolar, Advanced Energy). The array provides up to 325,000 kilowatt-hours (kWh) of renewable energy annually, which is enough electricity to power about 27 homes.

Member projects

Solar arrays were installed in 2014 and 2015 at sites owned by Great River Energy's members with project management led by Great River Energy. The installations are part of a series of 19 projects, each with an electricity generating capacity of 20 kW. The solar projects are helping Great River Energy and its member cooperatives

evaluate the impact of solar energy while providing up to 450,000 kWh of renewable energy annually, which is equivalent to powering about 38 homes.

The installations were managed by Great River Energy, which worked with each participating member cooperative to identify the ideal location for their project. Additionally, Great River Energy assisted the member cooperatives with interconnection efforts and collecting and displaying key information about energy production and system interaction. Most of the solar arrays are a packaged system design from tenKsolar, while one installation includes panels made by Silicon Energy and another uses panels by SolarWorld.

Nine of the participating cooperatives chose to add solar arrays to serve as community solar gardens that were installed at the same time as their 20-kW arrays in the same location, which was done at an incremental cost. This partnership with Great River Energy saved members nearly 40 percent on project installation costs and provides up to 430,000 kWh of renewable energy annually, equivalent to powering about 36 homes.

Reflections and next steps

These demonstration and membership projects provided Great River Energy an awareness and understanding of the variables tied to solar, which impact both the performance and economics along with the challenges associated with development and implementation of smaller-scale distributive solar projects.

The 2.25 MW Dickinson Solar Project serves Wright-Hennepin Cooperative Electric Association's membership.

As a result of the projects completed so far, Great River Energy firmly believes that community solar developed by the distribution cooperative is the best option for both the utility and end-use consumer. It provides the simplest, lowest cost solar solution and maintains the relationship between the distribution cooperative and end consumer. Great River Energy continues to assist and support its member cooperatives in their community solar garden ventures, with projects in development at Cooperative Light & Power, East Central Energy, Cooperative, Runestone Electric Association and Steele-Waseca Cooperative Electric.

In 2016, Great River Energy partnered with member cooperative Wright-Hennepin Cooperative Electric Association to install a 2.25 MW solar array that serves the co-op's membership. The Dickinson Solar Project, named due its location at the Dickinson Converter Station site, provides the membership experience in the development, installation and ongoing operations of a utility-scale solar installation. The array is the largest single solar resource to date for both cooperatives, and is the largest solar array installed by a cooperative in Minnesota.

Great River Energy staff continues to track and report on the long-term performance and maintenance of the demonstration and membership solar projects. Opportunities to further explore the understanding and involvement with distributed generation technologies, including battery storage and smart inverters, are ongoing.

To view the energy output from Great River Energy's statewide solar projects, visit **greatriverenergy.com/solar**.

Contact information

Vince Herda, principal engineer, generation
Great River Energy
vherda@grenergy.com

Mark Rathbun, renewable energy lead
Great River Energy
mrathbun@grenergy.com

Nathan Domyahn, director, peaking and generation engineering
Great River Energy
ndomyahn@grenergy.com

PROJECTS AND PROGRAMS

Community storage

Energy and environmental stakeholders are uniting around "community storage" to solve the electric industry's energy storage challenge. The Community Storage Initiative has received the support of key industry groups, including the nation's utility trade associations, environmental groups, manufacturers and more than a dozen individual utilities.

Both Great River Energy and the Minnesota Rural Electric Association are members of the initiative. Community storage refers to a spectrum of utility-sponsored programs which aggregate electric storage resources available throughout the community, such as water heaters and electric vehicles, to improve the efficiency of electric energy services for consumers. Community storage programs offer the industry the practical steps to rapidly increase the amount of energy storage available.

Initiative members have been implementing community storage programs and, through the Initiative, will work together to evolve those programs. Like community solar, community storage enables consumers and utilities to share the system-wide benefits of energy storage – environmental benefits, lower costs and grid optimization – in communities large and small across the country. Such programs maximize the value of distributed energy resources, many of which are already available to participate in energy storage programs through simple retrofits and program design.

The Initiative's advisory council includes representatives from the American Public Power Association, Edison Electric Institute, Natural Resources Defense Council, National Rural Electric Cooperative Association, and Peak Load Management Alliance. The Initiative is chaired by Gary Connett, director of member services at Great River Energy.

A list of founding supporters and brief descriptions of their community storage efforts is available on the Initiative's website: communitystorageinitiative.com. Initiative members are conducting a range of innovative community storage programs, including grid-interactive water heating, electric vehicle charging, grid-interactive space heating, ice storage technology, and residential battery storage.

Research conducted by The Brattle Group and sponsored by the Initiative's founding members recognized that the nation's 50 million residential electric water heaters collectively represent a significant and vastly underutilized energy storage resource capable of leveraging substantial environmental and cost benefits. An article in the November 2015 edition of Public Utility Fortnightly introduced the community storage concept. Links to both the report and the article can be found on the Community Storage Initiative's website.

The Initiative hosted a two-day forum in July 2016 at the University of Minnesota Law School campus where attendees heard group members explain their mission and guiding principles. Those in attendance also discussed where they fit into the growing collaborative and how to help further its vision.

Connett participated in a summit at the White House where federal and private sector organizations gathered to discuss scaling renewable energy and storage with smart markets and spoke about the Initiative. He also educated those on Capitol Hill about the Initiative during a congressional briefing about community storage, introducing the concept of how the energy industry can use tried-and-true household technologies to help meet consumer energy needs in a new era.

Electric thermal storage water heating

Electric thermal storage (ETS) water heating is a load control strategy that provides households with their daily hot water needs by charging their water heaters only during the lower-cost, off-peak hours. Member-consumers participating in the ETS program heat their water from the hours of 11 p.m. to 7 a.m. In exchange for this level of control, Great River Energy provides discounted wholesale energy to its member cooperatives for energy sales associated with the ETS program. The strategy requires that a household install a "large capacity" storage water heater, which is typically between 85 and 105 gallons in size, with the larger water heaters provided to households that have more family members.

Great River Energy's ETS resource

Great River Energy is able to store a gigawatt of energy each night by controlling the ETS water heaters of more than 65,000 end-use members. This effective form of community storage aggregates distributed energy technologies increases energy efficiency and allows for better integrate renewable energy resources onto the grid and reduce customers' monthly electric bill.

Electric vehicles

Electric vehicles provide another valuable form of community storage. Great River Energy continues to look at ways to make it easier for consumers to drive electric vehicles and currently offers rebates for residential charging stations that encourage off-peak or time-of-use vehicle charging. This strategy enables consumers to use more electricity during night-time hours when prices are typically lower and when the electricity is frequently produced from the region's abundant wind resources.

revolt℠
EMBRACE ELECTRIC VEHICLES

Great River Energy in 2015 launched Revolt, a first-of-its kind program that allows members of its 28 cooperatives to upgrade the electricity they use to fuel their PEVs to wind energy at no additional cost. While the PEVs enrolled in Revolt will be powered by wind energy, standard or offpeak rates still apply for the electricity used to charge them.

This program extends to members who already own or lease a PEV and members who purchase or lease one by Dec. 31, 2017.

Contact information

Gary Connett, director of member services
Great River Energy
gconnett@grenergy.com

Electric Thermal Storage water heating

The battery in your basement

Electric Thermal Storage (ETS) water heating

Electric thermal storage (ETS) water heating is a ***load control*** strategy that provides households with their daily hot water needs by charging their water heaters only during the lower-cost, off-peak hours. Member-consumers participating in the ETS program heat their water from the hours of 11 p.m. to 7 a.m. In exchange for this level of control Great River Energy provides discounted wholesale energy to its member cooperatives for energy sales associated with the ETS program. The strategy requires that a household install a "large capacity" storage water heater, which is typically between 85 and 105 gallons in size, with the larger water heaters provided to households that have more family members.

Great River Energy's ETS resource

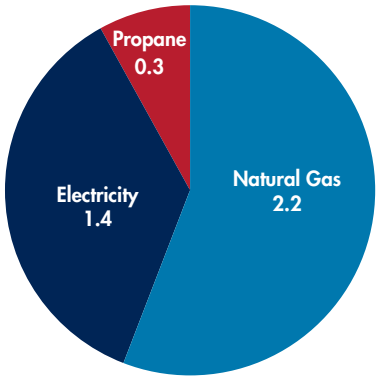
Great River Energy is able to store a gigawatt of energy each night by controlling the ETS water heaters of more than 65,000 end-use members. A recent study from the global economic consulting firm The Brattle Group dubbed this approach to energy storage as "community storage." By aggregating distributed energy technologies and home appliances, electric cooperatives are developing community storage to increase energy efficiency, better integrate renewable energy resources onto the grid and reduce customers' monthly electric bill.

Great River Energy, the National Rural Electric Cooperative Association (NRECA), the Natural Resources Defense Council and the Peak Load Management Alliance commissioned the study, "The Hidden Battery," to launch a community storage initiative to aggregate battery-like features of appliances.

Household water heating

Household water heating is one of the more predictable energy consuming activities in a household. The primary variable that dictates hot water consumption is household size. According to the Energy Information Administration's 2009 Residential End-Use Consumption Survey, water heating is responsible for approximately 15 percent of total household consumption.

Water Heaters by Type
Million Households | IA, MN, ND, SD

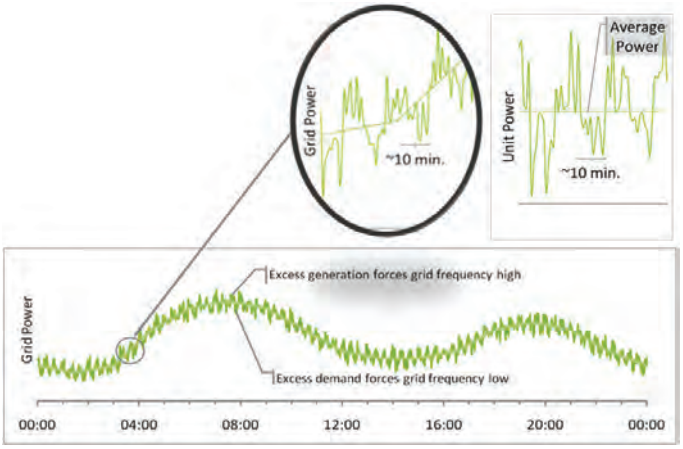


Water heaters are often one of the more under-appreciated appliances in a home. Typically located in the basement, they tend to be ignored until there is an issue and you run out of hot water. ***The only thing a homeowner expects from a water heater is hot water.*** A utility can utilize hot water heaters as a resource, but only if this basic function is met.

Grid-interactive water heating | *Can a water heater provide grid benefit?*

In response to the proposed water heating standards, which would effectively have eliminated the manufacture of electric resistance water heaters larger than 55 gallons, Great River Energy and the NRECA successfully pursued legislation that allows large capacity water heaters to be a component of utility demand response programs. In addition to strategies such as ETS and interruptible water heating, utilities across the country are beginning to look at water heaters to interact with the grid and provide ancillary services. Due to the variable nature of demand, which is now coupled with the variable nature of increased renewable generation, grid operators look at generators to

provide ancillary service to the wholesale market. The generator is turned up or down to provide regulation services which keep generation matched to load and help to maintain voltage throughout the system. This same type of system regulation can occur through the variable control of water heaters. By turning a number of water heaters on or off, or by dynamically increasing or decreasing the current to those water heaters, the natural variations of supply and demand can be managed more effectively at the grid level. It is Great River Energy's belief that as long as the hot water needs of a household are met, water heaters can effectively provide this type of service to the grid. Successful execution of this type of dynamic control strategy can reduce the wholesale cost of energy or cause it to be a revenue producer.



Type/Method	Energy Cost	Demand/Trans. Other Costs	Total Cost
Uncontrolled	$256	$50 - $200	$306 - $456
Grid-Interactive LMP Optimized	$108	0	$108
Grid-Interactive with Regulation	($80)	0	($80)

This is an estimate of potential market costs of a grid-interactive water heater vs. an estimate of market costs for a controlled water heater.

Integration with renewable energy

Steele-Waseca Cooperative Electric, based in Owatonna, Minn., has packaged its 102.5 kW community solar project with ETS water heating. A member can purchase a 410-watt solar panel for $170 when they join the ETS water heating program.

Contact information

Jeff Haase,
strategic energy and efficiency program representative
Great River Energy
jhaase@grenergy.com

Electric vehicles

As a cooperative, Great River Energy is motivated by listening to and providing services for its member-owners and their consumers. So when leaders noticed a growing interest in plug-in electric vehicles (PEVs), they decided to explore the technology and our potential role in that market.

What they discovered after Great River Energy's initial research efforts is the important role PEVs will play in increasing energy security, improving fuel economy, lowering consumers' overall fuel costs and reducing emissions.

Great River Energy also believes that electric utilities play an intrinsic role in consumers' consideration of PEVs as a personal transportation option. Fleet electrification may also prove beneficial for business and industry. Electric vehicles play an important role in utility community storage efforts. Community storage refers to utility programs which aggregate electric storage resources available throughout the community, such as electric vehicles and water heaters, to improve the efficiency of electric energy services for consumers. Community storage programs offer the industry the practical steps to rapidly increase the amount of energy storage available.

Great River Energy continues to look at ways to make it easier for consumers to drive electric vehicles and currently offers rebates for residential charging stations that encourage off-peak or time-of-use vehicle charging. This strategy enables consumers to use more electricity during night-time hours when prices are typically lower and when the electricity is frequently produced from the region's abundant wind resources.

Revolt℠ takes renewables on the road

Great River Energy is supporting the advancement of electric vehicles by embracing early adopters. Research showed that electric vehicle drivers were motivated primarily by the cars' reduced environmental impact. That inspired Revolt. It is the first program of its kind in the world,

allowing cooperative members to fuel their vehicles with wind energy at no additional cost.

Renewable resources represent a growing portion of Great River Energy's power mix, and the Revolt program provides a more direct connection between wind energy and the electric vehicle driver. To participate in Revolt, a cooperative member must own, purchase or lease a PEV or plug-in hybrid electric vehicle and register with their cooperative.

Standard or off-peak rates still apply for the electricity used to charge them. This program extends to members who already own or lease a PEV and members who purchase or lease one by Dec. 31, 2017.

It's important to listen to a variety of stakeholders regarding this effort. Great River Energy participates in Drive Electric Minnesota, a coalition of groups that work collaboratively to bring electric vehicles and plug-in charging infrastructure here. Great River Energy also conducted a summit in 2015 to learn more about PEVs from nonprofits, government and environmental groups, subject matters experts, electric engineers as well as PEV owners. Great River Energy held training on PEV charging and infrastructure for member co-ops as well.

revolt℠
EMBRACE ELECTRIC VEHICLES

As part of its effort to educate consumers on PEVs, Great River Energy and Revolt sponsored the first all-electric display at the Twin Cities Auto Show in 2016. The Electric Room hosted about a dozen electric vehicles from different manufacturers to help showcase and explain what separates them from hybrids and other types of cars. It was also an opportunity to dispel misconceptions consumers may have and show that, for a lot of people, an electric vehicle suits their everyday driving needs. Great River Energy's sponsorship of this room continued in 2017 with the 44th Twin Cities Auto Show, where the Chevrolet Bolt made its Midwest debut.

Great River Energy and its member cooperatives will continue making an effort to increase PEV market stimulation as well as go further down the paths of stakeholder engagement, research, demonstration, infrastructure pilots and partnerships. Great River Energy leaders believe they can provide utility leadership in educating members and promoting PEVs as a realistic transportation option.

Contact information

David Ranallo, leader, member services and marketing, and Revolt program manager
Great River Energy
dranallo@grenergy.com

Gary Connett, director of member services
Great River Energy
gconnett@grenergy.com

Energy Wise MN home

Background

Great River Energy and its 28 member cooperatives are committed to promoting energy efficiency, reducing environmental impact and educating member-consumers and communities on ways to use electricity wisely.

A wide assortment of rebates and incentives are offered to help home and business owners become more energy efficient. Great River Energy believes that with the right information and opportunities, member-owners can maximize the value of electricity without sacrificing their lifestyle or a single degree of comfort.

Great River Energy is now thinking beyond members participating in one program or taking advantage of a few rebates – but living in an entire Energy Wise MN home.

ENERGY WISE MN

Situation and strategy

Great River Energy want to continue educating member-consumers that electricity is a smart choice. The current market has created an opportunity for increased homebuilder activity on a national and local level, so it is important to inform members about the benefits of electricity-based applications for the homes they reside in now and the ones they may purchase or build in the future.

The approach is to create a "bundle" of smart-home options – thermostats, LED lighting, electric thermal storage water heaters, air source heat pumps, electric vehicle service equipment, community solar, among others – to make being energy efficient easier for homebuilders. This bundle, or Energy Wise MN home, offers consumer appeal due to its green energy and high-tech components.

There are different paths to different audiences in this strategy. Great River Energy's approach includes educating builders on why building an Energy Wise MN is now a viable option through bundled program rebates and incentives as well as why this type of home would give them a distinct advantage in the market place. Builders are looking for a "contribution to construction." Great River Energy also needs to educate consumers on why they should specify Energy Wise MN when buying or building a new house and how it delivers a more comfortable, economical and sustainable living experience.

Goals

Great River Energy's short-term goals include creating consumer-facing marketing and tools for cultivating relationships with builders as well as some of Great River Energy's member-owner cooperatives having a presence in 2016's and this year's Fall Parade of Homes event, presented by the Builders Association of the Twin Cities (BATC). Homes included in the service territories of member cooperatives Connexus Energy, Dakota Electric Association, Minnesota Valley Electric Cooperative and Wright-Hennepin Cooperative Electric Association are on

display for this event so that current and future homeowners and homebuilders could see these Energy Wise MN programs in use. Other cooperatives not in the BATC territory can apply these tools to model homes or existing homes in their territories.

Long-term goals include developing enhanced relationships with builders and other key audiences. There may also be opportunities to blend in renewable attributes to the concept of a "near net-zero" home option in the future as well as other automated technological advancements made possible through the use of electricity.

Essentially, Great River Energy is developing a contribution to the construction process for members that they can offer their builders that will bundle beneficial electrification technologies with enhanced rebates for new homes. Great River Energy will create and provide marketing and sales tools for builder meetings and program growth strategies.

Contact information

David Ranallo, leader, member services and marketing
Great River Energy
dranallo@grenergy.com

Geographic Information Systems (GIS)

Overview

A geographic information system or geographical information system (GIS) is a combination of hardware and software platforms designed to capture, store, manipulate, analyze, manage and present all types of spatial or geographical data.

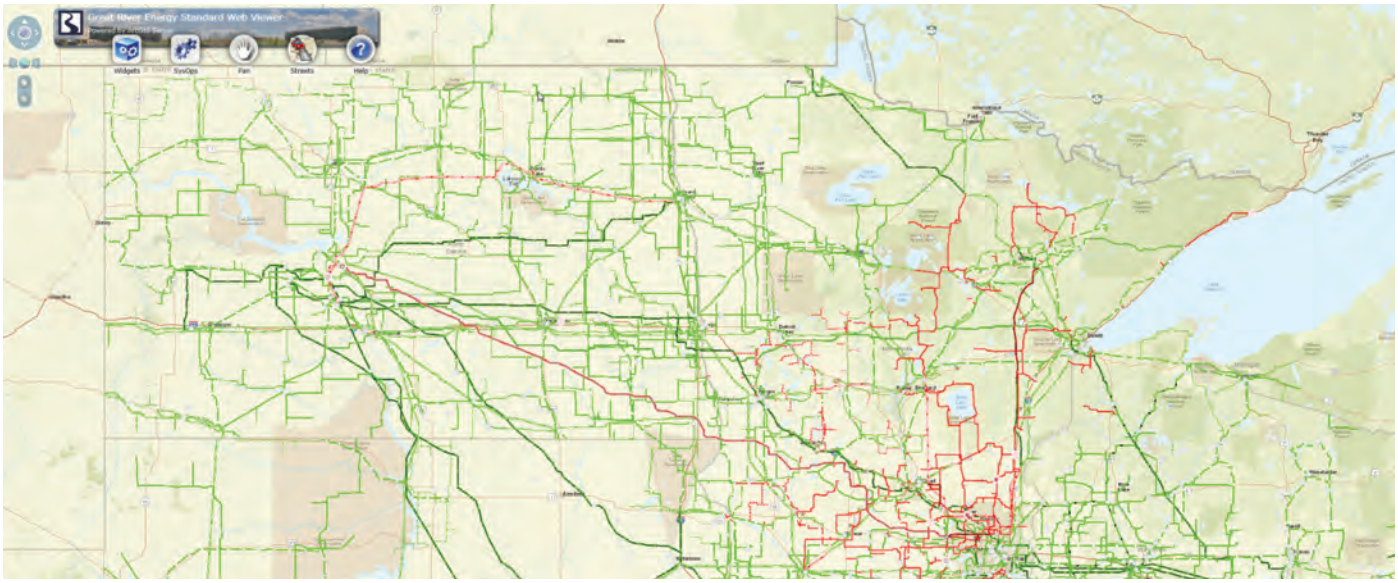
How we use it today

Virtually every department in Great River Energy currently uses some facet of GIS. We developed a standard web-based application for office employees to access GIS information from any Great River Energy facility. We also have both cloud based and mobile applications developed for viewing and capturing information real time from the field. These applications are tied to almost every other business system at Great River Energy and provide the foundation for the development of several targeted GIS solutions. Outlined below are few examples of GIS solutions currently being used at Great River Energy:

Transmission assets uses GIS to keep track of vegetation management. Status updates on clearing work come in from the field real-time and reports and maps can then be generated from this data to keep the foresters up to date on all vegetation clearing efforts.

Land Rights agents use GIS for site and route acquisition. Using GIS data on a mobile device, agents can see all of the parcel data in conjunction with the proposed route and any alternative routes. They can meet with landowners to discuss and pinpoint where the easements will be located on their property and make any adjustments to the route needed from the field device. Agents can also track the status of easement acquisitions and permitting using GIS.

A GIS dashboard and set of tools was developed for **System Operations**. This included redesigning Great River Energy's system one-line which is now tied and driven completely by GIS data. Three widgets were developed for the web viewer that allow the operators to view the locations of all Great River Energy service vehicles on the



The GIS standard web viewer contains all of the functionality of our enterprise GIS system and allows the user to zoom into and out of key assets and locations and get information about the assets from other connected business systems as well as overlay additional layers of spatial information.

map using data from our AVL system. They can view live weather and lightning information on a map and EMS predicted faults by capturing data from the SCADA system and using that data to trace downstream a give distance and placing a dot on the line to mark the possible location of the fault.

Field crews are using the GIS application on mobile devices for navigation and situational awareness. Combined with data from Great River Energy's asset management system, this mobile GIS application becomes a very powerful tools in storm restoration efforts. It is also a replacement for a paper map book which is outdated the day you print it. Finance uses GIS to help with property tax calculations. All of the projects outlined were a part of Great River Energy's first enterprise GIS road map designed to spatially enable all of Great River Energy's business systems. There are several more examples of uses and plans for future development of GIS at Great River Energy contained in GIS Road Map 2.

How we'll use it in the future

In the future, Great River Energy employees will be able create their own maps from GIS data and their department specific data to visualize and preform analyses. The possible uses for GIS solutions are endless.

Here are a few possibilities in Road Map 2:

- Provide tools and dataset to manage transmission asset projects from planning to close out. This will allow all employees and contractors that are working on these projects to collaborate with each other using an easy to use visual tool. We are looking to see where GIS can play a role in the development of future grid projects.
- Create ties to AMI and the meter data mart.
- Great River Energy employees will have the ability to visualize and preform analyses on meter data from these systems. GIS could show visually where the load is on the grid and with ties to DRMS; Great River Energy could make decisions on where to control the load and also see visually if it was controlled or not by changing the color of the controlled meters in the map.
- Developing GIS dataset and tools for the Transmission Construction and Maintenance Department which will include work order management, inspection tools, time reporting and status updates from mobile devices. This will help Great River Energy get into field force automation and streamline several processes which would result in considerable cost savings.
- In System Operations, GIS may become the front end of the EMS and SCADA system. Operators would use GIS to perform their day-to-day work rather than the native software that comes with these two systems. These are a few of the proposed uses for GIS in the future there are more outlined in Road Map 2.

Overall, the future of GIS at Great River Energy will put tools and data into the hands of the end users allowing them to visualize, maintain and preform analyses on data they are charged with maintaining.

Resources

- ESRI.com
- Arcgis.com
- Road Map 1
- Road Map 2

Contact information

Jeff Grussing, leader, GIS development
Great River Energy
jgrussing@grenergy.com

DryFining™

Fuel enhancement process

The DryFining™ fuel enhancement process developed by Great River Energy refines or beneficiates lignite coal through a thermal drying and mechanical segregation process. Drying utilizes residual or waste heat to raise the heating value of the coal per pound. The refining component segregates the lignite stream and removes the higher density compounds that contain higher levels of sulfur and mercury.

Great River Energy has proven results at its Coal Creek Station, a 1,180-megawatt lignite coal-fired plant in North Dakota, which has used DryFine lignite since 2009. Through the DryFining fuel enhancement process, fuel quality is upgraded to its original design specifications. Fuel moisture is reduced from 38 to 28 percent, and higher heating value is increased from 6,200 to 7,100 BTU. This lignite could be dried further. However, returning the heating value to the original boiler design is the best operating condition for this particular plant. DryFining drives off fuel moisture before combustion, reducing the total volume of flue gases throughout the entire balance of plant and increasing overall plant efficiency while reducing operating cost.

Increased efficiency

Over 25 years of operation, the quality of the coal delivered to Coal Creek Station had deteriorated from the 6,800 Btu/lb design specification to about 6,200 Btu/lb,

and the moisture in the coal had increased to about 38 percent by weight. As a result, more fuel was required for the plant to achieve its nameplate capacity, which increased the volume of flue gas and overworked the induced draft fans. Plus, processing the additional coal required all of the plant's pulverizers to operate at full capacity, leaving little opportunity for regular maintenance. It took up to 50 percent more hot air from the primary air fans to dry the higher moisture coal and move it along the conveyors to the burners. This also limited the amount of available air for burner optimization for NOx control.

Increases overall plant efficiency by ~4%

Reduces emissions:
Sulfur dioxide **>40%**
Mercury – up to **40%**
Nitrogen oxide **>20%**
Carbon dioxide **~4%**

Saves more than $20 million in annual O&M

DryFining™ FUEL ENHANCEMENT PROCESS

Powering what's possible

About Great River Energy

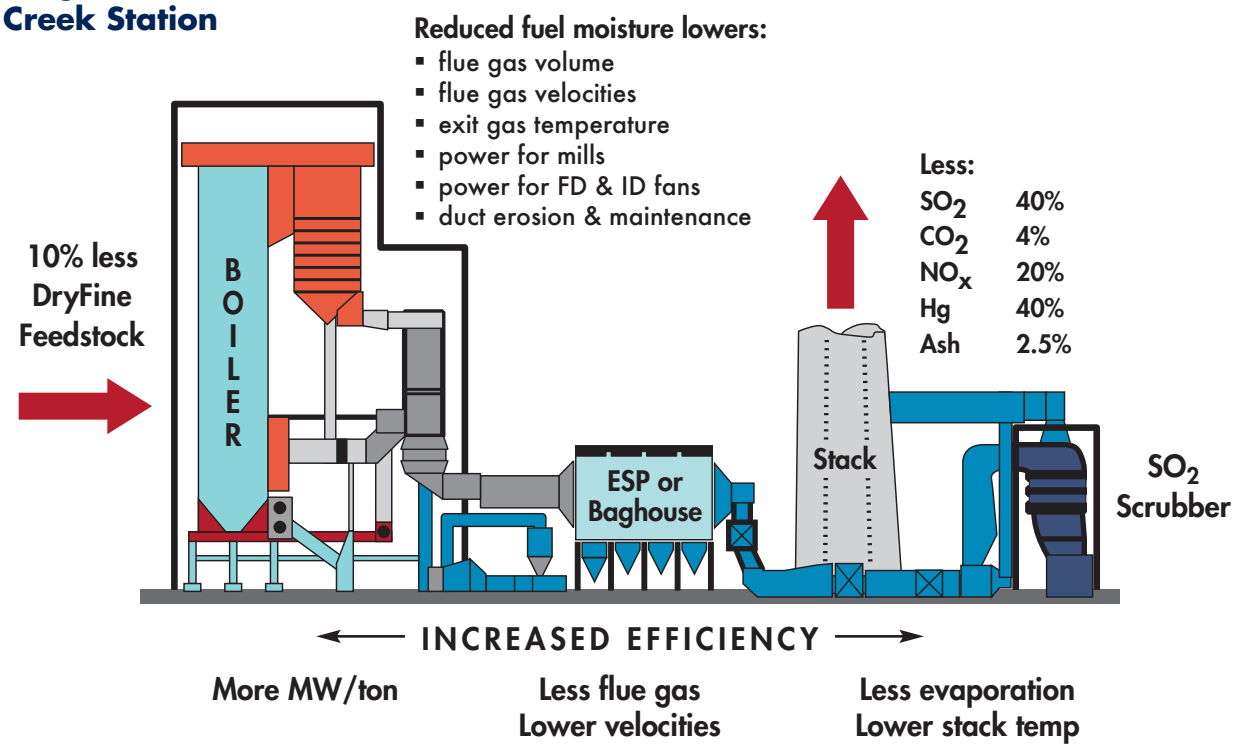
Great River Energy dries and refines additional quantities of lignite at its Coal Creek Station near Underwood, N.D., and then transports that DryFine coal to its Spiritwood Station east of Jamestown, N.D. That product is shipped over 150 miles in enclosed rail cars to prevent moisture from reentering the coal. At full capacity, Spiritwood Station uses approximately 610,000 tons of DryFine coal annually.

For more information on DryFine Technology commercialization

Business Contact
Sandra Broekema
Great River Energy
763-445-5304
Cell 612-280-8689
sbroekema@grenergy.com

Technical Contact
Charlie Bullinger
Great River Energy
701-250-2162
Cell 701-219-9745
cbullinger@grenergy.com

DryFining at Coal Creek Station



GREAT RIVER ENERGY™
Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369
763-445-5000

greatriverenergy.com

GRID RESILIENCE

Cybersecurity

Overview

A safe, stable and resilient cyberspace and infrastructure is critical to protecting the reliability and security of the electric power system. Since the North American Electric Reliability Corporation (NERC) introduced cybersecurity standards in 2005, Great River Energy has continued its commitment to compliance and taken proactive measures to safeguard Great River Energy from cyber threats and vulnerabilities. By partnering with industry, government and other related organizations in a collaborative effort, Great River Energy is in a better position to prevent, protect against and respond to cyber incidents in a constructive manner.

Current state

Great River Energy has implemented a standards-based security model and policy framework to ensure compliance with NERC standards. Meeting NERC standards has always been a part of Great River Energy's daily operations, and the organization continues to devote resources to compliance as the standards evolve.

Great River Energy's management regularly reports on cybersecurity issues and risks to its board of directors. The organization conducts periodic cyber intrusion scenario drills, which allows Great River Energy to test emergency response plans and communication protocols.

Collaboration with others

Great River Energy participates in the sharing of actionable intelligence around cybersecurity, including:

Electricity Subsector Coordinating Council (ESCC) – The ESCC is made up of industry CEOs who set strategies for addressing cybersecurity issues. The council works with US Government officials to coordinate and align utility efforts toward common national security, resilience and preparedness related goals.

Electricity Information Sharing and Analysis Center (E-ISAC) – The E-ISAC acts as an information clearing house and coordinates information sharing about cyber incidents for utilities.

Department of Energy Cyber Risk Information Sharing Program (CRISP) – CRISP enables near real-time exchange of threat and incident data. Great River Energy volunteered in 2014 to participate in the pilot project originally developed by the U.S. Department of Energy to protect highly sensitive government networks. Through the program, Great River Energy and others benefit by sharing and obtaining valuable cyber threat data, analyzing that data and receiving mitigation measures. Great River Energy was the first cooperative involved in the pilot project, which has now been extended to one of its member cooperatives, Minnesota Valley Electric Cooperative. Great River Energy continues to explore options to bring other members into the program.

NERC GridEx III – The two-day exercise, was designed to enhance the coordination of cyber and physical security resources and practices within the industry, as well as communication with government partners and other stakeholders, including those in Canada and Mexico. The biennial exercise gave participants, like Great River Energy, the opportunity to self-assess their emergency response and recovery plans through a simulated exercise that took place across North America.

Cooperative collaboration opportunities

Many cooperative collaboration opportunities exist through organizations like the Cooperative Research Network (CRN), Electric Power Research Institute (EPRI) and the National Rural Electric Cooperative Association (NRECA). Other opportunities to consider include cooperative best practice visits and participating in pilot projects.

Great River Energy hosted a one-day security summit for its member cooperatives to showcase best practices and provide an environment to facilitate information sharing. The idea took shape at the suggestion of members who underlined the importance of security issues facing all utility cooperatives. The agenda included member cooperative speakers, Great River Energy speakers, and external security experts.

The NERC Grid Security Conference (GridSecCon) will be held in St. Paul, Minn., Oct.17-20, 2017. The conference brings together cybersecurity and physical security experts from industry and government to share emerging security trends, policy advancements, and lessons learned related to the electricity sub-sector.

Employee accountability

Cybersecurity is not just about technology. Employee accountability for maintaining and improving security is critical at Great River Energy. Much like safety, security is everyone's responsibility. Every Great River Energy employee has responsibilities under the NERC compliance program. Through training and education, Great River Energy has created a culture of security and risk management. Employees understand that security is everyone's responsibility. Great River Energy has established a Security Policy Statement that guides employee actions. It reads:

Great River Energy recognizes the value of its physical, cyber and information assets in the ongoing operation and success of its business and the potential for significant harmful consequences should these assets be compromised or destroyed. As such, Great River Energy is committed to the establishment and implementation of controls to protect its assets that meet or exceed industry standards and practices. The protection and security of Great River Energy's assets is the responsibility of Great River Energy's employees, contractors and agents. Great River Energy will enforce compliance with its security standards; violations may result in disciplinary actions, termination of employment, legal prosecution and/or other actions as warranted.

Helping to shape the future

Great River Energy partnered with Thomas Edison State University, Utilities Telecom Council and other top utility cybersecurity professionals to design a master's degree program for students wanting to specialize in utility cybersecurity. The program, called the Graduate Certificate in Cybersecurity – Critical Infrastructure, blends both information technology and operational technology, and focuses specifically on critical infrastructure sectors such as energy, water, gas and transportation.

Contact Information

Marc Child, information security program manager
Great River Energy
mchild@grenergy.com

Aging infrastructure assessment tool

Great River Energy transmission leaders are researching how to best evaluate breakers, meters, remote terminal unit (RTU) and electro-mechanical relays to identify which ones are in need of being replaced and how to go systematically through the system to rank that equipment. Leaders are looking at a focused plan and the development of a prioritization tool that would dovetail into the budget cycle so that older equipment, which is prone to fail, would be replaced before any system impacts occur.

Of note, older equipment often continues to perform the tasks it needs to. This process and tool would analyze the health of the system and the individual components, based on age, condition criticality and obsolescence. The tool would help leaders understand which equipment to focus on and which need help.

What was Great River Energy doing before creating the assessment tool?

Before deciding to come up with an assessment tool, many of the projects were replaced when they failed or when there was a good case that they needed to be updated. It was up to individual groups to make those business cases.

Field services, system operations, relays and transmission line crews had a list of projects that they wanted to see funded. They'd bring those projects forth during the capital budget prioritization process, and leaders would decide which projects should be funded.

How will the assessment tool change the way Great River Energy does business?

Projects will be funded based on best business cases and if they will help Great River Energy overall.

Leaders are looking at how to assess these projects together. Oftentimes it's comparing apples to oranges. For example, a relay project doesn't look the same as a line project nor do the costs align or are they similar. What leaders are trying to do is come up with a uniform way for these projects to be standardized and then ranked, so that the best projects really do come out on top and receive appropriate funding during the prioritization process.

Which projects will receive funding?

Leaders are looking at certain criteria to determine which projects should be funded. Most of these projects replace something already out on the system. They might be "smarter" but essentially the equipment will perform the same basic function.

Transmission leaders are creating a standard evaluation that can be replicated for these very different projects, and so Great River Energy can determine how to rank them. The process is expected to be fully initiated by 2018.

Contact information

John Setala, manager, project management and engineering services, transmission
Great River Energy
jsetala@grenergy.com

Kerry Livingston, principal engineer, transmission
Great River Energy
klivingston@grenergy.com

Energy Sector Climate Resilience Partnership

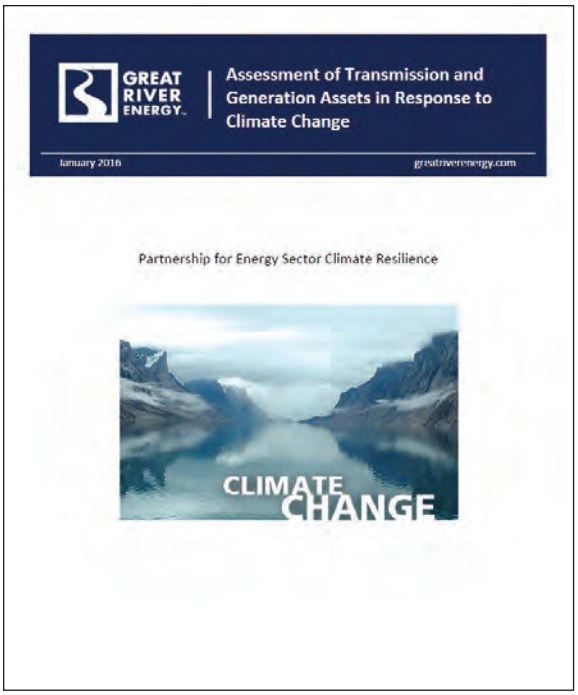
Overview

In early 2014, the Obama Administration released the first-ever Quadrennial Energy Review, which examines how to modernize the nation's energy infrastructure.

As part of the initial stage, the Energy Sector Climate Resilience Partnership was formed, with Great River Energy, the Department of Energy and 16 utilities as partners. CEOs from the 17 utilities that make up the partnership convened in April 2015 at the Department of Energy. The participating utilities represent a broad array of investor-owned, federal, municipal and cooperative utilities, including Great River Energy and Hoosier Energy. Great River Energy's President and CEO David Saggau attended the meeting.

The Partnership for Energy Sector Climate Resilience is an initiative to enhance U.S. energy security by improving the resilience of energy infrastructure to extreme weather and climate change impacts. The goal is to accelerate investment in technologies, practices, and policies that will enable a resilient 21st century energy system. Under this Partnership, owners and operators of energy assets will develop and pursue strategies to reduce climate and weather-related vulnerabilities. Collectively, these utility partners and the Department of Energy (DOE) will develop resources to facilitate risk-based decision making and pursue cost-effective strategies for a more climate-resilient U.S. energy infrastructure.

This partnership is an opportunity for Great River Energy to learn and share best practices as it relates to extreme weather, climate change and energy security. In addition, this partnership will help Great River Energy enhance its response to major events and gain knowledge on planning and transmission facility design. Transmission is a long-term investment and historical weather patterns may not be a good indicator of what to expect in the future. Great River Energy needs to plan and design its systems to meet the new challenges.



Great River Energy submitted this report to the Department of Energy as part of the Energy Sector Climate Resilience Partnership in February 2016.

Initial stage

In the initial stage, Great River Energy submitted a report in February 2016 called "Assessments of Transmission Assets in Response to Climate Change." The report looked specifically at Great River Energy's transmission and generation portfolio to determine how climate change might impact reliable service in the future. The report gave Great River Energy an opportunity to engage with others in the industry to better understand the vulnerabilities climate change could impose on the electric system and to find solutions.

Great River Energy shared key findings including: during the course of this century, climate change is expected to increasingly impact the Northern Great Plains and

Midwest region's energy infrastructure. Great River Energy's transmission system and generation facilities are forecasted to see a rise in flooding events, increased ice storms and warmer summers with prolonged heat waves. Since weather is one of the greatest risks Great River Energy faces in the generation and reliable delivery to its 28 member cooperatives, risks associated with climate change will continue to be assessed and mitigated.

The other utility partners also submitted their reports for review by the DOE.

Second stage

Great River Energy along with the other 18 utilities of the Partnership for Energy Sector Climate Resilience submitted their mitigation plans for Climate Resiliency in November. Great River Energy's approach for addressing climate change risk for the near–term period will focus on the prevention and recovery aspects of resiliency and evaluated for their impact on the reliability of electric system. Climate risks to generation have been reduced through proactive projects at Coal Creek Station and winterization measures at the combustion turbine facilities. Great River Energy annually reviews its Transmission System Restoration Response Plan and evaluates the plan's performance against the previous restoration events. The evaluation currently does not contain a long–term view for risks associated with climate change.

Future stages

Partnership met in January of 2017 to discuss its mitigation plans and the future of the partnership. Based on the work plan priorities the results point to the following top three topics:

1. Case studies and stories
   - Experiences (positive and negative) engaging with internal departments, customers, regulators, communities, suppliers, other stakeholders, etc.
   - Regional impacts and resilience strategies
   - Best practices (e.g., developing climate scenarios, screening resilience strategies, evaluating investments)
2. Inventory of benefits that could be considered in a cost-benefit analysis of resilience investments
3. Outreach to regulators on various topics (e.g., standards, benefits of resilience investments, guidance, success stories)

Resources

- http://energy.gov/epsa/partnership-energy-sector-climate-resilience
- Assessments of Transmission Assets in Response to Climate Change

Contact information

Gordon Pietsch, director, transmission planning and operations
Great River Energy
gpietsch@grenergy.com

Michael Brytowski, standards specialist
Great River Energy
mbrytowski@grenergy.com

Partners forming the Partnership for Energy Sector Climate Resilience

Consolidated Edison of New York
Department of Energy
Dominion Virginia Power Dominion
Entergy Corporation
Exelon Corporation
Great River Energy
Hoosier Energy
Iberdrola USA
National Grid
New York Power Authority
Pepco Holdings, Inc.
Pacific Gas and Electric
Public Service Electric and Gas
Sacramento Municipal Utility District
San Diego Gas and Electric
Seattle City Light
Southern California Edison
Tennessee Valley Authority
Xcel Energy

GridBallast research project

Great River Energy and Connexus Energy are taking part in a pilot research project funded by the Department of Energy (DOE) focused on grid reliability.

The DOE will invest $1.3 million in the GridBallast project to create low-cost, demand-side management tools for improving the resiliency of the country's electric grid and to better control peak demand. The effort is led by the National Rural Electric Cooperative Association (NRECA).

NRECA and its research partners plan to create two devices: a water heater controller and a smart circuit breaker capable of controlling plug-in appliances. The project team will develop an algorithm to continuously monitor the voltage and frequency of electricity feeds directly at the plug and automatically respond with rapid, low-scale adjustments. The goal of the GridBallast project is to make load management an inherent part of grid operations rather than a central control action, which is currently how demand-response programs are managed.

Unlike traditional demand-response programs that manage devices from a central location, the new controllers will function autonomously, monitoring electrical anomalies in the field and making rapid, low-scale adjustments. Averting the need for communications infrastructure, GridBallast could reduce load control costs by at least 50 percent, according to project's leaders.

The devices will be deployed at homes and businesses in Connexus Energy's service territory while Great River Energy will support the research and share those findings with its other cooperatives.

Researchers will focus on defining control algorithms that will allow GridBallast devices to work together without a network. The research team assembled by NRECA includes experts from Carnegie Mellon University, Eaton and SparkMeter. Eaton will develop the water-heater controller. SparkMeter will build a smart circuit controller. NRECA and co-ops will pilot the devices on their systems in partnership with cooperatives.

NRECA recently drafted a "Technology To Market" (T2M) document that outlines a strategy to move the technology as tested in the GridBallast program to a sustainable commercialized product. An Industry Advisory Board has been formed that includes representatives from participating cooperatives and NRECA leadership to provide guidance and support for the T2M portion of the project.

By participating in this project, Great River Energy hopes to further its knowledge on ways to help stabilize the grid as it undergoes a period of transition. This project is an opportunity to better understand the impact renewable energy resources will have on Great River Energy's system and how the cooperative can deploy autonomous intelligent technologies to respond rapidly, without human intervention, to maintain the power quality and reliability its members expect.

The GridBallast project will take place over a two-and-a-half year period with field demonstrations beginning in July 2018 and concluding in April 2019.

Contact information

Gary Connett, director, member services
Great River Energy
gconnett@grenergy.com

Tom Guttormson, principal technology engineer
Connexus Energy
tom.guttormson@connexusenergy.com

ICE pilot project results

Context

As interest in new generation sources increases, costs for wind and solar power decrease and battery storage becomes more feasible, adding distributed energy resources (DER) with battery storage to the electric system continues to become a more viable way to address reliability issues on the electric system.

Great River Energy worked on a pilot project in 2016 to study the differences between the benefits of investments in transmission assets versus distributed generation and storage as a means for improving system reliability. In this pilot project Great River Energy partnered with member cooperative East Central Energy to develop further understanding of the members being served and if investments in non-wire alternatives (distributed generation and storage systems) would be more prudent than investments in Great River Energy's transmission assets as a means to improve system reliability.

The pilot project served as a reference point for cost comparisons when considering replacement of transmission lines or potential benefits of distributed energy resource additions to the transmission system or to member distribution systems.

The pilot project idea emerged from Great River Energy's involvement in the Department of Energy's Energy Sector Climate Resilience Partnership, where participating utilities were introduced to a new Interruption Cost Estimator (ICE) tool. The ICE tool helps estimate the cost of service interruptions and/or the benefits associated with reliability improvements. Great River Energy saw an opportunity to leverage this tool to assist in planning efforts and identify cost-effective non-wire alternative investments.

Description

Great River Energy partnered with member cooperative East Central Energy to gather reliability data, which accounted for a 10-year average in industry standard metrics system average interruption duration index (SAIDI), system average interruption frequency index (SAIFI), and customer average interruption duration (CAIDI). Data for reliability at individual distribution substations and commercial and residential usage also were used.

From those inputs, the ICE tool could determine the cost of outages and potential outage reduction savings by investing in either non-wire alternatives or traditional transmission infrastructure. Using this information, customer socioeconomic data and time of day/year data, the total annual cost of sustained interruptions was calculated for each substation. There were 30 East Central Energy substations included in the analysis.

Why it mattered

Great River Energy has been committed to serving its members with a high standard of reliability since it was formed and has consistently made reliability improvements when needed. This study proved that those investments have created a highly reliable system. The results showed that deploying distributed energy resources as simply a way to improve reliability did not make sense for a number of reasons. First, Great River Energy's system is highly reliable. Interruptions—sustained and momentary—aren't so prolonged as to warrant extensive investment. Second, neither the load nor customer base is dense enough in any part of Great River Energy's service territory to create enough of an economic hardship that would drive the value proposition of non-wire alternatives such that investments would be worthwhile solely for reliability purposes.

The study considered two types of DER technologies in the study—battery storage and diesel generators. Solar was not considered in the cost of DER implementation due to the fact that reliability was the driving aspect of the study. If Great River Energy is looking to increase reliability with DERs, then the variable, non-dispatchable nature of solar wouldn't increase reliability without accompanying storage, which would increase the costs to a level that would preclude consideration.

The analysis showed that the pay back period for adding diesel generators to the system would be 59 years, and for a battery system the payback (only in terms of reliability) would be 208 years. The cash flows on an annual basis represented the ICE tool output for the value of a 40% improvement in SAIDI. Simply put, to install DER for reliability does not make sense for Great River Energy at this time. Several assumptions were made throughout the study to give a best case scenario look at the non-wire alternatives, and to attempt to stress-test the numbers to see if a positive NPV would be possible.

Ultimately, the annual benefits did not accrue to enough of a cash flow to offset initial investments and annual costs. The average battery project cost would have been $4.4 million, and average diesel project cost at $1.2 million. The investments were still borderline with a total elimination of interruptions, which would not be a realistic assumption. There is potential for battery storage to become economic, but only if additional value propositions outside of reliability were 'stacked' such that the sum of the values would create annual cash flows to offset the still large initial investments. Using DERs would not be a cost-effective alternative to transmission system upgrades to improve the reliability of the system.

Great River Energy can continue to use the ICE tool in the future as members want to see the cost of an outage and to use it in other areas.

The cost of battery storage is declining; the study used an aggressively optimistic cost estimate for installed costs of battery storage in 2020. For the economics to improve for battery investments, other benefits such as ancillary services payments from the Midcontinent Independent System Operator (MISO) would need to be included, as well as additional payments for a storage unit as a generator, as load, and as a transmission asset. Stacking payments could result in a cost-effective investment in battery storage technology. The MISO market is still lacking a defined construct for payments to storage assets, and Great River Energy will need to re-examine the assumptions of this project when a more defined market construct is in place. Currently, there are no state or federal subsidies on batteries that might help their value proposition.

Goals and objectives

The objectives of the pilot project included:

1. Identify the status and availability of the data that indicates the condition of Great River Energy's transmission assets that serve a co-op.
2. Develop a long term health/risk index for transmission assets that serve that co-op's load (another project is addressing health/risk for all Great River Energy transmission assets), predicated upon:
    - Asset condition
    - Historical reliability indices
    - Customers being served
    - Criticality to operations
3. Utilize the ICE tool to compare the cost benefits for improved reliability/resilience of investment in non-wire alternatives versus investment in transmission assets. A longer term goal would be to create a system that prioritizes existing transmission assets for replacement or upgrade in the capital projects process.
4. Inform the future grid steering committee, member managers, senior staff and board members on the study results, and provide recommendations to expand the analysis to other interested cooperatives.
5. This project will additionally serve to inform the longer term transmission and resource planning processes. The project may also serve as a reference for methods to identify and compare the costs of transmission and distribution facility replacements to the cost of implementing targeted DER.

Project start date: May 27, 2016

Project end date: Nov. 17, 2016

Participating Organizations

Great River Energy

East Central Energy

Department of Energy (provided tool used)

Contact information

Gordon Pietsch, director, transmission planning and operations
Great River Energy
gpietsch@grenergy.com

Michael Brytowski, standards specialist
Great River Energy
mbrytowski@grenergy.com

Zac Ruzycki, senior resource strategist
Great River Energy
zruzycki@grenergy.com

TODAY'S ENERGY MARKET

Portfolio evolution

Great River Energy is crafting a dependable and economical portfolio through new resources and using existing generation in new ways.

A rise of dispersed and variable renewable generation resources – primarily wind energy – has had major market effects that are shaking up the economics of conventional power plants.

Ten years ago, the Midwest energy market included 1,000 megawatts of wind generation. Today, there are 15,000 megawatts – and more development is expected.

Using existing resources in new ways

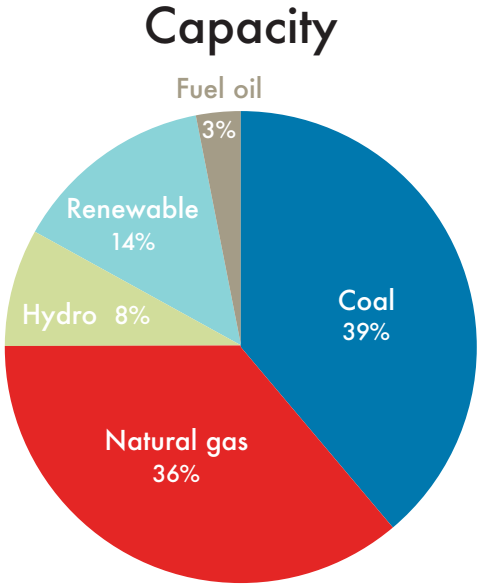
Because there is more energy available, market prices have fallen. And, since the output of renewable resources swings up and down depending on the wind, there is a growing need for generation resources that can adjust their output.

The roles of baseload and renewables have changed dramatically. Coal and natural gas power plants are now called on to be the steadying force in the market.

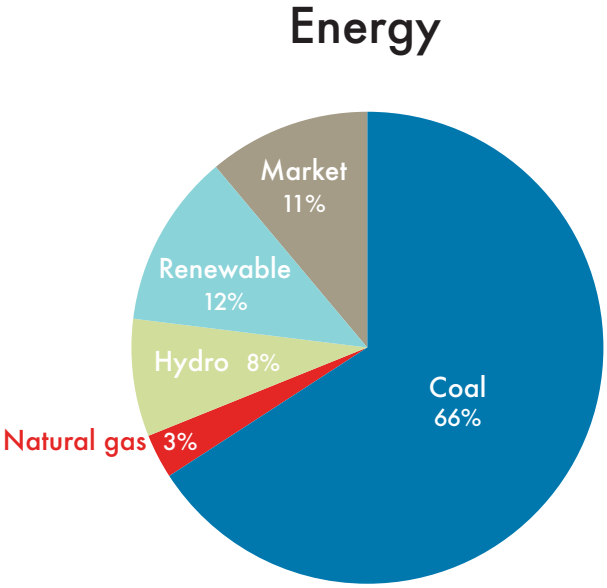
To remain competitive in today's power market, Great River Energy adapted Coal Creek Station to the new market forces. Operational changes and minor modifications will enable the 1,146-megawatt plant to ramp down to less than 300 megawatts.

More wind on the way

Great River Energy is taking advantage of favorable pricing of renewable resource and market trends to strategically expand its renewable portfolio. The 300-megawatt Emmons-Logan project is scheduled to begin providing power to Great River Energy's members in 2020. The project will bring Great River Energy's renewable energy capacity to more than 1,000 megawatts.



2016 capacity sources by fuel type



2016 energy sources by fuel type

Reducing reliance on coal

After serving Great River Energy's members for more than 50 years, the Stanton Station power plant will be retired in 2017. Retiring the plant was in the best interest of Great River Energy's member-owner cooperatives. The plant's closure will reduce Great River Energy's costs while also reducing the cooperative's carbon dioxide emissions and reliance on coal. The retirement of Stanton Station follows Great River Energy's 2015 exit from a contract for half the output of a Wisconsin coal plant.

Solar rising

Following its 2015 statewide buildout of solar arrays, Great River Energy applied its newfound knowledge to develop the largest cooperative-owned solar installation in Minnesota. Great River Energy and Wright-Hennepin Cooperative Electric Association collaborated on the Dickinson Solar Project, a 2.25-megawatt installation consisting of 8,352 panels on 13-acres in Buffalo, Minn.

Great River Energy's board of directors adopted a resolution in 2013 that includes the following provisions:

- Address potential base load stranded costs through the accelerated depreciation of Coal Creek Station and Stanton Station over the next fifteen (15) years, beginning in July 2013
- Manage carbon dioxide emissions to 2005 levels or lower
- Implement cost effective opportunities to reduce greenhouse gas emissions now and develop and implement a plan to substantially reduce Great River Energy's dependence on coal by 2028
- Meet any future growth with conservation, energy efficiency, renewable energy, natural gas and market purchases

GREAT RIVER ENERGY™

Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369
763-445-5000

greatriverenergy.com

Environmentally beneficial electrification

Technological progress is making appliances and other electric devices ever more efficient. Power plant retirements and renewable development will continue to reduce the environmental effect of the electric system.

These two converging trends are making one thing very clear: electricity is a smart choice.

As the electric system continues to become cleaner and more efficient, there is growing support for using electricity in new ways.

Great River Energy continues to offer its Revolt℠ program, which allows electric vehicle drivers to charge their cars entirely with wind energy at no added cost. Its member-owner cooperatives offer a catalog of programs that incentivize energy efficiency retrofits ranging from LED lighting to ground-source heat pumps.

In partnership with its member-owner cooperatives, Great River Energy also works to attract economic development through financial support and unique energy solutions.

Cooperatives are also leading the charge on community energy storage, which employs common household appliances to provide critical services the electric grid needs.

Benefits for co-ops

Electrification provides cooperatives with relief from financial pressure due to declining electric sales. It also builds member engagement by helping home- and business-owners save money and improve efficiency.

Regional transmission leadership

The electric industry is in the midst of an evolution that began more than 20 years ago. In the first 10 years, gradual but radical change in the transmission industry was driven by the federal government. Modernizing the grid became a national priority with concerns focusing on reliability, national security, the environment and the need for more efficient markets to keep electricity affordable and serve customers better.

Great River Energy and its members stayed ahead of the curve as:

- A founder and leader of the CapX2020 grid expansion
- Early members and market participants in the Midcontinent Independent System Operator (MISO)

Leading the CapX2020 grid expansion

Great River Energy was a founder and leader of CapX2020, a joint initiative of 11 investor-owned utilities, generation and transmission cooperatives, and municipal joint action agencies.

CapX2020 is upgrading and expanding the electric transmission grid in Minnesota, North Dakota, South Dakota and Wisconsin to ensure continued reliable and affordable service; meet state and regional energy policy goals; and support a diverse generation mix, including renewable energy.

A core objective of CapX2020 is collaboration in the planning and execution of projects. A University of Minnesota Humphrey School of Public Affairs report in 2016 said the CapX2020 organization ushered in a new era of multi-state transmission planning and served as an example that other utilities can and should emulate as they cooperate on regional projects.

There are five major CapX2020 projects that comprise a $2 billion investment in 800 miles of 230-kV and 345-kV transmission lines. It is the largest development of new transmission in the Midwest in nearly 40 years.

Prepared for today's transmission environment

Great River Energy is prepared for today's competitive transmission environment. Great River Energy was accepted as a MISO-qualified transmission developer in late 2014, which allows the cooperative to compete for the right to build certain regional transmission projects.

MISO created the qualified developer status in January 2014 in response to the Federal Energy Regulatory Commission's (FERC) Order 1000 that eliminated the "right of first refusal." Having the right of first refusal allowed utilities the right to develop new transmission facilities

more than 100 kV that connect to substations the utility owns and, in FERC's opinion, prevented competition in the market for transmission expansion projects.

Although Order 1000 eliminated the right of first refusal on the federal level, a number of states exercised their authority to address the issue at the state level. Minnesota, North Dakota and South Dakota each passed state laws retaining the right of first refusal (ROFR). Great River Energy, in collaboration with CapX2020, advocated for the Minnesota ROFR bill in 2012.

Also, Great River Energy is heavily involved in inter-utility and MISO transmission planning activities, working actively to help ensure appropriate regional-scale projects are approved by MISO when they would benefit its members.

Continued grid evolution

While transmission continues to evolve, exponential change is expected over the next 15 to 20 years on the distribution side of the grid and in retail markets. This time, change is not being driven by government but instead by customers. Key drivers include:

- High expectations of today's consumers
- Concerns about carbon and other emissions
- Rapidly developing technologies for consumerization of energy

GREAT RIVER ENERGY™

Great River Energy
12300 Elm Creek Boulevard
Maple Grove, MN 55369
763-445-5000

greatriverenergy.com

greatriverenergy.com

Powering what's possible

A Touchstone Energy® Cooperative