Before the
Department of Energy
Washington, D.C. 20585

In the Matter of	)
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Implementing the National Broadband	)
Plan by Studying the Communications	)
Requirements of Electric Utilities To	)
Inform Federal Smart Grid Policy	)

NBP RFI: Communications Requirements

COMMENTS OF GREAT RIVER ENERGY

I. Introduction

a. Identification/description of our company

Great River Energy (GRE) is a not-for-profit generation and transmission cooperative which provides wholesale electricity to more than 1.7 million people through 28 member distribution cooperatives in Minnesota and Wisconsin. Great River Energy is the second largest utility in the state, based on generating capacity, and the sixth largest generation and transmission (G&T) cooperative in the United States. Great River Energy's member cooperatives range from those in the outer-ring suburbs of the Twin Cities to the Arrowhead region of Minnesota to the farmland of southwestern Minnesota. Great River Energy's largest distribution cooperative serves more than 120,000 meters; the smallest serves just over 2,400.

II. Executive Summary

Great River Energy has deployed a fully integrated IP network to 750 remote sites of our electric system, 18 remote offices and 11 electric generating facilities. The IP network transports data information for SCADA, mobile radio voice traffic, metering information, corporate data and voice traffic between office sites, protection operations for power lines, and video surveillance.

Private networks were developed by Great River Energy due to lack of ubiquitous coverage by major carriers or operating telephone companies. No single vendor or combination of several vendors could provide an integrated solution. Prior to building out the private network we now have in place, proposals were solicited from carriers and telephone companies to provide a comprehensive integrated solution to serve the locations previously described above. Many chose not to bid, and all others could not meet the majority of the requirements. Great River Energy also approached several carriers to jointly build out existing networks to meet our needs. They were not interested in working with a mid size utility.

The rural environment and substations in particular present challenges. Carriers and telephone companies build to mass markets leaving rural areas under served. Substations are hazardous electrical environments and thus require expensive and complex protection systems for wire line communications. This has lead many utilities Great River Energy included, to rely heavily on wireless systems. Wireless covers large areas of geography and is not susceptible to the hazardous voltages.

This led Great River Energy to form an alliance with Arcadian Networks, Inc. (ANI) a wireless carrier, and a consortium of independent telephone companies with agency representation, to build the integrated IP network. ANI brought the broadband wireless spectrum, which GRE does not have access to. Independent telephone companies had fiber in the rural areas and were willing to interconnect to GRE owned fiber. The spectrum used today will not be enough in the future. As GRE members continue to add their Smart Grid distribution system applications to the wireless segment of the network the amount of data will grow. It is projected by the industry that utilities will go from moving and managing 7 terabytes of data to 800 terabytes.

Public carrier systems and sharing of spectrum with others has proved unreliable in the past. Public wireless networks degrade or fail during catastrophic events. This is the time utilities need them the most.

With greater than 99.95% reliability, our current network meets today's requirements.

III. Overview of communications networks

a. GRE operates a communications backhaul network comprised of approximately 2500 miles of fiber linked together in nine synchronous optical network (SONET) rings to provide a highly reliable backbone. Several radial digital microwave extensions extend the reach of this system. There are approximately 65 SONET nodes, which operate at a speed of 2.4 gigabits per second (OC 48), and the digital microwave extensions operate at 45 Megabits per second. Data from the systems described below are aggregated into the backbone system and delivered to the Great River Energy system control center. All nodes, including those that are owned and operated by commercial carriers have a minimum of 72 hour generator capacity.

b. For Supervisory Control and Data Acquisition (SCADA) communications, GRE partnered with ANI who leases spectrum from a company, Access Spectrum, who owns the two 1 MHz channels at 757 – 758 MHz and 787 – 788 MHz. This network was jointly built out between 2006 and 2008 by GRE and ANI, but is owned by ANI. ANI contracts GRE to monitor and maintain the network, so the network is still under the control of GRE and GRE can dispatch crews for repair 24 hours per day, 7 days per week, 365 days per year, as we do with all our telecommunications systems. All nodes on this network have generator backup for a minimum of 72 hours. ANI can sell service on this network to like entities for similar, SCADA type applications. Prior to this system deployment, every device in a substation needed its own communication circuit resulting in four or five communications circuits in some substations. By using a broadband network, which uses IP for its network layer, these applications were able to use one communication path for all disparate communication circuits. Management tools can remotely monitor the health of the network enabling GRE to be proactive in system response instead of reactive after a problem had caused an outage. By using Wi-Fi access points at the substations and switch locations, field personnel are able to access the internet or company's intranet in those locations enabling the same network to be used for network access in addition to SCADA applications. Prioritization is used on the network to ensure that SCADA data always gets through. Virtual Private Networks (VPNs) provide network security and isolation between the SCADA network and the corporate network.

c. Power Line Carrier (PLC) and fiber optics are used extensively for relaying and teleprotection throughout our transmission system.

d. For some down line devices that are within less than two miles, GRE connects them to the 700 MHz device, which typically resides in the substation, using unlicensed 900 MHz radio links or fiber optic cable. The 900 MHz, unlicensed links are typically used only in rural areas and are typically short distances to reduce susceptibility to interference.

e. GRE owns and operates a private trunked mobile radio system for voice communications from dispatch to field crews and for field crew to field crew communications. In addition to this communication system being used by GRE, it is also used by the majority of our member distribution cooperatives to make the most effective use of radio frequency (RF) spectrum and to make the system more cost effective. This system covers our 56,000 square mile service area in Minnesota and Wisconsin and an additional 10,000 square miles covering transmission lines from our plants in North Dakota. This is a narrowband (12.5 kHz) wide area, analog, trunked radio system which currently cannot support any data applications. This radio system must be available for communications from System Operations to field crews in the event that all other communications systems fail.

f. GRE owns and operates a VHF private radio system for load control. This load control system is used throughout GRE's service area and controls approximately 343,000 meters. The current system provides one way communication via a paging type system to receivers connected to meters. GRE's load control system can control between 350 MW and 550 MW of electrical load, depending on the time of year.

IV. Why private networks?

GRE's decision to install private telecommunication networks is based on reliability, control of the network, and security.

a. Reliability - GRE has generator back up at all of its major communication nodes which provide a minimum of 72 hours back up power. In most cases, there is enough fuel supply on site for two weeks. GRE is a black start company for a major portion of the upper Midwest. Owning and controlling these private networks allows GRE to dispatch for troubles 24/7 at its discretion.

b. Carriers typically do not guarantee reliability above 99.5%. The GRE network described above is 99.95%

c. Isolation of cyber assets, such as this network, eliminates the security and prioritization issues associated with a public network.

V. What technologies are used?

a. Backhaul

   i. Fiber - Fiber for this network is a combination of optical ground wire (OPGW) and fiber-based capacity leases from local independent telephone companies. The capacity leases are for exclusive use by GRE.

   ii. Licensed microwave - GRE has installed licensed microwave in the 6 GHz band for extension of the backbone.

   iii. Unlicensed microwave – 2.4 GHz and 5.8 GHz are used for shorter, less critical backhaul links.

b. Others

   i. SCADA

1. Licensed - The joint GRE/ANI network is IP to the substation over a wireless DOCSIS cable modem using licensed 700 MHz spectrum.
2. Unlicensed - 900 MHz unlicensed spread spectrum broadband, IP radios are used only for short distances (<2 miles) in rural areas that have less likely chance for interference. These radios allow us to expand our broadband SCADA network cost effectively as they are less expensive than the 700 MHz system.

ii. Voice Mobile Radio – GRE uses a proprietary Motorola analog, wide area, trunked mobile radio system. This system is nearing end of life and we anticipate that it will be replaced by an open standard wide area, digital radio system capable of operating at 6.25 kHz efficiency and capable of providing some mobile data capabilities.

iii. Load control - A licensed VHF one way, analog paging type system is used to perform load control.

c. Overview smart grid deployment plans

i. Types of applications and number of devices

1. Synchrophasors – GRE is in the process of deploying three synchrophasors as part of a Midwest Independent Transmission System Operator (MISO) project. GRE anticipates that eventually all its transmission substations will have synchrophasors installed which is about 100 devices.
2. GRE anticipates that more substation and downline devices will use the IEC 61850 standard which allows devices to communicate with each other and make intelligent decisions in the field instead of information going back to a central location. Initially, the majority of the deployments will be within a substation, but eventually substations may use this protocol to communicate between substations and to devices on the transmission line. This could be up to 2,000 devices.
3. Video surveillance and proximity readers. As NERC critical assets move farther and farther into the transmission and eventually the distribution substations, video surveillance and proximity readers will need to be deployed. There could potentially be approximately 700 substations that video surveillance and proximity readers would be deployed at.
4. The majority of Smart Grid applications reside in the distribution

environment. While GRE is not in the electrical distribution business, GRE does assist its member distribution cooperatives with their Smart Grid deployments. This includes providing backhaul and trying to maintain consistent solutions and providing support to 28 distribution cooperatives, many of whom have limited IT and engineering staff. There could be up to 700,000 meters and up to 4,000 downline devices with distribution automation that use the 700 MHz network for backhaul.

ii. Timeframe for deployment

1. Synchrophasors – Three locations in progress. Within five years, all transmission substation could have synchrophasors.
2. IEC 61850 will begin within the substation within the next year as a pilot and within five to ten years will be deployed to all substations.
3. Many distribution cooperatives already have AMR and AMI deployed that use the 700 MHz network for backhaul. This will continue to expand and more data will be required to be retrieved more often over this network in the future. Cooperatives that currently do not have AMR and AMI or that do not use the 700 MHz network will begin these deployments as well. The timeframe for these deployments vary widely as there are 28 cooperatives and all of them have their own timeframes for deployments. Within ten years, there will likely be AMI to all 700,000 residential meters and within five years, there will be significant deployment of downline devices with distribution automation capabilities.

d. Overview of communications requirements

i. Current

1. Currently, GRE polls approximately 800 RTUs at substations, switches, and capacitor banks every four seconds. This amounts to approximately 60,000 data points. Load control is an additional 8 byte message broadcast to all receivers attached to meters every five minutes during peak times when GRE is controlling load. Billing meter data is read daily from approximately 700 substation meters and is approximately 5 kilobytes of data. The frequency of these meter reads is expected to increase to hourly or every fifteen minutes in the future. Field personnel accessing the internet or intranet presents a much higher bandwidth

requirement, but is more sporadic in location, duration, and frequency.

ii. Future

1. Data requirements will expand dramatically in the future. The number of devices in the field will increase and the amount of data required for them is estimated to increase about 100 times the current amount. Synchrophasors transmit data 60 times per second and IEC 61850 for device to device communication requires high speed, high throughput communications. GIS will be used on AVL and mobile data communication systems will greatly increase mobile communications systems requirements. GRE will need to assist our 28 member distribution cooperatives with Smart Grid backhaul. If meters are read every 15 minutes as opposed to once per month, as they are now, that is 3000 times the amount of data. Down line distribution automation, which is currently limited in deployment, will be expanded as well, adding to the data requirements.

e. Assessment of existing networks to meet current and future communications needs

i. What are the communications gaps?

1. No dedicated, licensed, broadband spectrum for utilities to build out broadband communications for either SCADA applications which are becoming more data intensive, Smart Grid applications, and even for narrowband mobile voice. Even for the narrowband voice frequencies, which is our communications system of last resort and therefore of utmost importance for safety and operations of the electric grid, utilities compete for spectrum with cement companies, bus companies, pizza delivery and every other business that is eligible for these licenses in the Industrial Business band. Mobile data and automated vehicle location (AVL) applications, including Graphical Information System (GIS), are very data intensive and impossible to deploy at this time due to a lack of spectrum and a lack of coverage by commercial cellular providers.

ii. What do you need to fill those gaps?

1. Much like public safety, utilities, as a part of critical infrastructure, need reliable communications systems that they operate, maintain, and

control. In order to continue to do this effectively and provide for future communication requirements, utilities need dedicated RF spectrum.

2. Some non-critical applications, such as AVL and mobile data, could use commercial cellular service if there was adequate coverage in our service area. Currently, commercial, cellular coverage in rural areas is a major gap.

f. Commercial services

i. Do they currently meet utility needs?

1. Mission critical applications

a. Commercial services have not had sufficient generator back up. For utilities, this is imperative. GRE's communication systems have a minimum of 72 hour generator backup in order to allow for black start capabilities.

b. GRE is a rural generation and transmission company. We provide wholesale electricity to 28 member distribution cooperatives from suburban areas around the Twin Cities to very rural areas including farmland in southern Minnesota to extremely low population areas in northern Minnesota. Commercial wireless communication providers only build their networks to populated areas and along highway corridors. Many, many locations in our services area have either no commercial wireless service, or very poor commercial wireless service. GRE requires communication service everywhere that we have transmission lines and substations. In addition, we backhaul communication traffic for many of our distribution cooperatives, who have even more rural penetration requirements than we have.

c. Currently, there is no plan to allow utilities to have priority on commercial networks, if we were to use them. There has been a lot of discussion about joint Public Safety and commercial carrier systems which show a model for Public Safety having priority. Utilities, as a part of critical infrastructure also require priority if a commercial network is to be used.

d. Commercial networks fail due to lack of generator back up and high call volume during disasters. This has been the case from large disasters such as 9/11 and hurricane Katrina to smaller disasters such as flooding in the Red River Valley in Minnesota and North Dakota and during many local storms. GRE's service area is in a tornado prone area and our private communication systems have been used for power restoration during disasters when commercial networks have failed.

e. Commercial networks take maintenance outages during the middle of the night based on low call volumes. GRE requires rigid change control procedures for all maintenance outages which would be difficult to coordinate with commercial carriers. In addition, commercial network providers do not always repair and restore on a 24/7 basis resulting in extended network or circuit outages.

2. Non-mission critical applications

a. Non-critical applications such as AVL and mobile data could use commercial networks where there is coverage. There are still many areas where voice cellular calls cannot be made and 3G coverage is only available in populated areas or along highway corridors. GRE views commercial carriers as part of our communications solution. Commercial networks could be used where there is coverage and only for non-critical applications.

b. GRE is a not for profit company and the cost of generating and transporting electricity continues to rise. We need to do everything we can to keep our costs low to the member distribution cooperatives we serve. Commercial networks and their service models are much more expensive than our private networks. Typically with commercial networks, power levels are much lower, and more infrastructure is needed resulting in higher system costs. Telecommunication systems need to be cost effective.

ii. How can they be improved?

1. Commercial networks need to have on site backup generators at all their

nodes, including their backhaul sites. There needs to be a guaranteed on site fuel supply for a minimum of 72 hours.

2. If a utility is going to use a commercial network, then that commercial carrier needs to work with the utility to understand where the utility's service area is and build out its networks into those areas. This does not mean only highway corridors. It means along power lines, both transmission and distribution, and it means providing communications to each electric meter on the system, no matter how remote that customer is.
3. If a utility chooses to use a commercial network, then prioritization of that traffic to allow the utility priority above the general public is required.

VI. Smart grid and communications requirements today

a. Detailed description of smart grid applications (e.g. AMI, DA, and DR).

i. Describe the types of applications, the extent of their deployment and whether they are mission critical.

1. SCADA has been deployed throughout our system for many years. This is a very critical system that needs to have high security and high reliability. When a line is remotely switched in or out it is imperative for both system operators and field personnel to know whether a power line is energized or not. This is a matter of life and death for the line workers in the field. These systems need to have backup generators to ensure that lines can be controlled at all times especially when the electrical system is not functioning properly.
2. GRE's Demand Response system is used extensively throughout our service territory. It allows us to control between 350 MW and 550 MW depending on the time of year. This system needs to be able to successfully send codes to the receivers to control load during peak times. This saves GRE from building a large generator station. While this communication system needs to be secure and reliable, it does not need to have generator back up since if the electrical system is not functioning, loads do not need to be controlled.
3. GRE is a Generation and Transmission company and as such, does not have as many Smart Grid requirements as distribution companies do.

However, GRE provides backhaul to carry our 28 distribution cooperative's Smart Grid applications and we work very closely with our distribution cooperatives to help them meet their requirements.

b. Functional requirements needed to support those smart grid applications.

i. What are your specific requirements with regard to cost, Coverage, Capacity (Bandwidth), Latency, Reliability, Back-up power (AC Independence), and Security for each of these applications?

1. Security is the most important component in all our communications systems.
2. Reliability is extremely important for reasons described above.
3. AC independence for SCADA and mobile voice radio applications is extremely important.
4. Coverage throughout our service area for all applications is very important. Most of our communications systems are designed for 97% - 98% coverage, depending on the system.
5. Low latency is very important for SCADA and mobile voice radio systems.
6. Capacity or bandwidth is currently the least important of these factors.
7. Cost is a very important factor that must be weighed against the functional requirements of communications systems.

VII. Smart grid and communications requirements of tomorrow

a. Detailed description of future smart grid applications

i. Describe the types of applications, the extent of their deployment, and whether they are mission critical.

1. All current systems will remain requirements in the future. However, it is anticipated that data requirements will increase on existing systems.
2. Synchrophasors will be deployed in all transmission substations. The communication systems that these devices will use are mission critical.
3. Substation and down line devices will use IEC 61850 for device to device communication. The communication systems that these devices will use are mission critical.

4. AVL and mobile data communication systems for applications such as switching orders, GIS and mapping applications, e-mail, and field personnel network connectivity will be deployed. It is not anticipated that these systems will be mission critical, but as business processes are defined using these systems, they will become more critical.

b. Functional requirements needed to support those smart grid applications.

i. What are your specific requirements with regard to cost, Coverage, Capacity (Bandwidth), Latency, Reliability, Back-up power (AC Independence), and Security for each of these applications?

1. Functional requirements for the items listed above are not anticipated to be different in the future than they are today. However, capacity requirements will increase dramatically in the future, potentially up to 100 times the capacity requirements we have today.

VIII. Technology Options and Other Considerations

a. What technology options are available to meet your needs?

i. Wireless

1. Licensed

a. Microwave for backhaul

b. 700 MHz broadband for last mile communications for GRE (also considered to be middle mile for member distribution cooperatives)

c. Narrowband mobile radio. This is somewhat able to meet our needs, but it would be better if more, dedicated bandwidth for a combined mobile voice and mobile data system could be used, similar to the options that public safety has for building joint voice and data systems.

d. GRE's VHF load management system is a one way paging technology system. Currently, this system meets our needs. However, if two way load control systems are needed in the future, this system will not meet those requirements. Due to the power level and low height of the meters, two way wireless communication for load control requires more base stations located closer to the receivers in the meters.

2. **Unlicensed**

   a. A few unlicensed microwave radio hops are used for less critical backhaul paths.

   b. While GRE does not typically use unlicensed wireless radios for critical communications systems, we do deploy them under some circumstances such as tap switches or for connecting closely spaced substations. We typically limit these deployments to less than two mile paths in rural areas.

ii. **Wireline**

1. **Fiber**

   a. Backhaul, relaying, and teleprotection.

2. **PLC or other private wire line**

   a. PLC used for relaying and teleprotection.

   b. Leased copper circuits from telephone companies present a unique challenge in that bringing copper into a substation also brings with it remote ground which can lead to hazardous currents being carried out of the substation during an electrical fault within the substation. In order to protect against this hazard it can cost up to $10,000 to install special isolation equipment. In addition, it has been challenging and time consuming to get telephone circuits into substations, sometimes taking up to a year for installation.

b. **What other considerations come into play in terms of choosing a technology option for your utility?**

i. **Terrain, Foliage, Customer Density, Size of Service Territory, Overhead/Underground Grid Topology, etc.**

1. GRE operates in three states. Our service territory is approximately 56,000 square miles in Minnesota and Northwestern Wisconsin and provides wholesale power to 28 member distribution cooperatives. This distribution territory is served by approximately 4500 miles of load serving transmission lines. GRE also operates generation facilities in

North Dakota along with transmission lines to provide generation outlets. Transmission consists of 230 kV AC and +/- 400 kV High Voltage Direct Current lines.

2. Our service territory is mostly rural with an average of seven customers per mile (distribution cooperatives that GRE serves).
3. GRE's terrain varies from flat farmland in southern MN to dense foliage and hills in northern MN.
4. Wireless is preferred due to the large amount of territory that we cover and the large distances between sites that we serve.

ii. Cost

As costs of providing electricity increases, and is only anticipated to increase in the future, electric companies are under increasing pressure to keep costs down. Communications systems that are as low cost as possible that meet the business requirements are required.

IX. Recommendations

i. Based on your functional requirements and applications, what technology options would you prefer to use for your utility

ii. Current

1. Backhaul
    a. Fiber
    b. Licensed Microwave
2. Mid-mile/Last mile
    a. Licensed 700 MHz
3. Voice
    a. Licensed 450 MHz
4. Last mile
    a. License 150 MHz

iii. Future

1. Backhaul
    a. Fiber
    b. Licensed Microwave
2. Mid-mile
    a. Licensed 700 MHz – currently the bandwidth meets our

requirements. However, we anticipate that the 2 MHz of bandwidth will not be adequate in the future as data requirements expand.

3. Voice
    a. Licensed 450 MHz – currently this meets our requirements. However, we anticipate that this will not meet our requirements for mobile data applications nor does it allow for the most widely deployed worldwide mobile radio standard, TETRA (which requires 25 kHz contiguous bandwidth that 4 channels operate in, making it 6.25 kHz efficiency), to be used.
4. Last mile
    a. Licensed 150 MHz – this will not be adequate for two way load control.

X. Commercial systems

a. Do they meet your needs?

Commercial systems may be able to meet some of our needs. GRE would consider using commercial wireless systems for AVL and mobile data if coverage is adequate.

b. What improvements would meet your needs?

Commercial systems will most likely never be used for critical systems such as SCADA control, synchrophasors, relaying, and devices using the IEC 61850 standard. In order for GRE to consider using commercial systems for applications such as SCADA monitoring and meter reading, they would need to have generator backup and they need to build out to rural areas throughout our service area. In addition, we would need prioritization above commercial traffic for some applications.

XI. Conclusion

Utilities are being asked to provide more information to consumers, have more reliable and secure electric and cyber networks, which in turn means more and faster data, while keeping the cost of electricity low. And yet, utilities do not have any dedicated spectrum to do this, nor do we have access to broadband spectrum. Electric utilities are being pushed to operate the electric grid on commercial services which have historically not provided reliable communications when needed nor do they provide coverage in areas where utilities are required to provide service. Utilities need to have dedicated, broadband spectrum in order to maintain reliable and secure electric systems.

Respectfully submitted,

Great River Energy

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