OBJECTIVE: The purpose of this guideline is to provide technical guidance to assist the applicant desiring to interconnect new or make qualified changes to existing facilities to an electric transmission system owned and/or operated by Great River Energy (GRE), in establishing the interconnection in an efficient and consistent manner to meet the minimum requirements for safe and reliable operation of the interconnection. This document is designed to comply with the North American Electric Reliability Corporation's (NERC) compliance directive to establish facility connection standards.

SCOPE: This document governs the interconnection of new or make qualified changes to existing facilities transmission to transmission tie-lines or transmission-connected, load serving substation. It does not cover interconnection of generators to transmission. Generation interconnection requirements are described in Transmission Division Operating Guideline 202 (TDOG 202), "Generation Interconnection Guidelines."

BACKGROUND: Process documentation is a reference for those interconnecting to GRE's System and ensures compliance with NERC Reliability Standards that address Facility Interconnection requirements.

Reference documents

Name of document, not version

TDIV-14 Transmission Line Design Criteria
Great River Energy Transmission to Transmission and Transmission to Load Interconnection Request Form **https://greatriverenergy.com/transmission-and-delivery/developer-interconnection-guidelines/**
MISO's BPM-020 Transmission Planning
TDOG-18 Transmission Planning Procedures and Planning Criteria
TSP-01 Interconnection Transmission Owner's Planning Study Procedure

Document review history

Version	Date reviewed (MM/DD/YY)	Reviewed by	Description	Manager approval date (MM/DD/YY)	Approving manager
5.0	06/01/13	Kevin Lennon	Annual Review 1. NERC audit recommendations (specifically calling out document references 2. Conform metering requirements (section III G) with GRE standards 3. Reformat document to be consistent with other GRE TDOGs 4. Change of ownership from Cassie Polman to Kevin Lennon *NOTE: Revision numbers were not formally tracked before this date on TDOG 204; according to available records, this is revision 5.*		
5.1	05/01/14	Paul Hamel	Annual Review 1. Change name of MISO from Midwest Independent Transmission System Operator, Inc. to Midcontinent Independent System Operator, Inc. 2. Change of ownership from Kevin Lennon to Paul Hamel.		
5.1	06/01/15	Paul Hamel	Annual Review, no changes.		
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Version	Date reviewed (MM/DD/YY)	Reviewed by	Description	Manager approval date (MM/DD/YY)	Approving manager
5.2	05/31/17	Paul Hamel	Annual Review 1. Change the title of the interconnection contact person at GRE. 2. Include reference to GRE's TDOG 108 in section II. A. 3. Change Billing Metering Requirements to require only internet protocol connection to the revenue meter.		
5.3	06/08/18	Paul Hamel	Annual Review, Add Pam Bagley as the TDOG approver.	06/08/18	Pam Bagley
5.4	05/01/19	Krystal De Bruine	Annual review, minor wording changes.	05/01/19	Tony Ramunno
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7.0	01/09/23	Matt Nitschke	Annual review. Change to the requirement of payment due upfront and minor verbiage changes.	05/01/23	Krystal De Bruine Greg Schutte
8.0	08/10/23	Matt Nitschke	Updated contact information and revised glossary terms.	08/10/23	Krystal De Bruine Greg Schutte
9.0	11/17/2023	Tosha Barthel	Updated terminology MISO's 2024 BPM-20	12/11/2023	Krystal DeBruine

Versions reviewed annually, not to exceed 15 months.

GREAT RIVER ENERGY

TIE-LINE AND SUBSTATION

INTERCONNECTION

GUIDELINES

Revision 9.0

January 2, 2024

NOTE: Revision numbers were not formally tracked before
June 2013 revisions; according to available records, this is revision 9.0

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ACKNOWLEDGEMENTS

Great River Energy gratefully acknowledges permission granted by Otter Tail Power Company to utilize many portions of their "Guidelines for Generation, Tie-Line and Substation Interconnections." Otter Tail acknowledged utilizing documents from Northern States Power Company and Georgia Power Company.

I. INTRODUCTION

A. Objectives

The purpose of this guideline is to provide technical guidance to assist the applicant desiring to interconnect new or make qualified changes to existing facilities with the Great River Energy (GRE) electric transmission system ("GRE System") in establishing the interconnection in an efficient and consistent manner to meet the minimum requirements for safe and reliable operation of the interconnection. This document is designed to comply with the North American Electric Reliability Corporation's (NERC) compliance directive to establish facility connection standards.

These guidelines, along with GRE's transmission line design criteria and co-located processes, are not intended to be a design specification or instruction manual but to provide the technical guidance needed to achieve the following:

- Ensure the safety of the general public and GRE personnel
- Avoid degradation to the reliability and service of all users of the GRE System
- Minimize the possible damage to the property of the general public, GRE customers, and GRE
- Minimize adverse operating conditions on the GRE System
- Permit the applicant to operate with the GRE System in a safe, reliable, and efficient manner
- Accurately measure and account for all injections and extractions from the interconnected system

B. Applicability

This document governs the interconnection of new or make qualified changes to existing facilities transmission to transmission tie-lines or transmission-connected, load serving substation. It does not cover interconnection of generators to transmission. Generation interconnection requirements are described in Transmission Division Operating Guideline 202 (TDOG 202), "Generation Interconnection Guidelines."

GRE's transmission facilities are heavily integrated with those of other utilities. The requirements listed here may need to be modified on a case-by-case basis if the interconnection impacts facilities owned by other utilities.

All capitalized terms that are used in these Tie-line and Substation Interconnection Guidelines that are not defined herein shall have the meanings given to them in the MISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (the "MISO Tariff"), or other relevant MISO documents.

C. Company Contacts

Any applicant intending to interconnect new or make qualified changes to existing facilities to the GRE System is required to complete an application for Transmission-Transmission/Transmission-Load Interconnection Request Form. All new interconnection applicants should initiate the interconnection process by contacting the following:

Director, Transmission Business Strategy & Development
GREAT RIVER ENERGY
12300 Elm Creek Boulevard
Maple Grove, MN 55369-4718
(763) 445-5000
dltransmissionbusinessrelations@grenergy.com

II. GENERAL POLICY AND REQUIREMENTS

A. Compliance with Interconnection Requirements

The requirements set forth by this document are intended to comply with the FERC's final rules on Open Access (FERC Orders 888, 889), all state and federal regulatory agency requirements and other applicable requirements of other entities related to owners and operators of electric systems and associated interconnected facilities such as NERC, MISO, applicable reliability corporation, or any successor agency assuming or charged with similar responsibilities related to the operation and reliability of the North American electric interconnected transmission grid. Specifically, MISO's BPM-020 "Transmission Planning", GRE's Transmission Planning Procedures and Planning Criteria (TDOG 108) and GRE's Interconnection Transmission Owner's Planning Study Procedure (TSP-01) shall be followed. While these requirements comply with today's industry standards, the electric industry continually develops, and changes can be expected.

Existing interconnections of transmission facilities or electricity end-user facilities seeking to make a qualified change on the transmission system needs to report the qualified change. The qualified change is defined as: i) transmission system topology change; ii) protection configuration change that could negatively impact contingency performance, short circuit, or dynamic performance; iii) change the electrical characteristics of a circuit (i.e., change of impedance, current transformers) that could negatively impact contingency performance, short circuit, or dynamic performance.

These Guidelines are general and may not fully address the circumstances of a specific interconnection request. Additional or different requirements may also be necessary for a specific project as a result of planning and engineering reviews of the interconnection request. The applicant needs to work closely with GRE to keep up to date on the interconnection requirements. GRE will determine the charge for study costs based on benefits to GRE from the transmission interconnection.

It is the responsibility of the applicant to obtain all permits and approvals of the governing bodies and to comply with all applicable electrical and safety codes.

The applicant is responsible for ensuring that the interconnection complies with all NERC, MISO, applicable regional entity, Rural Utilities Service and other applicable industry planning, design, and operating standards – including any periodic testing that may be required.

The Interconnection customer shall abide by transmission standards, policies & procedures and other requirements of general applicability that are developed by GRE in its sole discretion for the interconnection of generation resources or load to GRE Transmission System and operation of such generation resources and load, as such may be amended from time to time and made available to the interconnection customer, including by posting on GRE's OASIS. This includes but is not limited to GRE's Distribution Export Policy/Process.

Information requirements

1. Transmission Interconnection Request Steps

Complete the Transmission to Transmission and Transmission to Load Interconnection Request Form. Forms for electronic format may be obtained from the contacts below. Specify the location of the requested interconnection (county, town and street or section, township and range), a 10-year demand forecast (MW and MVAR), the number of transformers and their proposed nameplate capacity in mega volt-amps (MVA), and the proposed in-service date. Any reductions in load at other interconnection or delivery points due to the addition of this new interconnection point should also be specified. The ultimate point of interconnection and voltage level will be determined based on the applicant's review of the GRE interconnection study. The requesting party must also provide their proposed equipment ratings as required by GRE to allow the establishment of the facility rating for the interconnection facilities or as required to allow appropriate system simulation modeling of the interconnecting facility. Final required facility ratings will be agreed to based on the results of the interconnection study. In addition to completing the interconnection request form, the applicant shall include a statement for the need of the interconnection project.

2. Submit Interconnection Request

Return completed Transmission to Transmission and Transmission to Load Interconnection Request form, along with a single-line diagram, and statement of need to GRE's Transmission Business Relations Department as listed below:

Transmission Business Relations
GREAT RIVER ENERGY
12300 Elm Creek Boulevard
Maple Grove, MN 55369-4718
DLTransmissionBusinessRelations@GREnergy.com

3. GRE staff review the Interconnection request

GRE staff will review the interconnection request for completeness and evaluate the need for studies. GRE staff will contact the applicant within 30 calendar days. Study cost estimates, depending on the complexity of the request or workload, are generally available along with the study agreement, if needed, within 30 calendar days of the receipt of the interconnection request. If studies are needed, the cost of the studies will be borne by the party requesting the interconnection, with 100% of the estimated study cost due when the study agreement is executed. At the completion of the study a final bill will be compiled and any unused funds will be refunded, if the final bill exceeds the initial estimate a final payment will be due.

4. Types of Interconnection Studies.

System Impact Study

The System Impact Study, if required, will determine if the transmission system has adequate load serving capability and will determine the major components required to interconnect with the GRE Transmission System. The System Impact Study may include: power flow analysis, fault study, stability study (if required), transient switching analysis, and impact to other customers on the GRE Transmission System. System Impact Studies may take 6-8 weeks to complete. Depending on the complexity of the interconnection, and other projects being studied, the study time may be extended. During the analysis, additional details of the proposed facility may be required and will be requested from the interconnecting party as necessary.

Following receipt of the completed study, the party requesting interconnection will have 15 business days to decide whether to proceed. A decision to proceed may lead to additional studies or directly to the negotiations for an Interconnection Agreement. The interconnecting party confirms their decision to proceed by submitting a letter, or e-mail communication to that effect.

Facilities Study

The Facilities Study, if required, will determine the detailed engineering design and final requirements for the interconnection to proceed and costs based upon the equipment configuration determined by the interconnecting party and GRE. The Facilities Study report will provide the following information:

- Interconnection facility cost estimate.
- System upgrade requirements for interconnection, not transmission service related.

GRE and the interconnecting party will enter into a Facilities Study Agreement to perform the required detailed engineering. The scope of the study will be identified in the agreement. The Interconnecting party shall pay for all costs associated with the Facilities Study. GRE's analysis will be limited to the requirements to protect GRE's equipment, personnel, and customers from adverse impacts due to the interconnecting party's interconnection.

The applicant shall provide all requested items as soon as practical to facilitate completion of necessary studies and agreements. After GRE has received all the required information, the Facilities Study may take 6-8 weeks to complete. Depending on the complexity of the interconnection, and other projects being studied, the study time may be extended. To establish installation details, meetings may be held with the GRE representative, the applicant, the applicant's consulting engineer, the contractor, and the equipment manufacturer.

The facilities study may include, but not limited to; fault study, stability study, harmonic analysis, minimum protection requirements, and impacts to other customers on the GRE transmission System.

Following receipt of the completed study, the party requesting interconnection will have 15 business days to decide whether to proceed. A decision to proceed may lead to additional studies or directly to the negotiations for an Interconnection Agreement. The interconnecting party confirms their decision to proceed by submitting a letter, or e-mail communication to that effect to GRE's agreement contact.

5. Interconnection Agreement

Upon completion of the various studies, GRE and the interconnecting party shall negotiate an interconnection agreement that identifies the interconnection provisions, including the ownership, operation, SCADA control, maintenance, engineering and design, and financial responsibility provisions of the facilities, and diagram sketch of the new interconnection.

6. Interconnection lead times

GRE requires a minimum of two years advance notice prior to the project in-service date for interconnecting to GRE's Transmission System. This allows GRE time to complete the various studies, execute agreements, obtain project approval, allocate resources, procure project materials, and construct the required transmission facilities for the interconnection. For projects with fewer than two years advance notice, GRE cannot guarantee the interconnecting party will meet its requested in-service date, but GRE will expedite the interconnection process as much as possible.

B. Responsibility and Approval

GRE does not assume responsibility for protection of the applicant's interconnected equipment or of any other applicant equipment. The applicant is solely responsible for protecting its equipment to prevent damage from faults, imbalances, or other disturbances on the GRE System. GRE will not be responsible for damage to the applicant's equipment due to out-of-phase reclosing. Such an event will likely cause damage to the applicant's equipment and must be carefully addressed. Technical aspects addressing protection requirements are expanded in Section VI.

Approval of the proposed interconnection only ensures that GRE has reviewed the interconnection to make certain that the GRE System can be maintained and that other GRE customers are not adversely affected by operation of the interconnecting facilities. GRE will not assume any liability or responsibility for applicant-owned equipment.

C. Financial Obligation Associated with Interconnection to the GRE System

Through appropriate agreement(s), GRE may make provisions to recover costs, including, but not limited to the following expense categories:

- Meter installation, tests, maintenance, parts and related labor
- Meter data management and scheduling
- Telemetry installation, tests, maintenance, parts and related labor
- Operating expenses, including telecommunication circuits

- Study analysis and related expenses
- Securing regional reliability organization or equivalent acceptance
- Modifications to the GRE System and related labor/engineering
- Protective device installation/equipment cost and related labor
- Protective device settings review and coordination.
- Review of design, inspection and testing costs
- Programming costs to incorporate generation and tie-line data into GRE's energy management system
- Land, rights-of-way, licensing, engineering, etc.
- Balancing Authority Area services costs

Any cost responsibilities detailed in the interconnection agreement between GRE and the Customer that conflict with this section will take precedence over these guidelines.

- **Ownership**

GRE will normally own and operate all transmission facilities constructed for the interconnection of a Customer's facilities to the GRE system that are determined to be part of the transmission system. GRE shall own all GRE Interconnection Facilities and System Upgrades that GRE determines that it is appropriate to own. This includes, but is not limited to, revenue meters, relaying, control systems, breakers, switches, bus work, and transmission lines. When a foreign utility interconnects with a GRE owned transmission line, GRE will own and operate the air break switch and motor operators. The galvanized steel deadend structure and any grading structures required will also be owned by GRE. Design of the proposed air break switch installation shall be completed by GRE or an approved consultant that is versed in GRE's design criteria and construction standards. GRE shall provide its transmission line design criteria upon request. GRE may, at its option, contract with the Customer or a third party for construction of any or all of these facilities.

The Customer will normally construct and own, at a minimum, all Customer Interconnection Facilities, unless the parties agree in the interconnection agreement that GRE will construct these facilities. Any responsibilities detailed in the interconnection agreement between GRE and the Customer that conflict with this section will take precedence.

D. Financial Penalties

If operation of the applicant's facility causes GRE to be out of compliance with any applicable rules, regulations, and/or requirements of NERC, MISO, Applicable Regional Entity, or any successor agency assuming or charged with similar responsibilities related to the operation and reliability of the North American electric interconnected transmission grid, and if GRE is assessed a penalty, fee, or charge for such non-compliance, said penalty will be passed through to the applicant.

E. Requests for Transmission Service

The ability to interconnect to the GRE System does not mean the applicant can deliver power over GRE's facilities at all times and to any location. This determination is made under the Regional Transmission Organization tariff through the reservation of transmission service.

F. GRE as a Balancing Authority Area Operator

GRE is the Balancing Authority Area Operator for a large geographic area comprising parts of Minnesota, North Dakota, and Wisconsin. Considering this operating responsibility, some requirements set forth in these guidelines will be applicable to all interconnections made within the GRE Balancing Authority Area and not exclusively for GRE customers. Any operations of interconnected equipment or facilities will fall under the direction of the Balancing Authority Area Operator. MISO is the Balancing Authority (BA) for Great River Energy. If the point of interconnection (POI) for the pending project is in another transmission owner's Local Balancing Authority (LBA), GRE will notify the Transmission Operator (TOP) for the affected LBA of the pending interconnection project during the interconnection study.

The applicant is required to obtain or provide for ancillary services (or portions of such services as required by FERC or NERC) for any electric load served from the interconnected electric grid. The GRE Balancing Authority Area provides ancillary services, including load regulation, load imbalance, load following, voltage control, scheduling, dispatching, as defined in the reliability policies and criteria by NERC, MISO, Applicable Regional Entity, or any successors assuming or charged with similar responsibilities.

III. COMMON INTERCONNECTION REQUIREMENTS AND RESPONSIBILITES

A. Control and Protection

GRE plans its protective relays and control schemes to provide for personnel safety and equipment protection and to minimize disruption of services during disturbances. Interconnections onto the GRE System usually require additions or modifications of GRE's protective relays and/or control schemes. New interconnections must be compatible with GRE's existing protective relay schemes. Sometimes the additions of voltage transformers (VTs), current transformers (CTs), or pilot schemes (transfer trip) are necessary, based on the Point of Interconnection. Exact protective requirements are outlined in Section VI.

B. Dispatching and Maintenance

GRE operates and maintains its system to provide reliable customer service while meeting the seasonal and daily peak loads even during equipment outages and disturbances. Project integration requires that the equipment at the Point of Interconnection not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all GRE customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the Point of Interconnection for acceptable operation of the system.

C. Remedial Action Schemes

Consideration for the use of Remedial Action Schemes (RAS) will be based solely on transmission issues that arise for transmission infrastructure weaknesses that may lead to cascading events, system collapse or large loss of load as defined by MISO. When a situation is identified that will impact the reliability of the transmission grid that involves potential for the above conditions, GRE will analyze installations of RAS as an alternative to transmission infrastructure investment. In order to allow RAS to facilitate such automated facility tripping the following criteria are required:

System operation within applicable reliability criteria

The system must operate within the applicable NERC and Regional Entity reliability criteria at all times. This includes operation prior to, during, and recovery from a system disturbance.

RAS control

The controls used to sense the system conditions of concern and to trip the facility must meet all the criteria and guidelines of a NERC and Regional Entity defined RAS including dual redundancy of all components of the RAS and the ability to stay within all applicable reliability criteria with the failure of a component of the RAS. Testing of the RAS and documentation of the testing is also required.

RAS tripping or runback generation only at one point of interconnection to transmission system

The RAS must not require facilities that interconnect at different locations to be tripped. An Interconnect location is defined as a substation or switching station. The RAS can trip at a substation, but all must interconnect to the transmission system at that location or via communication lines already existing at that substation.

No single event can initiate multiple RAS tripping

If an RAS already exists for the event identified as requiring an RAS to meet NERC compliance, a new RAS cannot be added to trip additional facilities at existing location or another location.

Temporary

GRE will consider a RAS valid for a maximum of 5 years. The use of a RAS should be assumed to be temporary to allow for planned transmission upgrades to be completed. The transmission resolution will need to be placed into the MTEP process and scope and schedule will need to be approved by GRE prior to the installation and granting of the RAS. An extension of the RAS will not occur unless transmission cascading events, system collapse, or large loss of load are an issue. Any cost of extending the RAS will be borne by the requesting party including any cost for documentation requirements to the Reliability Organization, Planning Authority or Reliability Coordinator.

D. Station Service

Power that is provided for local use at a substation to operate lighting, heat and auxiliary equipment is termed station service. Alternate station service is a backup source of power, used only in emergencies or during maintenance when primary station service is not available.

Station service power is the responsibility of the applicant. The station service requirements of the new facilities, including voltage and reactive requirements shall not impose operating restrictions on the GRE System beyond those specified in applicable NERC, MISO, and Applicable Regional Entity reliability standards.

Appropriate provisions for station service and alternate station service will be determined during the interconnection planning process. Generally, the local utility will be the provider of primary station service unless it is unable to serve the load.

The applicant must provide metering for primary station service and alternate station service, as required by service provider, or work out other acceptable arrangements.

E. Inspection, Test, Calibration and Maintenance

The applicant has full responsibility for the inspection, testing, calibration and maintenance of its equipment, up to the Point of Interconnection, consistent with the Interconnection and Operating Agreement. GRE will be responsible for maintenance of the GRE owned equipment associated with the interconnection at and after the point of interconnection.

1. Pre-energization Inspection and Testing

Before initial energization, the applicant shall develop an inspection and test plan for pre-energization and energization testing. GRE will review and approve the test plan prior to the test. Any costs incurred by GRE as a result of the inspection and testing will be passed through to the applicant. The applicant will also be responsible for any additional tests that may be required by GRE but were not specified in the applicant's inspection and test plan. The applicant shall provide GRE with copies of all drawings, specifications, and test records of the interconnection equipment and pertinent to the interconnected operation for GRE's records.

2. Calibration and Maintenance

a. Metering Equipment

Upon installation of, and at applicant's expense, meter owner shall provide adequate information, including notification of the testing date and test reports, to GRE in order for GRE to certify standards are met and measurements are accurate. Thereafter, the meter testing frequency shall, at a minimum, be based on industry accepted practices and guidelines outlined in ANSI C12.1. GRE's present testing practices are based on the type of metering situation and the jointly agreed-to requirements of both parties involved. If requested to do so by applicant, GRE shall inspect equipment or test metering more frequently , at the expense of the applicant.

b. All Other Electrical Equipment

The applicant shall maintain its facilities and equipment, to the extent they might reasonably be expected to have an impact on the operation of the GRE System and GRE's other systems: (1) in a safe and reliable manner; (2) in accordance with good utility practice; (3) in accordance with applicable operational and/or reliability criteria, protocols, and directives, including those of NERC, MISO, Applicable Regional Entity, or any successor agency assuming or charged with similar responsibilities; and (4) in accordance with the provisions of the Interconnection and Operating Agreement and any attachment, appendix or exhibit thereof.

F. Energization of GRE Equipment by the Applicant

No applicant(s), independent of interconnection type or generator size, shall energize a de-energized GRE circuit. The necessary control devices shall be installed by the applicant on the equipment to prevent the energization of a de-energized GRE circuit by the applicant's interconnected facility. Connection may be accomplished only via synchronization with the GRE System. All interconnecting circuit breakers/devices that tie another source to GRE will require synchro-check relaying. Authorization to energize a circuit may only be provided by the Local Balancing Authority Operator.

IV. SUBSTATION GROUNDING

Each interconnecting substation must have a ground grid that solidly grounds all metallic structures and other metallic equipment. This grid shall limit the ground potential gradients to such voltage and current levels that will not endanger the safety of people or damage equipment which are in, or immediately adjacent to, the station under normal and fault conditions. The size, type and ground grid requirements are in part based on local soil conditions and available electrical fault current magnitudes. In areas where ground grid voltage rises are not within acceptable and safe limits (due for example to high soil resistivity or limited substation space), grounding rods and wells can be used to reduce the ground grid resistance to acceptable levels.

If the Substation Site is close to another substation, the two ground grids may be isolated or connected. If the ground grids are to be isolated, it is suggested that metallic ground connections between the two substation ground grids be separated by at least 10 feet. Cable shields, cable sheaths, station service ground sheaths, and overhead transmission shield wires can all inadvertently connect ground grids. Fiber-optic cables are the preferred option for telecommunications and control between two substations to maintain isolated ground grids. If the ground grids are to be interconnected, the interconnecting cables must have sufficient capacity to handle fault currents and control ground grid voltage rises. GRE must approve any connection to a GRE substation ground grid.

The interconnection of lines and/or generation may substantially increase fault current levels at nearby substations. Modifications to the ground grids of existing substations may be necessary to keep grid voltage rises within safe levels. The Interconnection Study will determine if modifications are required and the estimated cost.

The Reference section of this document supplies a list of ANSI/IEEE technical resources for grounding.

V. INTERCONNECTION FACILITY OPERATING LIMITS

Operating criteria have been defined for applicant facilities interconnecting with the GRE System in order to minimize the impact that adverse operating conditions could have on the electric service provided to other customers on the GRE System. The interconnection technical requirements are outlined in this section and where applicable, requirements specific to size and/or type of interconnection are noted.

A. Voltage

The applicant's equipment shall not cause excessive voltage excursions. The applicant shall provide an automatic means of disconnecting its equipment from the GRE System within three seconds if the steady state voltage cannot be maintained within the required tolerance.

Portions of GRE’s system at 12.5 kV and below are voltage regulated. When the interconnection is with a portion of the GRE delivery system that is regulated, then the applicant shall be capable of tolerating steady-state voltage fluctuations of ± 5 percent of the nominal voltage level.

Transmission doesn’t include a provision for voltage regulation. For interconnections to the transmission system, voltage levels ± 10 percent from nominal can be expected. If the applicant’s equipment cannot operate within the above range, the applicant may need to provide regulation equipment to limit voltage level excursions. GRE will approve the proposed type of regulation equipment. GRE follows the NERC standard for Facility Ratings (FAC-008).

If the design of the applicant’s facility is such that islanded conditions are possible, appropriate zero sequence sources must also be provided. The usual customer voltage concern refers to line-line values, but generation installed on distribution lines must also control the line-ground voltage during an islanded condition.

Consistent with the Applicable Regional Entity’s system performance criteria and technical study guidelines, the GRE System is designed to avoid experiencing dynamic voltage dips below .70 pu due to external faults or other disturbance initiators. The applicant should allow sufficient dead band in its voltage regulation equipment control to avoid reacting to dynamic voltage dips.

B. Flicker

Voltage fluctuations may be noticeable as visual lighting variations (flicker) and can damage or disrupt the operation of electronic equipment. The flicker limits defined below are applicable to all interconnections made to the GRE System. In the case where the applicant owns a dedicated line so that GRE’s other customers will be protected, a waiver may be permitted.

Applicants are not allowed to produce flicker to adjacent customers that exceeds the GRE guideline shown below (Figure 1). The applicant will be responsible and liable for corrections if the interconnecting facility is the cause of objectionable flicker levels.

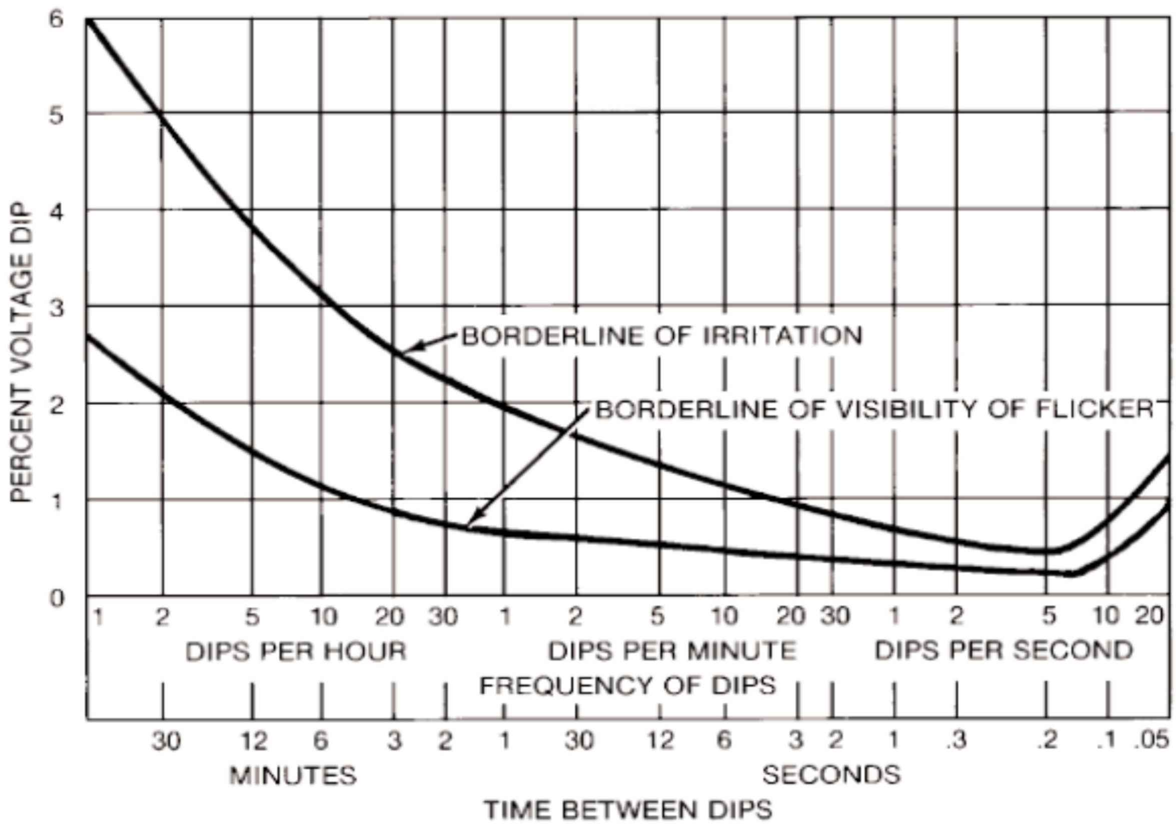

Figure 1. GRE Voltage Flicker Guideline

C. Harmonics

Harmonics can cause telecommunication interference, increase thermal heating in transformers, disable solid state equipment and create resonant overvoltages. In order to protect equipment from damage, harmonics must be managed and mitigated. The applicant's interconnecting equipment shall not introduce excessive distortion to the GRE System’s voltage and current waveforms per IEEE 519.

The harmonic distortion is defined as the ratio of the root mean square (rms) value of the harmonic to the rms value of the fundamental voltage or current. The harmonic distortion measurements shall be made at the point of interconnection between the applicant and the GRE System and shall be within the limits specified in the tables below. GRE advises the applicant to account for harmonics during the early planning and design stages. Refer to Tables 1 and 2 for voltage distortion limits.

Table 1. Voltage Distortion Limits

Bus Voltage At PCC	Individual Voltage Distortion IHD %	Total Voltage Distortion THD %
Below 69 kV	3.0	5.0
69 kV to 115 kV	1.5	2.5

115 kV and above	1.0	1.5
Source: IEEE 519, Table 1		

Table 2. Current Distortion Limits For Non-Linear Loads At The Point Of Common Coupling (PCC) From 120 To 69,000 Volts

Maximum Harmonic Current Distribution in % of Fundamental Harmonic Order (Odd Harmonics)						
I(sc)/I(l)	**<11**	**11<h<17**	**17<h<23**	**23<h<35**	**35<h**	**THD**
20	4.0	2.0	1.5	0.6	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
1000	15.0	7.0	6.0	2.5	1.4	20.0
Where: I(sc) = Maximum short circuit current at PCC I(l) = Maximum load current (fundamental frequency) at PCC PCC = Point of Common Coupling between applicant and utility Generation equipment is subject to the lowest I(sc)/I(l) values Even harmonics are limited to 25% of odd harmonic limits given above *Source: IEEE 519, Table 2*						

A special study will be required for situations when the fault to load ratio is less than 10.
Lower order harmonics, particularly the third and ninth harmonics, will often be of more concern to the owner of generator. These are often related to generator grounding, and to the type of transformer connections that may be involved. It is to the applicant's advantage to work these problems out early enough so that applicant and GRE equipment can be acquired to achieve proper control.

D. Fault Current

The combined available fault current of the GRE System and the applicant's facilities must not overstress GRE equipment. The applicant shall provide any necessary provisions to satisfy this requirement.

If the installation of applicant-owned equipment causes fault current limits to be exceeded, the applicant must install equipment to limit the fault current on the GRE delivery system or compensate GRE for the additional costs of installing equipment that will safely operate within the available fault current. The exact value of available fault depends upon location and circuit configuration and will be determined in the interconnection studies. The applicant must work closely with GRE at the time of interconnection design to determine the available fault current at the specific location of interconnection.

E. Minimum Power Factor Requirements

Substation - Specific Power Factor Requirements

The interconnecting entity will generally be expected to provide for its own as well as its customers' reactive power requirements.

Points of Interconnection (POI), transformer additions, and planned transformer capacity upgrades are expected to provide sufficient reactive power (leading or lagging) such that the power factor (PF) is between 98% lagging or leading at the POI when POI load is greater than 85% of maximum load. POI, transformer additions, and planned transformer capacity upgrades are expected have a PF that is not leading when the load is less than 50% of maximum load. As practical, the interconnecting entity will maintain a power factor between 98% lagging or leading at the POI when the load is between 50-85% of maximum. With mutual agreement of all affected parties, reactive power support may be considered for installation at an adjacent substation provided that the substation is in electrically close proximity. (An example is when a nearby substation has adequate support for the whole circuit.)

The interconnected entity is responsible for keeping their equipment in good working order so that PF requirements are always met.

If during normal operation (system intact or under transmission contingency conditions) the voltage in a portion of the transmission system deviates from the range described in Section V. Part A, GRE will survey the interconnected substations which, in its opinion, may contribute to the voltage concern and require the interconnected entity to demonstrate, either by transmission-side metering or low-side metering corrected for transformer reactive power consumption, that the interconnected entity meets the intended level of PF correction. Compliance in meeting the PF requirement will reasonably exclude time periods of the interconnected entity's emergency conditions, during the interconnected entity's switching operations, and periods when transformer loading and required PF correction would result in transformer resonance conditions. Any unacceptable deviations are to be corrected in a timely manner.

Some portions of the GRE power system are in or adjacent to areas where power suppliers utilize "ripple" load management systems. These systems employ an on/off keyed carrier signal (typically in the range of 150-400 Hz) injected into the power systems to address site load management devices. Installation of shunt capacitor banks, as may be required for power factor correction of induction machines, or for providing capacitive output capability, may cause degradation of the ripple signal strength due to shunting to ground of the ripple signal through the capacitor bank(s). To prevent such degradation, appropriate tuned blocking filters may be required.

Transmission Facilities

Each party recognizes and agrees that it has a responsibility for maintaining voltage and VAR support at POI in accordance with applicable Midwest ISO protocols and policies. GRE is responsible for maintaining transmission system voltage and VAR flows on its system. Transmission facility owners are responsible for controlling Transmission System voltage and VAR flows on their respective systems. Each party shall use a combination of static and dynamic reactive sources at various locations to address reactive power supply issues. Each party shall operate its system in such manner that the voltage levels on the system are maintained at reliable levels.

F. Frequency During Disturbances

Power system disturbances initiated by system events such as faults and forced equipment outages expose the system to oscillations in voltage and frequency. It is important that generators and lines remain in service for dynamic (transient) oscillations that are stable and damped.

To avoid large-scale blackouts that can result from excessive generation loss, major transmission loss, or load loss during a disturbance, underfrequency load shedding has been implemented by the Applicable Regional Entity. When system frequency declines, loads are automatically interrupted in steps occurring at 59.3, 59.0, and 58.7 Hz, respectively. Load shedding attempts to stabilize the system by balancing the generation and load.

VI. PROTECTION REQUIREMENTS FOR ALL INTERCONNECTIONS

An important objective in the interconnection of facilities to GRE's system is minimizing the potential hazard to life and property. A primary safety requirement is the ability to disconnect immediately when a fault is detected. The protection equipment for an interconnected facility must protect against faults within that facility and faults on the GRE System. No new facility on the GRE System should degrade the existing GRE protection and control schemes or lower the levels of safety and reliability to other customers.

GRE's minimum protection requirements are designed and intended to protect GRE's System only. As a rule, neither party should depend on the other for the protection of its own equipment. GRE shall assume no liability for damage to applicant-owned facilities resulting from mis-coordination between the applicant's protective device(s) and GRE's protective devices. It is the applicant's responsibility to protect its own system and equipment.

Several factors may determine what protective devices are required on the applicant's interconnection. The following three major factors generally determine the type of protective devices required at the Point of Interconnection:

- The type and size of the applicant's interconnecting equipment
- The location of the applicant on the GRE System
- The manner in which the installation will operate (one-way vs. bidirectional power flow)

The addition of the applicant's facility may also require modifying the GRE System or other interconnected facilities. This determination will be made by GRE during the preliminary portion of the interconnection study process. Each interconnection request will be handled individually and GRE will solely determine the protective devices, system modifications, and/or additions required. GRE will work with the applicant to achieve an installation that meets the requirements of both the applicant and GRE. The applicant shall bear all costs for protective devices and GRE System modifications required to permit the operation of the parallel interconnection.

GRE shall operate all GRE-owned protective equipment at the interconnection to ensure that the protection and control requirements and objectives are met. During interconnection studies, GRE will approve the proposed type of interconnection protective devices, ownership, operating details and equipment settings. GRE follows the North American Electric Reliability Corporation (NERC) standard for System Protection Coordination (PRC-027). **Do not confuse interconnection protection in this section**

with applicant-provided facility protection. GRE is not liable or responsible for protection of the applicant's facilities.

A. Disconnect Switches/Device

A disconnect device should be installed to isolate the GRE System from the applicant's facility. This device must have load break capability or means must be provided to trip off the source or load before operating the disconnect. During normal switching GRE would coordinate with the applicant facility to verify all sources are offline prior to operating the disconnect switch. In an emergency situation we would de-energize the sources by either opening the transmission line breaker(s) or a transmission line load break switch. This disconnect shall open all the poles except the neutral and shall provide a visible air gap to establish required clearances for maintenance and repair work of the GRE System. GRE may require the design to allow the application of safety grounds on the GRE side of the disconnect (or breaker). OSHA lockout/tag requirements must be followed.

The disconnect (or breaker) must be accessible at all times to GRE personnel. Disconnects should allow for padlocking in the open position with standard GRE padlock. The applicant shall not remove any padlocks or GRE safety tags. The disconnect (or breaker) should be located outside of the building if possible. If not possible, applicant must provide access to disconnect (or breaker) at all times (24-hour day phone number, guard desk, etc.) The disconnecting equipment must be clearly labeled. The disconnecting equipment shall be National Electrical Manufacturers Association (NEMA) approved for the specific application and location.

B. Protective Relay Requirements

Protective relays are required to promptly sense abnormal operating or fault conditions and initiate the isolation of the faulted area. Protective relays can generally be categorized into two major groups: industrial grade and utility grade. Utility grade relays have a higher degree of reliability and accuracy and are required. Protective relay settings on interconnect breakpoints must be approved by GRE. GRE follows the North American Electric Reliability Corporation (NERC) standard for System Protection Coordination (PRC-027).

GRE requires line-protective equipment to either 1) automatically clear a fault and restore power, or 2) rapidly isolate only the faulted section so that the minimum number of customers is affected by any outage. Fault-interrupting equipment should usually be located at the point of interconnection to GRE or as close to the interconnection point as practicable. High-speed fault clearing may be required to minimize equipment damage and potential impact to system stability. The need for high speed fault clearing shall be determined on a case-by-case basis by GRE.

The applicant shall install only GRE approved relays on the part of their system that can impact the operation of the GRE System. These relays must, at a minimum, meet IEEE Standards C37.90, C37.90.1, and C37.90.2. Applicants shall submit complete control and relaying documentation that pertains to protection of the GRE System. GRE may suggest or comment on other areas; however, the applicant is responsible for the design of protection schemes protecting applicant facilities.

Table 3 provides protective device recommendations necessary to protect GRE equipment and its customers' equipment against electrical faults (short circuits), degraded voltage or frequency operation, unwanted power flow and inadvertent out of phase closing of breaker/switches. Some protective devices may or may not be required for applicants as determined by GRE on a case-by-case basis. Most line relaying depends on the existing system configuration, the existing protection, and line characteristics such as impedance, voltage, ampacity and available fault duty, at the location in question. All necessary protective requirements will be identified during the interconnection study process.

Table 3. Basic Line Protection Devices (Protection must be redundant at 34.5 kV and above for all applications. For lower voltage systems redundancy is only required for some specific areas of the system. Pilot relaying is required at 115kV and above for all applications.)

Protection Device	**Device Number**	**Less than 34.5 kV**	**34.5 kV to 69kV**	**115 kV and above**	
Phase Overcurrent (Radial systems)	50/51	X			
Ground Overcurrent (Radial systems)	50/51N	X			
Phase Directional Overcurrent	67	X[1]			
Ground Directional Overcurrent or Transformer Neutral	67N 50/51N	X[1]	X	X	
Phase and Ground Distance Relay Underreaching Zone 1	21Z1		X	X	
Phase and Ground Distance Relay Overreaching Zone 2	21Z2		X	X	
Directional Comparison Blocking (DCB)	21Z3C			X	
Line Current Differential	87L			X	
Directional Comparison Unblocking (DCUB)	21/67T			X	
Permissive Overreaching Transfer Trip (POTT) or Hybrid	21/67T			X	
Power Fail Trip[3]	27		X[1]	X	
Direct Transfer Trip	TT		X[2]	X	

1 May be required depending on local circuit configurations.
2 Transfer trip may be required on interconnections depending on GRE circuit configuration and loading, as determined by GRE.
3 Power failure tripping may be required on load tie-line interconnections to facilitate restoration of customer load after a transmission line or area outage.

C. Reliability and Redundancy

The failure to trip during fault or abnormal system conditions due to relay or breaker hardware problems, or from incorrect relay settings, improper control wiring, etc. is always a possibility. The protection system must be designed with enough redundancy that failure of any one component still allows the facility to be isolated from the GRE System under a fault condition. GRE may suggest or require back-up protection. If the facility's breaker does not trip, the incoming breaker should trip after a predetermined time delay. Similarly, if the incoming breaker fails to trip, the facility's breaker should trip. Where there is no incoming breaker, the GRE tie breaker may be tripped.

D. Line Protection

Applicant's line-protection and/or facility relays must coordinate with the protective relays at the GRE interconnected substation for the line on which the applicant's facility is connected. The typical protective zone is a two-terminal line section with a breaker on each end. In the simplest case of a load on a radial line, current can flow in one direction only, so protective relays need to be coordinated in one direction and do not need directional elements. However, on the typical transmission system, where current may flow in either direction depending on system conditions, relays must be directional. In addition, the complexity and the required number of protective devices increase dramatically with increases in the number of terminals in each protective zone. Because of this complexity, GRE does not permit lines with greater than three terminals.

In coordinating a multi-terminal scheme, GRE may sometimes require installation of transmission line protective devices at the applicant's substation site. This is commonly the case whenever three-terminal communication assisted trip schemes are employed to protect the line. Because this type of line relay participates in a scheme to protect the GRE System, GRE must ensure the maintenance, testing and reliability of this particular type of relay. Existing relay schemes may have to be reset, replaced, or augmented with additional relays at the applicant's expense, to coordinate with the applicant's facility.

If transfer trip protection is required by GRE, the applicant shall provide and maintain at its expense, a communications circuit, and must have an end to end signal relay of no more than 8 milliseconds. This circuit may be power line carrier or fiber optic cable. In rare cases a communication line from the telephone company or microwave communication circuits may be acceptable. The line must have high-voltage protection equipment on the entrance cable so the transfer trip equipment will operate properly during fault conditions.

The addition of any new interconnected facility to the GRE System must not degrade the existing protection and control schemes or cause existing GRE customers to suffer lower levels of safety and/or reliability.

Table 3 lists the minimum protection that GRE typically requires. Higher voltage interconnections require additional protection due to the greater potential for adverse impact to system stability and the greater number of customers who would be affected. Special cases such as distribution-level network interconnections, if acceptable, may have additional requirements. The acceptability and additional requirements of these interconnection proposals shall be determined by GRE on a case-by-case basis.

E. Fault-Interrupting Devices

The fault-interrupting device selected by the applicant must be reviewed and approved by GRE for each particular application.

There are three basic types of fault-interrupting devices:

- Circuit breakers
- Circuit switchers
- Fuses

GRE will determine the type of fault-interrupting device required for a facility based on the available fault duty, the local circuit configuration, the size and type of generation, and the existing GRE protection equipment.

1. Circuit Breakers

Ownership of the intertie circuit breaker will be determined during the interconnection study. However, GRE will have the operational authority to operate all intertie circuit breakers at all substation or tie-line interconnections installations. Upgrading existing circuit breakers within or outside the area of the interconnection may be required due to the increased fault current levels. If this system modification is necessary, it may be at the applicant's expense.

A three-phase circuit breaker at the point of interconnection automatically separates the applicant's facility from the GRE System upon detection of a circuit fault. Additional breakers and protective relays may be installed in the applicant's facility for ease in operating and protecting the facility, but they are not required for the purpose of interconnection. The interconnection breaker must have sufficient capacity to interrupt maximum available fault current at its location and be equipped with accessories to:

- Trip the breaker with an external trip signal supplied through a battery (shunt trip)
- Telemeter the breaker status when it is required
- Lockout if operated by protective relays required for interconnection

Generally, a three-phase circuit breaker is the required fault-interruption device at the point of interconnection, due to its simultaneous three-phase operation and ability to coordinate with GRE line-side devices.

2. Circuit Switchers

A circuit switcher is a three-phase fault-interrupter with limited fault interrupting capability. These devices have typically been used at voltages of 115 kV and below and may substitute for circuit breakers when the fault duty is within the interrupting rating of the circuit switcher. Since circuit switchers do not have integral current transformers, they must be installed within 30 feet of the associated current transformers to minimize the length of the unprotected line/bus section.

3. Fuses

Fuses are single-phase, direct-acting sacrificial links that melt to interrupt fault current and protect the equipment. Blown fuses need to be replaced manually after each fault before the facility can return to service. Overhead primary fuses shall be replaced by trained, qualified personnel. Because fuses are single-phase devices, all of them may not melt during a fault and therefore would not automatically separate the interconnected facility from GRE. Large primary fuses which do not coordinate with the GRE substation protective relays could cause all the customers on the circuit to lose power due to a fault inside the applicant's interconnected facility and therefore will not be allowed.

For load-only facilities, GRE may approve the use of fuses if they coordinate with the GRE line-side devices for both phase and ground faults. In these cases GRE requires time current curves. In limited cases, fuses may be used as a primary protective device (e.g. rural, 69 kV and 115 kV lines, generally when the applicant's substation is 10 MW or less). However, if fuses are approved by GRE, the applicant should consider installing a negative sequence relay and/or other devices to alarm for single-phase conditions.

F. Single-Phase Devices - Fuses/Oil Circuit Reclosers

It may be necessary to replace GRE-owned single-phase devices (line fuses, single-phase automatic circuit reclosers) with three-phase devices when they are installed between the GRE source substation with breakers and the applicant substation or tie-line. This is to minimize the possibility of single-phasing an applicant's three-phase load or tie. Single-phase sectionalizing equipment may be installed on the main circuit past the applicant location, or on radial circuits that tap the main circuit between the source substation and the applicant location.

Because the applicant is responsible for protecting its equipment from the effects of excessive negative sequence currents, the applicant must know if there are single-phase devices located between its facility and the GRE source substation.

G. Automatic Reclosing/Voltage Check Schemes

GRE normally applies automatic reclosing to all transmission lines. Prior to automatic reclosing, the applicant must ensure that the applicant's facility is disconnected from GRE. It may be necessary to install voltage check schemes at various locations on the GRE System to prevent automatic reclosing in the event that an applicant's facility remains connected to an isolated, unfaulted section of the GRE System. These voltage check schemes may be located at the interconnection point, at automatic circuit reclosers on the line feeding the applicant, or on an GRE source substation feeder breaker. These schemes may also be required on alternate circuits that may be used to feed the applicant. Details of any modifications to GRE reclosing practices and/or addition of voltage check schemes will be determined during the interconnection study process.

GRE shall assume no responsibility for damage to applicant's equipment due to out-of-phase reclosing.

In general, reclosing practices should be as follows:

- There should be no automatic reclosing for the incoming breaker.
- The GRE substation breaker may have one or more timed reclosures, with the first set at a minimum of 2 to 15 seconds at 69 kV and below. It is expected that either the generator or the tie breaker will open before reclosing takes place. Reclosing times may be faster above 69 kV.
- Where islanding is possible, the GRE substation breaker may need the function of voltage supervision from the tie-line.

H. Insulation Coordination

Power system equipment is designed to withstand voltage stresses associated with expected operation. Adding or connecting new facilities can change equipment duty, and may require that equipment be replaced or switchgear, telecommunications, shielding, grounding and/or surge protection added to control voltage stress to acceptable levels. Interconnection studies may identify additional requirements to maintain an acceptable level of GRE System availability, reliability, equipment insulation margins, and safety.

Voltage stresses, such as lightning or switching surges, and temporary overvoltages may affect equipment function. Remedies depend on the equipment capability and the type and magnitude of the stress. In general, stations with equipment operated at 15 kV and above, as well as all transformers and reactors, shall be protected against lightning and switching surges. Typically, this includes station shielding against direct lightning strokes, surge arresters on all wound devices, and shielding with surge arresters on the incoming lines. The following requirements may be necessary to meet the intent of GRE's Reliability Criteria.

1. Surge Protection

The interconnection shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE/ANSI C62.41 and IEEE C37.90.1.

GRE highly recommends the applicant to install surge arresters for protection of transformers and other vulnerable equipment. Arresters shall be mounted in such a manner as to protect any of GRE's facilities from surge voltages. In general, all GRE incoming lines, and lines electrically connected to GRE shall be protected with surge arresters located on the line side of the disconnect switch. GRE staff will recommend the appropriate level of entrance protection as well as other specifications for surge arresters during the interconnection process.

2. Lightning Surges

If the applicant proposes to tap a shielded transmission line, the tap line to the substation must also be shielded. For an unshielded transmission line, the tap line does not typically require shielding beyond that needed for substation entrance. However, special circumstances such as the length of the tap line may affect shielding requirements.

Lines at voltages of 69 kV and higher that terminate at GRE substations must meet additional shielding and/or surge protection requirements. Incoming lines must be shielded for ½ mile at 69-161 kV and 1 mile at 230 kV and higher. Arrestors must also be installed at the station entrance. For certain customer service substations at 230 kV and below, GRE may require only an arrester at the station entrance in lieu of line shielding, or a reduced shielded zone adjacent to the station. These variations depend on the tap line length, the presence of a power circuit breaker on the transmission side of the transformer, and the size of the transformer. Such exceptions can be discussed with your GRE representative.

3. Temporary Overvoltages

Temporary overvoltages can last from seconds to minutes, and are not characterized as surges. These overvoltages are present during islanding, faults, loss of load, or long-line situations. All new and existing equipment must be capable of withstanding these duties.

a. Islanding

A 'local island' condition can expose equipment to higher-than-normal voltages. Special relays to detect this condition and isolate local generation from GRE facilities may be required.

b. Neutral Shifts

When generation or a source of 'back-feed' is connected to the low-voltage side of a delta-grounded wye customer service transformer, remote end breaker operations initiated by the detection of faults on the high-voltage side can cause overvoltages that can affect personnel safety and damage equipment. This type of overvoltage is commonly described as a neutral shift and can increase the voltage on the unfaulted phases to as high as 1.73 per unit. At this voltage, the equipment insulation withstand-duration can be very short. Several alternative remedies are possible.

- Provide an effectively grounded system on the high-voltage side of the transformer that is independent of other transmission system connections.
- Size the high-voltage-side equipment to withstand the amplitude and duration of the neutral shift.
- Rapidly separate the back-feed source from the step-up transformer by tripping a breaker using either remote relay detection with pilot scheme (transfer trip) or local relay detection of overvoltage condition.

Effectively grounded is defined as an $X_0/X_1 \leq 3$ and $R_0/X_1 \leq 1$. Methods available to obtain an effective ground on the high-voltage side of the transformer include the following:

- A transformer with the transmission voltage (GRE's) side connected in a grounded-wye configuration and low voltage (Connection Point) side in closed delta
- A three-winding transformer with a closed-delta tertiary winding. Both the transmission and distribution side windings are connected in grounded wye
- Installation of a grounding transformer on the transmission voltage (GRE's) side

Any of these result in an effectively grounded system with little risk of damage to surge arresters and other connected equipment.

I. Maintenance of Applicant-Owned Interconnection Protective Devices

Interconnection protective devices owned by the applicant (as determined by the interconnection study process) should be maintained and inspected according to manufacturer recommendations and/or industry standards. Procedures must be established for visual and operational inspections. Additionally, provisions should be established for equipment maintenance and testing. Equipment should include, but not be limited to:

- Circuit breakers
- Protective relays
- Station batteries
- PTs, CT’s, fuses, switches, SCADA equipment
- Metering

NERC requires that all Bulk Electric System (BES) transmission/substation facilities shall have a documented maintenance and testing plan. Applicant shall establish and perform this plan per current NERC requirements. GRE maintains the right to review maintenance, calibration and operation data of all protective equipment for the purpose of protecting GRE facilities and other GRE customers. The applicant is responsible for providing the necessary test accessories (such as relay test plugs, instruction manuals, wiring diagrams, etc.) required to allow GRE to test these protective devices. Verification may include the tripping of the intertie breaker.

If GRE performs work on the applicant's premises, an inspection of the work area may be made by GRE operating personnel. If hazardous working conditions are detected, the applicant will be required to correct the unsafe conditions before GRE will perform the work.

J. Communication Circuit

GRE may require that a communication circuit and associated communication equipment be installed as part of the protective scheme. This circuit may consist of power line carrier, leased telephone line, pilot wire circuit, fiber optic cable, radio, or other means. The communication circuit is required in cases where it is necessary to remotely send a signal to remove the applicant's facility from the GRE System due to a fault or other abnormal conditions that cannot be sensed by the protective devices at the applicant's location. Some instances may require installation of communication equipment in GRE substations to initiate the protective signals. GRE shall be reimbursed by the applicant for the cost of this equipment and its installation.

Another communication circuit may be needed for monitoring and control purposes. Telemetry requirements are defined in Section III.H. Specific communication circuit requirements will be determined during the interconnection study process. The cost of installation and additional monthly fees for this circuit will be the responsibility of the applicant.

VII. METERING AND SCADA/TELEMETERING REQUIREMENTS

A. Metering

- Metering equipment (CTs, PTs, Meter, etc.) shall adhere to ANSI standards C12.1 and IEEE standard C57.13.

- Minimum instrument transformer accuracy per GRE requirements:
  - Current transformers (all ratios): High accuracy, extended range class 0.15B1.8
  - Potential transformers (all ratios); High accuracy class 0.3Y
  - Previously, the GRE standard for current transformers was an accuracy of 0.3. These existing connections will be allowed (grandfathered) within GRE's system as they currently exist. As these instrument transformers are upgraded, they will need to conform to the current guideline.

- Instrument transformer test reports shall be provided to GRE. A DC power source with a minimum of 8 hours of backup capability will be provided by the interconnection customer to the meter for continuous energization of the meter electronics.

- Metering for revenue billing should have the following requirements: MV90 compatible device, minimum 15-minute stored interval data for KWh and KVarh both delivered and received quantities; and sufficient memory for at least 45 days of data. GRE requires an internet protocol connection to the revenue meter. GRE does not allow a communication connection to our device. Alternate data sharing arrangements will be made.

- Metering instrument transformers shall be dedicated for metering purposes only. Connecting other equipment to the CT and PT metering circuits and GRE owned meter is not permitted.

- It is desirable to install the meter at the point of interconnection. If this cannot be accomplished, loss compensation will be incorporated into the billing meter.

- If a generator is added in addition to the load serving interconnection, the metering must be designed such that load can be identified separately from the net generator output. Such net output is the kWh output of the generator less the generation station auxiliary load. See TDOG 202.

B. Telemetry

The requirements for telemetry are based on the need of the System Control Center to protect all users of the transmission and distribution system from unacceptable disturbances. The need for requiring telemetry may include the ability to monitor the following conditions:

- Detecting facility back feed onto otherwise de-energized lines
- Providing information necessary for reliable operation of GRE equipment (feeders, substation, etc.) during normal and emergency operation
- Providing information necessary for the reliable dispatch of generation

- Hourly frozen accumulators for MWh delivered and MWh received. The hourly freeze signal must emanate from a single source; typically an Energy Management System (EMS) or substation RTU with GPS time synchronization.

Telemetry is required by GRE when:

- There is the potential for back feeding onto the GRE System or islanding a portion of GRE's System
- The facility plans to provide its own ancillary services
- There is intent to sell power and energy over GRE facilities
- The facility is required to meet the manual or automatic load shed requirement
- Substations classified at 34.5 kV and above that are equipped with circuit breakers or circuit switchers, and for all substations classified at 115 kV and above
- FERC requires telemetering for normally open or emergency tie connections

If "islanding" is a possibility, it will be identified during the interconnection study process. In such instances, the following telemetry may be required:

- Voltage representative of the GRE service to the facility
- Status (open/close) of facility and interconnection breaker(s)
- Position of incoming and tie breakers or switches
- Applicant load from GRE service (kW and kVAr)

When telemetry is required, the applicant must provide the communications medium to GRE. High capacity interconnections may require redundant metering and telemetering.

C. Supervisory Control and Data Acquisition (SCADA)

Real Time Data Required

Data Requested	Data Type	Periodicity	Data Format
Real-time status points for substation equipment (circuit breaker, switch, etc.)	Status – Open, Closed, Between	By Exception (10 minute integrity scan)	ICCP/RTU
Real-time MW measurements (lines, transformers, etc.)	MW	2-24 seconds	ICCP/RTU
Real-time MVAR measurements (lines, transformers, capacitors, reactors, etc.)	MVAR	2-14 seconds	ICCP/RTU
Voltage measurements (busses, lines)	kV	2-14 seconds	ICCP/RTU
Load Tap Changing (LTC) tap position for transformers	Transformer Tap Setting	2-24 seconds	ICCP/RTU

VIII. OPERATING GUIDELINES

The applicant shall operate its equipment within the guidelines of this document and any special requirements set forth by executed agreements. GRE will operate all GRE-owned equipment (e.g. transmission switch) unless there is another agreement between GRE and the local balancing authority operator. Where there is conflict or inconsistency with the terms of the agreement(s) and this document, the terms in the agreement(s) shall apply.

GRE reserves the right to open the intertie circuit breaker or disconnect device for any of the following reasons:

- GRE is performing hot line maintenance work on the GRE System
- GRE System emergency
- Inspection of the applicant's equipment and protective equipment reveals a hazardous condition
- Failure of the applicant to provide maintenance and testing reports when required
- The applicant's equipment interferes with other customers or with the operation of the GRE system
- The applicant has modified the equipment or protective devices without the knowledge or approval of GRE
- Operation, by applicant, of any unapproved interconnected equipment
- Personnel safety is threatened
- Failure of the applicant to comply with applicable OSHA safety tagging and lockout requirements as well as MISO, Applicable Regional Entity, and GRE switching guides and safety standards or any successor agency assuming or charged with similar responsibilities

The interconnection customer shall supply GRE with contacts for emergency and normal operations, including 24-hour x 7 day a week contact information. Contact the Great River Energy Operations Control Center at (763-241-2340) for the following conditions:

1. Telemetry Failure
   When telemetering is inoperative, the interconnection customer shall report hourly the capacity delivered each hour and the energy delivered each day to the Transmission Operator's control center.

2. Interconnecting to and separating from the transmission system
   The interconnection customer will notify the Transmission Operator's control center prior to interconnecting or separating from the transmission system. For unexpected separations from the transmission system the interconnection customer will inform the Transmission Operator's control center of the nature of the problem (i.e. overvoltage, underfrequency, ground fault, etc.) and report on relay target operations.

3. Clearances and Switching Requests
   These requests will be handled through the Transmission Operator's control center. The facility shall have an approved disconnect for operation by the Transmission Operator's personnel as a clearance point.

4. Unusual or Emergency Conditions
   Unusual operating conditions or other factors that may affect the capability or the reliability of the interconnection customer's generation must be reported to the Transmission Operator's control center as soon as possible. Conditions imperiling life or property shall be reported to the Transmission Operator's control center immediately. The Transmission

Operator’s control center shall be notified of any “forced outage” and the Transmission Operator’s control center will notify the interconnection customer of any unusual transmission conditions that may affect the interconnection customer’s generation.

The failure of GRE to open the intertie circuit breaker or disconnect device shall not serve to relieve the applicant of any liability for impacts of non-metered power, injury, death or damage attributable to the negligence of the applicant.

Changes to the GRE System, or the addition of other customers with generation in the vicinity, may require modifications to the interconnection protective devices. If such changes are required, the applicant may be subject to future charges for these modifications.

IX. GLOSSARY

Alternating Current (AC): That form of electric current that alternates or changes in magnitude and polarity (direction) in what is normally a regular pattern for a given time period called frequency.

Ampere (AMP): The unit of current flow of electricity. One ampere flow of current is equal to one coulomb per second flow.

Apparent Power: For single phase, the current in amperes multiplied by the volts equals the apparent power in volt-amperes. This term is used for alternating current circuits because the current flow is not always in phase with the voltage; hence, amperes multiplied by volts does not necessarily give the true power or watts. Apparent power for three-phase equals the phase to neutral volts multiplied by ampere multiplied by three.

Applicable Regional Entity: The reliability region of NERC, or its successor, in which the facility is located.

Automatic: Self-acting, operated by its own mechanism when actuated by some impersonal influence as, for example, a change in current strength; not manual; without personal intervention.

Automatic Reclosing: A circuit breaker has automatic reclosing when means are provided for closing without manual intervention after it has tripped under abnormal conditions.

Automatic Tripping (Automatic Opening; Automatic Disconnecting): The opening of a circuit breaker under predetermined conditions without the intervention of an operator.

Balanced Load: An equal distribution of current on all phases of an AC circuit.

Balancing Authority: The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Balancing Authority Area: The collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load resource balance within this area.
Balancing Authority Area Load: A balancing authority area load is the entire demand for energy within a specified **Balancing Authority Area**.

Capacity: The number of amperes of electric current a wire will carry without becoming unduly heated; the capacity of a machine, apparatus or device, is the maximum of which it is capable under existing service conditions; the load for which a transformer, transmission circuit, apparatus, station or system is rated; for a generator, turbine, the URGE rating.

Circuit: A conducting path through which an electric current is intended to flow.

Circuit Breaker: A device for interrupting a circuit between separable contacts under normal or fault conditions.

Closed Continuously Parallel Transition: In this scheme, an applicant's source of power is supplied from the utility grid and from the local generation source. The applicant's load is not interrupted if the local generation source is not available.
Closed Momentary Parallel Transition: In this scheme, an applicant's source of power is transferred from Source 1 to Source 2 and vice-versa by momentarily connecting the two sources together. The applicant's load is not interrupted during the transfer process.

Cogeneration: The concurrent production of electricity and heat, steam or useful work from the same fuel source.

Current: A flow of electric charge measured in amperes.

Current Transformer (CT): A transformer intended for metering, protective or control purposes, which is designed to have its primary winding connected in series with a circuit carrying the current to be measured or controlled. A current transformer normally steps down current values to safer levels. A CT secondary circuit must never be open-circuited while energized.

Delivered Energy: Energy sold to the applicant from GRE.

Delta Connected Circuit: A three-phase circuit with three source windings connected in a closed delta (triangle). A closed delta is a connection in which each winding terminal is connected to the end (terminal) of another winding.

Demand: The rate at which electric power is delivered to or by a system; normally expressed in kilowatts, megawatts, or kilovolt-amperes.

Direct Current (DC): An electric current flowing in one direction only and substantially constant in value.

Disconnect: A device used to isolate a piece of equipment. A disconnect may be gang-operated (all poles switched simultaneously) or individually operated.

Dispatchable: Capable of having generator output (real and reactive power) adjusted ("dispatched") upon request of GRE power system operator. The adjustment includes capability to start-up and shut down generating units.

Energy Losses: The general term applied to energy lost in the operation of an electrical system. Losses can be classified as transformation losses, transmission line losses or system losses.

EMS: Energy Management System. The computer system GRE uses to provide real-time status and remote control of its electrical transmission system.

Facility: The applicant's electric generating, tie-line, or substation facility identified generally in the Interconnection and Operating Agreement and more specifically identified in the "as built" drawings provided to the company in accordance with Section 9.4 of the Interconnection and Operating Agreement, together with the other property, facilities, and equipment owned and/or controlled by the applicant on the applicant's side of the Points of Interconnection.

FERC: Federal Energy Regulatory Commission. FERC is an independent body within the Department of Energy (DOE) regulates interstate transmission of electricity, natural gas, and oil, and also regulates hydropower projects and natural gas terminals.

Frequency: The number of cycles occurring in a given interval of time (usually one second) in an electric current. Frequency is commonly expressed in Hertz.

Fuse: A short piece of conducting material of low melting point that is inserted in a circuit for the purpose of opening the circuit when the current reaches a certain value.

Ground: A term used in electrical work in referring to the earth as a conductor or as the zero of potential. For safety purposes, circuits are grounded while any work is being done on or near a circuit or piece of equipment in the circuit; this is usually called protective or safety grounding.

Hertz: The term denoting frequency, equivalent to cycles per second.

Incoming Breaker: The applicant-owned breaker that connects GRE source of power to the applicant's bus.

Interconnection: The physical system of electrical transmission between the applicant's generation and the utility.

Interrupting Capacity: The amount of current a switch, fuse, or circuit breaker can safely interrupt.

Interruption: A temporary discontinuance of the supply of electric power.

Island: A part of an interconnected system that may be isolated during a system disturbance and start operating as a subsystem with its own generation, transmission and distribution capability. Then the subsystem becomes an island of the main interconnected system without a tie. In such a case, the islanded system and the main interconnected system will operate at different frequencies and voltages.

Isolated: In this scheme, the generating unit will supply all of the needs of the connected load.

Kilovolt (kV): One thousand volts.

Kilovolt-Ampere (kVA): One thousand-volt amperes. See the definition for Apparent Power.

Kilowatt (kW): An electric unit of power that equals one thousand watts.

Kilowatt hour (kWh): One thousand watts of power supplied for one hour. A basic unit of electric energy equal to the use of 1 kilowatt for a period of one hour.

Lagging Power Factor: Occurs when reactive power flows in the same direction as real power.

Leading Power Factor: Occurs when reactive power flows in the opposite direction of real power.

Line Losses: Electrical energy converted to heat in the resistance of all transmission and/or distribution lines and other electrical equipment.

MISO: Midcontinent Independent System Operator, Inc., or successor organization.

NERC: North American Electric Reliability Corporation. regulates interstate transmission of electricity, natural gas, and oil, and also regulates hydropower projects and natural gas terminals.

OASIS: Open Access Same-time Information System - An Internet based system designed to allow all participants in the power market to obtain information concerning the capability and use of the transmission system in a non-discriminatory manner.

Ohm: The practical unit of electrical impedance equal to the resistance of a circuit in which a potential difference of 1 volt produces a current of 1 ampere.

One-Line Diagram: A diagram in which several conductors are represented by a single line and in which various devices or pieces of equipment are denoted by simplified symbols. The purpose of such a diagram is to present an electrical circuit or circuits in a simple way so that their function can be readily grasped.

Operating Reserve: The sum of Spinning and Non-Spinning Reserve.

Parallel Operation: The operation of an applicant-owned generator while connected to the utility's grid. Parallel operation may be required solely for the applicant's operating convenience or for the purpose of delivering power to the utility's grid.

Peak Load: The maximum electric load consumed or produced in a stated period of time.

Point of Energy Exchange: The point in the delivery system where one party takes delivery of the energy from the other party. This point is defined in the contract between GRE and the applicant. It is often the point where facility ownership changes. This point may also be called the Point of Interchange when dealing with a bi-directional energy exchange or the Point of Delivery if the energy flows in one direction.

Point of Interconnection (POI): The point or points where the facilities of the applicant interconnect with the facilities of GRE (point of ownership change).

Point of Metering: The point where metering equipment (meters, current transformers, potential transformers, etc.) is or will be installed to measure the power flow and energy exchange between GRE and the applicant.

Power: Actual, Active or Real Power. The time rate of transferring or transforming energy or the power that accomplishes work. Measured in watts.

Power Factor (PF): The ratio of actual power (kW) to apparent power (kVA).

Power Flow: One-way power flow is the condition where the flow of power is entirely into the applicant's facility. Two-way power flow is the condition where the net flow of power may be either into or out of the applicant's facility depending on the operation of the generator and other customer load.

Protection: All of the relays and other equipment that are used to open the necessary circuit breakers to clear lines or equipment when trouble develops.

Reactive Power: (VAr) The power that oscillates back and forth between inductive and capacitive circuit elements without ever being used. The function of reactive power is to establish and sustain the electric and magnetic fields required to perform useful work.

Received Energy: Energy received by GRE from the applicant.

Reclose: To return a circuit breaker to its closed position after it has opened by relay action.

Relay: A device that is operative by a variation in the condition of one electric circuit to affect the operation of another device in the same or in another electric circuit.

Switch: A device for making, breaking or changing the connections in an electric circuit.

Synchronism: Expresses the condition across an open circuit wherein the voltage sine wave on one side matches the voltage sine wave on the other side in frequency and amplitude without phase angle difference.

System: The entire generating, transmitting and distributing facilities of an electric company.

System Control Center: Systems and System Operators used in the coordination and deployment activities required to support the safe and reliable operation of interconnected systems.

System Operator: A person authorized to operate or supervise the operation of the interconnected systems within the Balancing Authority Area.

Transformer: An electric device, without continuously moving parts, in which electromagnetic induction transforms electric energy from one or more other circuits at the same frequency, usually with changes of value of voltage and current.

Voltage: Electric potential or potential difference expressed in volts.

Volt-Ampere: A unit of apparent power in an alternating-current circuit.

VAr: Volt ampere reactive, see Reactive Power.

Watt-Hour: A unit of work or energy equivalent to the power of one watt operating for one hour.

Wheeling: The use of transmission facilities of one utility system to transmit power to another utility system, or between customer facilities within a single utility system or between systems.

Wye or "Y" Connected Circuit (Star Connected): A three-phase circuit in which windings of all three phases have one common connection.

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IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems, IEEE C37.90.1.

IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers, IEEE C37.90.2.

IEEE Surge Voltages In Low-Voltage AC Power Circuits, IEEE C62.41.

MRO Manual, Midwest Reliability Organization – or the Reliability Manual of MISO, Applicable Reliability Council, or its successor.

NERC Reliability Standards, North American Electric Reliability Corporation.

NERC Operating Manual, North American Electric Reliability Corporation.

National Electrical Code, NFPA 70, National Fire Protection Association, Quincy, MA 02269.

National Electrical Safety Code, IEEE C2-, Institute of Electrical and Electronics Engineers, Inc.

OSHA Safety Tagging and Lock-out Procedures.