OBJECTIVE: TDOG108 (Transmission Planning Procedures and Planning Criteria) provides information to those entities who are considering interconnecting to the Great River Energy (GRE) transmission system.
(*NERC FAC-001*)

SCOPE: This document describes the procedures and criteria that the GRE Transmission Planning Department utilizes during the development of transmission plans for the transmission system. This includes the evaluation of new and materially modified existing interconnections.
The GRE Transmission Planning Department has the responsibility to analyze the existing transmission system to determine whether expansion (new transmission projects) is required to continue to provide reliable and economic service to GRE load, generation, and transmission service customers.
As necessary and at GRE's discretion, this document may be revised from time to time as changes in procedures or criteria may be needed to meet changing system requirements such as new technologies, changes in transmission usage (load, generation, or transmission service) or changes in regional or local criteria. This includes changes to standards or criteria developed by the North American Electric Reliability Corporation (NERC), the Midcontinent Independent System Operator (MISO), or the Midwest Reliability Organization (MRO) as well as other, adjacent transmission owners and operators.

Reference documents

Name of document, not version

If the document refers to other TDOGs, department processes or GRE policies or procedures, list here.
TDOG202: Generator Interconnection Guidelines
TDOG204: Tie Line and Substation Interconnection Guide

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Index to references to NERC Requirements

1.0 Introduction

The GRE Transmission Planning Department has the responsibility to ensure that the GRE-owned transmission system and the transmission systems of adjacent transmission owners have sufficient capability to reliably, and economically, serve GRE's member-owners and customers. GRE is responsible for planning the Bulk Electric System (BES) that GRE owns and which may affect service to GRE customers.

In addition, GRE has contracted to perform the transmission planning functions for Glencoe Light and Power.[1]

The procedures and criteria included in this document are intended to be a minimum set of information needed to analyze the existing system and develop new projects to ensure continued reliable and economic service into the future. GRE planners are encouraged to add additional analysis, criteria, and procedures as necessary to enhance the service to GRE customers and member-owners. (NERC FAC-001)

2.0 Planning study procedures and coordination

GRE will conduct system planning analysis in accordance with GRE's planning criteria (see Appendix). Analysis and planning for the BES will include the contingences and performance requirements of Categories P0-P7 in NERC Standard TPL-001-5. For the remainder of the system, including GRE's underlying transmission system less than 100-kV, Category P0, P1, and P2 contingency analysis will be conducted. (NERC TPL-001-5)

For all new interconnections (generation, transmission, and end-user) to GRE transmission system, GRE transmission planners will perform analysis to assess the reliability impact of the interconnection. (NERC FAC-002-2)

For modifications to existing interconnections (generation, transmission, or end-user) to the GRE transmission system, GRE transmission planners will determine whether the modification should be considered a material modification. Based on this determination, additional analysis may be conducted to determine whether the modification has adverse impacts to system reliability and mitigation is required to address those impacts. (NERC FAC-002-2, R1(ii))

GRE will coordinate its analysis with the Midcontinent Independent System Operator (MISO) as the Planning Coordinator (PC), in accordance with the requirements of the Business Practice Manuals, and potentially affected transmission owners when evaluating any requests for new or materially modified interconnections to the GRE-owned transmission system, including generation interconnection requests. GRE's local planning

[1] This list of entities for which GRE provides transmission planning services may change from time to time.

criteria will apply in addition to other applicable NERC standards and regional or local planning criteria. (NERC FAC-002-2)

GRE will conduct system planning studies to develop long-range plans for the GRE transmission system, as well as plans for specified areas within the boundaries of GRE's transmission system. These plans will address future customer needs, problems and/or other developments in the areas served by the GRE transmission system. The scope of the planning studies may be tailored to address specific areas of concern, such as high load growth areas, to manage the scope of the planning study.

The goal within the GRE footprint is to develop an "umbrella" plan for the area, that is, a combined, coordinated, overall plan that emphasizes projects that serve multiple purposes or solve multiple problems within the transmission system. The area approach is intended to address requirements for support to the local distribution systems in that area on a least cost basis. It is anticipated, however, that several projects that span more than one area or possibly even beyond the GRE transmission system boundaries, may evolve. Such projects will involve coordination with other transmission owners or regional transmission organizations.

When planning, GRE will consider alternatives to transmission solutions on the transmission system as appropriate or as required for regulatory approval. Such alternatives could include, but are not limited to, central station generation, Distributed Energy Resources (DER), load management and conservation measures. GRE will use sound judgment in assessing whether non-transmission alternatives are applicable on a case-by-case basis, keeping in mind that GRE is a generation and transmission cooperative and does not serve as a load serving entity for retail load.

3.0 Types of planning studies

3.1 Annual planning assessment

On a periodic basis as determined by GRE's Planning Coordinator (MISO), GRE will work in conjunction with MISO to assess the MISO transmission footprint for a near-term period (1 to 5 years) and a long-term period (6 to 10 years). These assessments are usually conducted as part of the MISO Transmission Expansion Plan (MTEP). The assessments will investigate potential system performance issues that may arise based upon NERC Standards requirements. Such assessments will involve steady state, short-circuit and dynamic simulations using regional models created through the regional model building process. GRE's responsibility includes reviewing the MISO results for accuracy and providing Corrective Action Plans for its impacted facilities.

The results of the annual assessment are included in the MISO MTEP report that is shared with GRE's neighboring transmission planners and other entities that request a copy of the report. (NERC TPL-001-5)

3.2 Load serving study

GRE also maintains a 10-year plan with the primary purpose of assessing the continued capability of the transmission system to maintain or improve the reliability of service to loads, both existing and projected. This plan includes consideration of costs, economics, reliability, and aesthetics. If needed, a 20-year assessment will be included in the plan.

The 10-year plan is an electronic dashboard used as a source of information to GRE's members and customers in the development of the GRE transmission system. This is not a public tool, and only provided to distribution entities under GRE's transmission service obligation. A primary use of the 10-year plan is for projecting financial obligations and forecasting construction activities. Planning engineers can also use this document as a guide to identify areas of need, a source of information of the existing system and a planning tool to determine alternatives, particularly DER and demand-side management, for an integrated resource plan. Due to the uncertainty of load growth in the future, the facilities included in the 10-year plan may be changed, delayed, advanced, or canceled in lieu of a lower cost alternative. Projects receiving GRE board approval to move forward will be placed in the MISO MTEP process.

Other area studies will be performed if certain planning areas have received unanticipated growth, such as a new industrial plant. These plans may use information and transmission development alternatives from the 10-year plan if applicable or create new options depending on the load requirements.

Load serving studies will involve at minimum both summer and winter peak scenarios. Other scenarios will be studied as necessary for those conditions where, for example, local loading of the transmission is more stressful than the summer or winter peak load conditions. Consideration will also be given to the impacts of local generation outages that result from market dispatch conditions or forced outages.

3.3 Generation interconnection study

Generation interconnection studies will involve, at a minimum, summer peak and summer off-peak for most generation plants. A light load (minimal load) analysis will also be performed if the generation is likely to be on during those periods of time. Energy storage devices such as battery storage or pumped hydro may be treated as both a generator and a load depending on reliability concerns.

Other considerations should include:

- The loss of the largest distribution load in the vicinity of the generator as a valid n-1 event;
- All local network and energy resources at rated Pmax. (see note below);

- Local generation should not be included in the generation adjustment for the addition of the new generation resource;
- Power transfers through the region;
- Winter peak analysis (if an area is impacted by winter power flow patterns and increased loads);
- Transient stability and/or harmonic analyses may, based on engineering judgment, be performed; and
- Other applicable NERC Standards

Dynamic ride through

All synchronous machines, inverter-based generation sources and/or other dynamic control devices shall be able to ride through the applicable faults in TPL-001, Table 1 with the system adhering to system criteria. Additional guidance can be found in IEEE 2800 for transmission interconnections and IEEE 1547, for distributed energy resources.

Note: Generators that have an approved, MISO Attachment Y[2] agreement will be modeled as on-line in models that cover the planning periods prior to the retirement or suspension dates indicated in Attachment Y.

There are additional requirements for the planning and construction of generator interconnections which can be found in GRE's TDOG 202: Generation Interconnection Guidelines.

3.4 Transmission interconnection study

Transmission interconnection studies will be conducted as necessary to ensure that the modified transmission system meets all local and regional planning criteria and applicable NERC standards. Power flow models, like those required for generation interconnection studies, will be developed as necessary to accommodate the analysis. Additional studies, such as small signal, short-circuit, or voltage stability, may also be required depending on the nature of interconnection request. GRE will accept interconnection studies from other Transmission Owners[3] to meet FAC-002 requirements when interconnecting to GRE facilities, if the study was collaborated and jointly planned between the two parties.

There are additional requirements for the planning and construction of generator interconnections which can be found in GRE's TDOG 204: Tie-Line and Substation Interconnection Guideline.

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[2] Attachment Y is a MISO tariff provision that provides a change of status notification of a generation resource, synchronous condenser, or a pseudo-tied generator.

[3] Per North American Electric Reliability Corporation Glossary of Terms Glossary_of_Terms.pdf (nerc.com)

3.5 Transient stability analysis

Transient stability assessments are generally performed to assure adequate avoidance of loss of generator synchronism, prevent system voltage collapse and determine whether there are sufficient system reactive power resources within 20 seconds of a system disturbance.

GRE will perform dynamic stability assessments when a need is indicated or on an annual basis per NERC Standards. These assessments will include, but are not limited to, consideration of the following system load conditions:

- Summer peak
- Summer off-peak
- Winter peak
- Light load

The first and third conditions are typically used for voltage stability studies. The second condition is primarily used for angular stability studies.

3.6 Transfer capability study

GRE will rely on MISO as the Planning Coordinator to perform all the necessary studies to determine Transfer Capability. GRE will support the MISO methodology as long as GRE planning criteria is met. (NERC FAC-013—2)

3.7 System operating limit analysis

GRE establishes System Operating Limits (SOLs) and Interconnection Reliability Operating Limits (IROLs) for its transmission planning area that covers the planning horizon. The SOLs and IROLs are consistent with the MISO methodology[4] through the following procedure (FAC-014-2, R4):

- GRE provides modeling data and receives modeling data for the GRE transmission planning area through the MISO model-on-demand process.
- Engineering staff at the MISO performs preliminary calculations of SOLs and IROLs and prepares the results for review by GRE (and the other MISO transmission planners).
- GRE planning engineers review the preliminary results to determine whether the results are valid for establishing SOLs and IROLs for the GRE transmission planning area.
- GRE provides comments to MISO as to whether the results need to be updated based due to system changes (topology, ratings) or operating procedures (guides) are in place.
- Engineering staff at the MISO updates the results.

[4] The current version of the MISO methodology is contained in Appendix L of BPM-020-r30 (December 1, 2023)

- GRE reviews the updated results.
- GRE indicates to the MISO that the results represent the SOLs and IROLs for the GRE system.
- GRE provides GRE planning horizon SOL/IROL results to those entities who request the information.

3.8 Reliability analysis

3.8.1 MW-mile analysis

In order to assess the planned reliability of the transmission system, GRE performs a MW-Mile analysis to prevent a single-contingency outage of a transmission circuits from affecting a large number of customers or a large geographic area.

The methods used for calculating radial and looped transmission circuits MW-Mile values and the criteria for the analysis is included in Appendix I.

<u>Radial MW-Mile Analysis</u>: This analysis involves radial fed loads on the GRE system. MW-mile calculations are used to determine when radial fed substations may be qualified to receive looped service. Other factors include:

- The reliability of the radials;
- The cost of looping the system;
- Effects of the loop on the system power flow;
- Future needs in the area;
- Backfeed capability of the distribution system; and
- Double-end of distribution substation.

When developing new transmission facility plans, GRE favors alternatives that will provide a looped feed to the new substation. GRE tries to minimize the use of radial lines because of potentially lower reliability. Radial lines are acceptable if the resulting quality of service is compatible with the customer’s needs.

<u>Breaker MW-mile analysis</u>: This analysis is for the looped transmission system between circuit breakers. Breaker MW-mile calculations are used to determine when line exposure between two or three circuit breakers affect the load being served by the respective line. Breaker MW-mile values above the criteria may lead to additions of sectionalizing equipment to limit the load outage. Sectionalizing will consist of new circuit breakers, motor-operated switches, or normally open switches on the system. Timing of system restoration is also a factor. Circuit breakers can return a load almost instantaneously, whereas switching operations will take a few minutes with

motor-operated switches and possibly a few hours to open or close manual switches in limited access areas.

3.8.2 Facility condition assessment

As part of their planning assessment, GRE will collaborate with GRE Substation Engineering and GRE Transmission Line Engineering to assess the age and condition of any GRE transmission equipment implicated in the planning assessment and determine if equipment upgrades are required.

3.8.3 Historical reliability assessment

GRE system operations also maintains records of transmission that reflect the reliability of the system. This outage information, along with other operational records, influences system improvement decisions. GRE planners will use this information to make rational decisions on new facilities. GRE will also provide these records to parties of concern upon request.

4.0 Facility rating methodology

4.1 Steady state facility ratings

The GRE facility ratings criteria are consistently applied among GRE planning, engineering, and operations. (NERC FAC-008-3)

Facilities to be considered include, but are not limited to, overhead line conductors, underground cable, bus conductors, transformers, autotransformers, circuit breakers, disconnect switches, series and shunt reactive elements, VAR compensators, current transformers, wave traps, jumpers, bushings, lightning arrestors, meters and relays (both overcurrent/directional overcurrent/impedance settings and thermal limits). GRE will establish facility ratings for its solely and jointly owned facilities that are consistent with the associated "Facility Ratings Methodology".

For jointly owned facilities where GRE is the majority owner, GRE will coordinate the equipment owner's information with its own information to determine the appropriate facility rating. When GRE is the minority owner, GRE will coordinate and provide the GRE-owned equipment data to the responsible modeling parties or as requested to any appropriate entities.

GRE will provide facility ratings for its solely and jointly owned facilities that are new facilities, existing facilities, modifications to existing facilities and re-ratings of existing facilities to its associated reliability coordinator(s), planning coordinator(s), transmission owner(s), transmission planner(s) and transmission operator(s) as scheduled by such requesting entities. (NERC FAC-008-3,R8)

Updates to facility ratings are usually done annually via the MISO Webtool[5], the MISO Model on Demand (MOD) and, when a valid request is made, via direct communications. In some cases, a facility rating may not match an off the shelf model as a facility may have been upgraded, degraded, or removed from service since the model was developed.

4.2 Dynamic operating ratings

Dynamic Operating Ratings (DOR) are time dependent facility ratings based on GRE's Facility Ratings Methodology that allow for a facility to be operated outside the steady-state rating for a short period of time, typically 5 to 10 minutes. DORs are generally intended for use during a limited timeframe (usually less than five years) as a result of a forced outage of other transmission facilities or a delay of projects under construction.

The DOR will be cancelled when a permanent fix is installed, in the event NERC or MISO's reliability criteria affecting the facilities change or at the discretion of GRE in the event implementation of the DOR becomes burdensome. In any event, the allowed use of the DOR will terminate in five years unless GRE deems extension is warranted.

GRE will not allow DOR of its transmission facilities to be used as a temporary fix to delay the installation of facilities required for generation interconnection requirements or as a substitute for transmission upgrades to allow for the addition of generation capacity. If completion of the proposed infrastructure is delayed, the generation plant will be limited to output levels that do not put the existing system at risk.

GRE will only allow an emergency DOR of facilities if the following criteria are met:

- GRE Design Engineering has performed an evaluation confirming the capability of a DOR.
- The DOR will be based on GRE Facility Rating Methodology.
- The long-term mitigation plan must be already identified, or a facility study must be in progress before the DOR can be utilized.
- Real time data needed to calculate the DOR is scanned directly by the GRE Energy Management System. This may include monitoring of conditions local to the facility such as ambient temperature, facility temperature, or wind speed.
- DOR can only be utilized on facilities where redispatch can reduce the transmission line to or below its normal rating within the time limit for which the DOR was calculated.

[5] Data entered by GRE System Operations

- DORs are not allowed for approval of a Transmission Service Request (TSR) because TSRs represent firm transmission service. DOR lines do not have firm ratings beyond the static limit.
- Only one DOR operation guide will be allowed per facility.
- In the event that data communication is lost, the normal rating of the line continues to be the static limit.

5.0 Reliability criteria

5.1 GRE planning criteria

In addition to the NERC Standards, regional and local planning criteria are established to address the reliability issues unique to the regional and local transmission systems, respectively. In order to continue to provide acceptable service for the needs of the customers served by the GRE transmission system, local planning criteria are used to measure system performance. Some of the items included in GRE's local transmission planning criteria are:

- Voltage limits
- Facility loading
- MW-Mile limits
- Maximum number of source terminals
- Voltage flicker
- Harmonic Voltage Distortion
- Allowed use of Remedial Action Schemes
- GRE's local transmission planning criteria is included in Appendix of this document.

5.2 Foreign systems

In performing planning assessments, GRE will respect the planning criteria of those foreign systems included in the study.

5.3 NERC requirements

For those GRE planning studies used to comply with NERC standards, GRE will ensure that the study meets the requirements of the standard applicable to the study.

6.0 Load forecasting & modeling

GRE gathers historical load data measured at its metered locations and then scales the data using the load growth projections to produce GRE's forecasted load. The historical data gathered includes peak values for summer, fall, and winter seasons. GRE forecasts peak load levels for these four seasons, as well as for light load and summer off-peak situations. The GRE methodology for developing, aggregating, and maintaining load forecast information are in accordance with NERC Standard MOD-031.

GRE models several different loading situations, which are defined in the "MISO Reliability Planning Model Data Requirements and Reporting Procedures":

- Summer peak is the peak demand expected during the months June, July and August. A reduction in load is included for controlled demand-side management and peak shaving loads.
- Winter peak is the peak demand expected during the months December, January, and February. A reduction in load is included for controlled demand-side management and peak shaving loads.
- Summer off-peak or summer shoulder peak is defined as 70 percent of the summer peak value. This case is modeled because high interchange has been observed in the north-central MRO region under this condition.
- Fall peak is the peak demand expected during the months September, October, and November.
- Spring light load is typically expected during early morning hours but could occur at any time during the year. GRE defines this load level to be 40 percent of the summer peak load for that year.

GRE applies a baseline power factor requirement[6] at every delivery point that serves member-owner systems and other customers. In general, GRE models 0.98 leading power factor in minimum load studies and 0.98 lagging power factor in peak load studies.

7.0 System performance analysis

7.1 Model development

7.1.1 Power flow models

The starting point for the GRE power flow models is the MISO MOD modeling database and modeling data submitted by others through the planning coordinators and other transmission planners.

The following power flow models are usually developed:

- Summer peak
- Winter peak
- Summer off-peak
- Fall peak
- Spring light load

Variations of the above models will be developed as necessary to properly model other conditions such as high-transfer, low-wind, high-wind, or extremely light load events. Model data (loads, generation output, facility ratings, etc.) may be adjusted as appropriate for the type of study being conducted.

7.1.2 Transient stability models

[6] As measured at the Point of Interconnection or the high-side of distribution transformers (including losses).

For transient stability assessments, GRE uses transient stability models that are part of the MISO model development process. The dynamic models will be modified as required to add, delete, or modify parameters in order to meet the scope requirements of a particular transient stability study.

7.2 PSS/E tools

GRE uses the PSS®E software developed by Siemens PTI for steady state and transient stability simulations of the power system. GRE also uses post-processing tools for summarizing the output of multiple PSS®E simulations to compare results of the different simulations.

7.3 Other tools

Other software tools (such as PSCAD, TARA, and TSAT) may be used for engineering calculations of short-circuit current, harmonic distortion, small-signal analysis, etc. as necessary to properly analyze the performance of the transmission system.

8.0 Development of transmission alternatives

8.1 General procedures for developing alternatives

The fundamental purpose of transmission planning is to develop a future transmission system that can be operated reliably and economically serves customers and GRE member-owners. The development of new transmission projects comes from the analysis of alternatives that are proposed based on a transmission planning engineer's experience. It will also require the consultation of other planners, system operators, design engineers, and regulatory permitting staff as alternatives are evaluated, accepted for further consideration, or rejected based on discussions.

The sections below describe some of the evaluations that take place when considering alternatives. Additional areas of discussion will likely be required based on the unique nature of each alternative.

8.2 Planning criteria

Any new alternatives that are developed to correct criteria violations found during planning assessments should be analyzed in accordance with GRE's planning criteria and NERC Standards. Each alternative should be compared using the same assumptions as any other alternatives that may be considered to correct a deficiency.

8.3 Engineering standards

All alternatives should meet GRE's engineering standards. GRE Substation and Transmission Line engineering departments should be consulted as necessary during this review.

8.4 Operational feasibility

All transmission alternatives, including reconfiguration of the topology or operational procedures, should be reviewed by GRE System Operations at an appropriate time.

8.5 Facility age and condition

During the development of transmission alternatives, there should be consideration of the age and condition of the existing transmission facilities. This should include operating reports that may highlight areas of the transmission system that experience above average outages due to local conditions such as weather or equipment access. It may be possible to justify a project based on operational improvements in addition to the benefits of mitigating criteria.

8.6 Use of Remedial Action Schemes (RAS)

GRE does not allow the use of new, permanent Remedial Action Schemes (RAS), previously known as Special Protection Systems (SPS), on the GRE transmission system in order to meet reliability criteria. The use of a RAS on a temporary basis, not to exceed five years, is allowed provided the transmission system upgrades required to permit operation without the RAS have been approved for construction.

8.7 Environmental Analysis

The environmental impacts of each alternative must be included in the analysis. In some cases, the adverse environmental impacts may eliminate some alternatives from continued engineering and economic consideration.

8.8 Economic analysis

8.8.1 The overall cost of a proposed alternative should include not only construction costs, but permitting (regulatory filings, environmental assessments, etc.) and operating costs. Operating cost should include, if possible, an assessment of any increased or decreased system losses caused by the project.

8.8.2 The economic analysis should be conducted to bring the cost of each alternative to a common base point during the economic analysis. This could be total annual costs over the entire life of the project or a net total cost (present worth) to a common starting year.

Appendix – GRE Planning Criteria

(includes Table 1- Steady State & Stability Performance Planning Events)

	Transmission Planning Criteria	Department	Transmission planning
		Issue Date:	March 20, 2024
		Previous Date:	December 19, 2022

1.0 SCOPE/purpose

This document contains the planning criteria that Great River Energy (GRE) uses to ensure its transmission system is adequate to reliably deliver power to customers, provide support to interconnected distribution systems, deliver energy from existing and new generation facilities, and support effective competition in energy markets. This document may be revised from time to time as appropriate, in response to new system conditions, new technologies, and new operating procedures.

The criteria described below is subject to change at any time at GRE's discretion. Situations that could precipitate such a change could include, but are not limited to new system conditions, extraordinary events, safety issues, operational issues, maintenance issues, customer requests, Midcontinent Independent Transmission System Operator (MISO) requirements, regulatory requirements and Regional Entity (RE), e.g. Midwest Reliability Organization (MRO) or North American Electric Reliability Corporation (NERC) requirements.

New or materially modified interconnections to the GRE transmission system will be analyzed[7] to determine whether system performance is degraded to the point where it violates the planning criteria. When GRE is required to model the facilities of foreign transmission owners to conduct an assessment, GRE will adhere to the facility owner's planning criteria requirements.

2.0 Requirements in NERC standards

The transmission system will be evaluated for compliance with the requirements in NERC Standard[8] TPL-001-5 (Categories P0 to P7). Both GRE-owned facilities and facilities in foreign areas will be evaluated.

[7] Per GRE TDOG-108, "GRE Transmission Planning Procedures and Planning Criteria"

[8] NERC Standards can be found at: NERC Reliability Standards

3.0 System modeling criteria

3.1 General system modeling

Steady state and transient assessments are performed to assure avoidance of equipment overloads, prevention of unacceptable system voltage levels and satisfactory system reactive power resources. A detailed analysis will be conducted on the system conditions which are likely to cause the most severe impact to criteria. Assessments will include consideration of the following system load conditions for possible further analysis:

- Summer peak
- Winter peak
- Summer off-peak
- Spring peak
- Fall peak
- Minimum load

3.2 Modeling for generator studies

For generator interconnection studies, the analysis will be conducted with the new generation and all other local area generation at full output, at both minimum load and peak load conditions, to determine whether the aggregate of the generation in the local area can be delivered to the aggregate of load on the transmission system. A generator must be directly connected to the GRE transmission system to be considered for network upgrades identified in the GRE LPC analysis, however any generation that has no alternative path to the greater transmission grid but through GRE transmission corridor or breaker stations will be considered connecting to the GRE transmission system.

The local area will be determined by the impedance grid based on the generation location on the grid. A Line Outage Distribution Factor (LODF) will be calculated. Any line segment that has a distribution factor greater than or equal to 5%, will result in the lines endpoints, as in substation buses, being part of the local area. Generation units radially or directly tied to these endpoints will be adjusted to their full output.

3.3 Special system studies

Based on engineering judgment and operational experiences it may be necessary to conduct system studies of transient voltage performance, voltage flicker, and switching transients. This may include EMT (Electro-Magnetic-Transient) analysis on the addition of new generation, particularly inverter-based generation, or new devices such as capacitors, variable-frequency motor drives, SVCs, or STATCOMs. GRE transmission planning will review the topology of the transmission system in the area of concern and provide rationale for the need for the additional studies.

4.0 Voltage criteria

GRE's planning criteria regarding voltage limits on equipment are shown in Table 1. The criteria in Table 1 applies for voltage performance during GMD events pertaining to NERC standard TPL-007-4.

Table 1
GRE Voltage Criteria

Voltage Ranges	Allowable Planned Voltage Tolerances Per Unit of Nominal					
	Normal		Emergency		Transient[9]	
Facility	Max	Min	Max	Min	Max	Min
Hubbard 230 & 115-kV [10]	1.05	0.97	1.05	0.92	1.20	0.75
Wing River 230 & 115-kV [10]	1.05	0.97	1.05	0.92	1.20	0.75
Ramsey 230-kV	1.05	0.95	1.05	0.90	1.30 for 200 msec[11]	0.70
Balta 230-kV	1.05	0.95	1.05	0.90	1.30 for 200 msec[11]	0.70
Load Serving Buses	1.05	0.95	1.05	0.92	1.20	0.70
Remaining Buses	1.05	0.95	1.05	0.90	1.20	0.70
Voltage Flicker (%)	3%	NA	5%	NA	NA	NA

The timer starts after the event has cleared. Figure 1 shows the desired range. For the upper bound of voltage profile, GRE has the following criteria:

- Fast switched capacitor sites: <= 1.65 p.u. for five cycles (83.3 msec.), transitioning to 1.3 p.u. for seven more cycles (116.7 msec.)
- All other sites: <= 1.3 p.u. for 12 cycles (200 msec.)
- <= 1.2 p.u. from 12 cycles to 30 cycles (0.5 seconds)
- <= 1.1 p.u. from 30 cycles to 20 seconds
- Post contingent criteria of 1.05 p.u. or below after 20 seconds

For the lower bound of voltage profile, GRE has the following criteria:

- Below 0.7 p.u. for five cycles
- >= 0.7 p.u. from five cycles to 30 cycles
- >= 0.8 p.u. from 30 cycles to 10 seconds
- >= 0.9 p.u. from 10 seconds to 20 seconds
- Post contingent criteria of 0.9 p.u. or above after 20 seconds, except for GRE load-serving substations whereby a 0.92 p.u. or above criteria applies

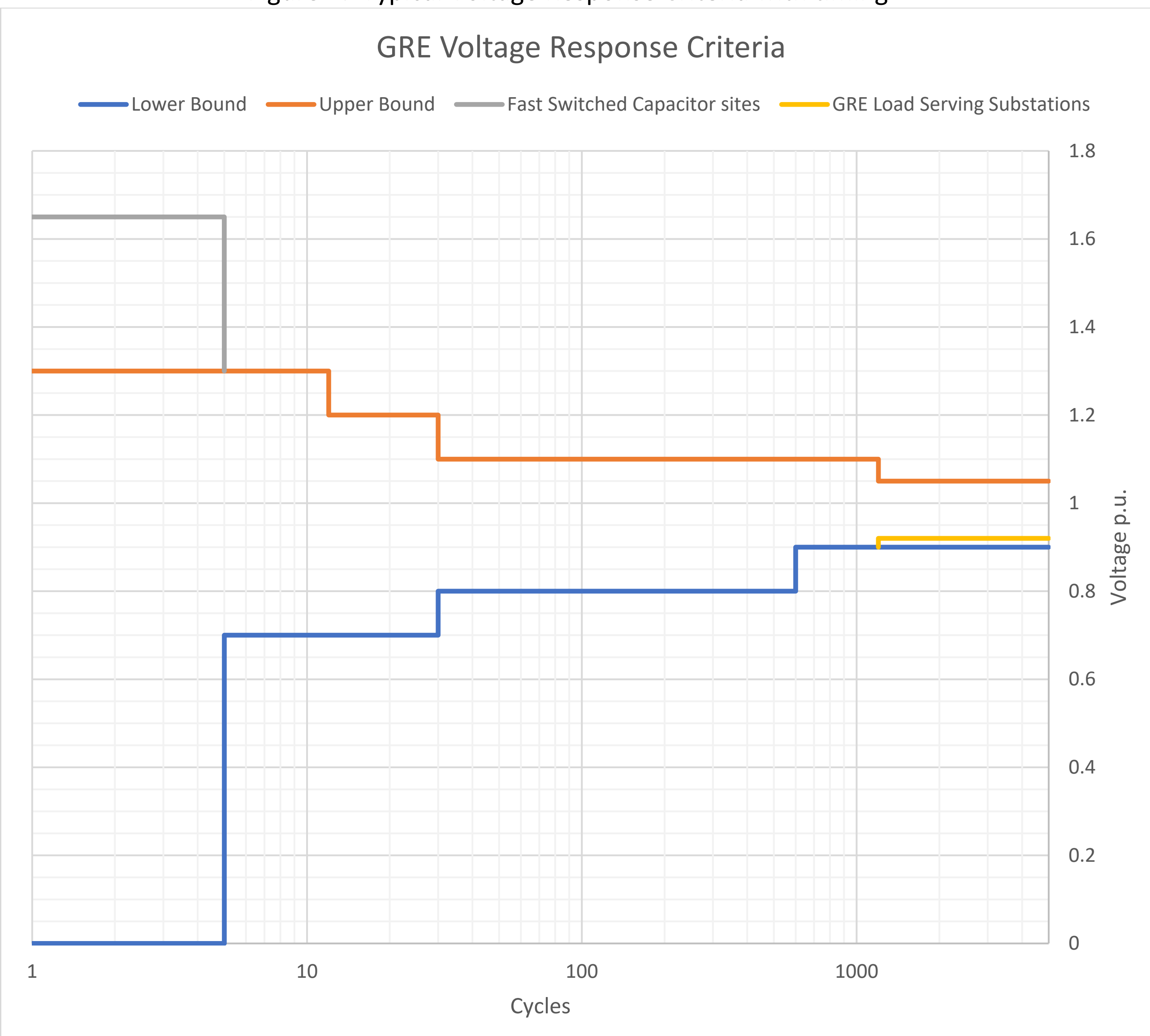
[9] Typical range of operation.
[10] Minnesota Power planning criteria applies.
[11] Fast switched capacitor site is allowed 1.65 per unit for 5 cycles, if capacitors triggered on.

Further analysis of the voltage profile may need to be performed if it remains above a critical state for an extended period, typically 1 second or longer for impact on:

- Capacitor overvoltage trip setting above 1.1 p.u.
- Overvoltage/undervoltage relaying elements with pickups typically 120%/80% of nominal range

Figure 1 is largely for load-serving aspect. Generation facilities may have different requirements to maintain ride-through aspects.

Figure 1: Typical Voltage Response Criteria with timing [12]



[12] Table 1 may identify locations with special criteria that may not fit this voltage criteria.

5.0 Facility loading criteria

GRE's planning criteria for the loading of transmission facilities is shown in Table 2.

Table 2
GRE Facility Loading Criteria

Facility Ratings	Line		Station Equipment		Transformer	
Condition	Loading	Duration	Loading	Duration	Loading	Duration
Normal	100%	Continuous	100%	Continuous	100%	Continuous
Emergency[13]	100%	NA	100%	NA	100%	Study

Per GRE's Facility Rating Methodology, a 25% emergency level for transformers is allowed for non-firm aspects for a four-hour period. GRE reports a non-emergency rating in system models to flag all line, equipment, and transformer overloads at its top continuous normal MVA rating. If a violation occurs based on a TPL-001 event, an investigative study will be performed to determine if the transformer is impacted by firm generation or firm transfers per TPL-001, Table 1, footnote 4 and 9. If loading is caused by non-firm transactions or load that has a cyclic characteristic, the emergency level will be applied, however, based on engineering judgement further detailed transformer loading analysis may need to be performed. System adjustments that can be made within a four-hour period will be considered as viable option to return the transformer loading to be under its normal criteria.

From GRE's aspect, emergency means application to single contingency TPL-001 events, P1 and P2, and multiple contingency events, P4, P5 and P7. Any violation will require mitigation if the investigative study shows no resolution to the violation.

Multiple contingency events, P3 and P6, may consider system adjustments such as operating processes that may change the topology of the system or result in reductions of load or generation. Any violation of this criteria will be investigated by GRE including determining the risk that GRE will take with its property and the probability of the event. Any allowance beyond the above criteria will be documented with the event if found acceptable. The allowances are as follows:

- No allowances have been identified at this time.

6.0 MW-mile criteria

6.1 Radial MW-mile analysis

- The MW-mile value for a radially fed circuit is calculated by summing the flow across each radial line segment times the length (in miles) of the respective segment.

[13] GRE will conduct an engineering analysis, when needed, to determine whether a specific facility is capable of a short-term emergency rating for a limited time duration.

- The MW-mile value of the circuit should not exceed 100 MW-miles.

6.2 Breaker MW-mile analysis

- The Breaker MW-Mile calculation is based on the product of the total real power components (load and generation) on the line(s) between the circuit breakers and the total line mileage of the same line(s) between the same circuit breakers.
- MW-mile magnitudes of less than 1000 are typical and acceptable.
- MW-mile magnitudes between 1000 and 2000 are higher than usual. If records indicate poor reliability, then corrective action shall be investigated.
- MW-mile magnitudes higher than 2000 indicate a high amount of exposure and risk to the system. Corrective action shall be investigated.

7.0 Maximum of three source terminals

New interconnection requests will be reviewed to determine if the proposed configuration will result in more than three, normally-closed source terminals into protected line sections. Additional breakers or new breaker stations will need to be added to limit the number of source terminals to three. In some cases, breakers may be operated normally open to limit the number of sources. DER interconnection flowing onto the transmission grid will need to be reviewed with GRE Substation Engineering to determine if the DER could act like a terminal. Generation interconnecting to the transmission grid will be considered a terminal.

In addition, new three-terminal circuits will be reviewed to determine whether adequate relay protection exists in the proposed configuration. Resolution of potential relaying concerns can be accomplished by adding additional breaker protection or by opening the system. Also, any newly proposed transmission system topology should be analyzed for compliance with other portions of this planning criteria including, but not limited to, contingency analysis.

8.0 Transmission system planning performance requirements

8.1 Steady State Assessments

GRE will maintain appropriate planning criteria for all categories of events allowing for some loss in demand for some Category P2 events. Please refer to NERC Standard TPL-001-5, Table 1 for a further description of the performance requirements for the various event categories.

8.2 Transient stability assessments

8.2.1 Transient and dynamic stability assessments are generally performed to assure the avoidance of loss of generator synchronism, prevention of system voltage collapse and the adequacy of system reactive power resources during the 20 seconds following a system disturbance. The transient and dynamic system stability performance criteria to be utilized by GRE shall include the following factors.

8.2.2 GRE will perform transient stability assessments when a need is indicated or on a regular basis per NERC Standards. These assessments will include, but are not limited to, consideration of the following system load conditions:

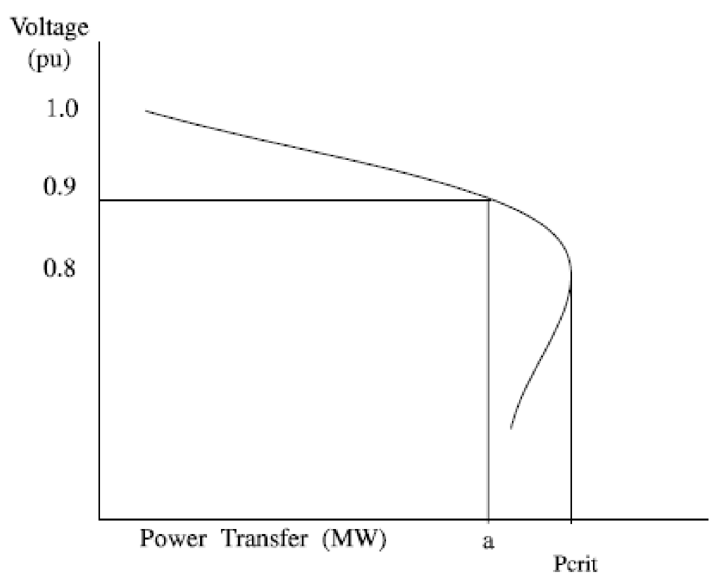
- Summer peak
- Summer off-peak
- Winter peak
- Minimum load

The first and third conditions are typically used for voltage stability studies. The second and fourth conditions are primarily used for angular stability studies.

GRE will simulate local and regional disturbances for assessment purposes on Category P1 through P7 events. All disturbances will be given a one (1) cycle margin on breaker clearing time.

The performance assessment will be based on:

- Voltage stability based on meeting GRE transient criteria or the criteria of the facility owner.
- Voltage stability will be maintained by operating at or below the P_{limit} (shown in below figure as point "a") defined as the power transfer limit across the critical interface. P_{limit} will be 90 percent of the $P_{critical}$ where $P_{critical}$ is defined as the maximum power transfer (the nose of P-V curve).



- Angular stability will avoid separation of the system unless some generation units are deliberately islanded.

- Cascade tripping of transmission lines will be monitored and avoided unless planned cascading is initiated.
- Uncontrolled loss of load will be avoided.
- No unit will exhibit poorly damped angular oscillations or unacceptable power swings. All machine rotor angle oscillations will be positively damped and calculated from the Successive Positive Peak Ratio (SPPR) of the peak-to-peak amplitude of the rotor oscillation. SPPR and the associated Damping Factor will be calculated as:

  - SPPR = Successive swing amplitude / Previous swing amplitude and,
  - Damping Factor = (1 - SPPR) * 100 (in %)

  The damping criteria are as follows (with increased damping required for higher probability events):

  - For disturbances (with faults): SPPR (maximum) = 0.95; Damping Factor (minimum) = 5%
  - For line trips: SPPR (maximum) = 0.90; Damping Factor (minimum) = 10%

  The calculation of damping is based on successive positive peak ratios. In some cases, the SPPR calculation fails due to a constant rate of change of rotor angles caused by a significant generation loss and resulting significant frequency change. In these cases, Prony[14] analysis should be utilized to calculate damping ratios on the appropriate modes of oscillation, and the damping ratio criteria (equivalent to the damping factor criteria above) are as follows:

  - For disturbances (with faults): Minimum Damping Ratio = 0.0081633
  - For line trips: Minimum Equivalent Damping Ratio = 0.016766

  Oscillations should be well-damped within 20 seconds with engineering judgement determining if appropriate response is achieved.

[14] Prony analysis is a process that will determine whether the dynamic performance if properly damped in order to avoid system instability and subsequent collapse.

8.3 Voltage flicker

Voltage fluctuations may be noticeable as visual lighting variations (flicker) and can damage or disrupt the operation of electronic equipment. Sources of flicker are not allowed to produce flicker to adjacent customers that exceeds the GRE guideline shown below (Figure 1). The source will be responsible and liable for corrections if the interconnecting Facility is the cause of objectionable flicker levels.

The flicker limits defined below are applicable to all interconnections made to the GRE system. The criteria for acceptable voltage flicker levels are defined by the requirements of regulatory entities in the states in which GRE owns and operates transmission facilities, IEEE recommended practices and requirements and the judgment of GRE.

The flicker level criteria will be modeled at periods that the element causing the flicker is expected to be integrated into or removed from the transmission grid. If electrically close, non-base load generation should be scheduled off-line. GRE requires that studies be performed for normal conditions and with the most limiting prior outage.

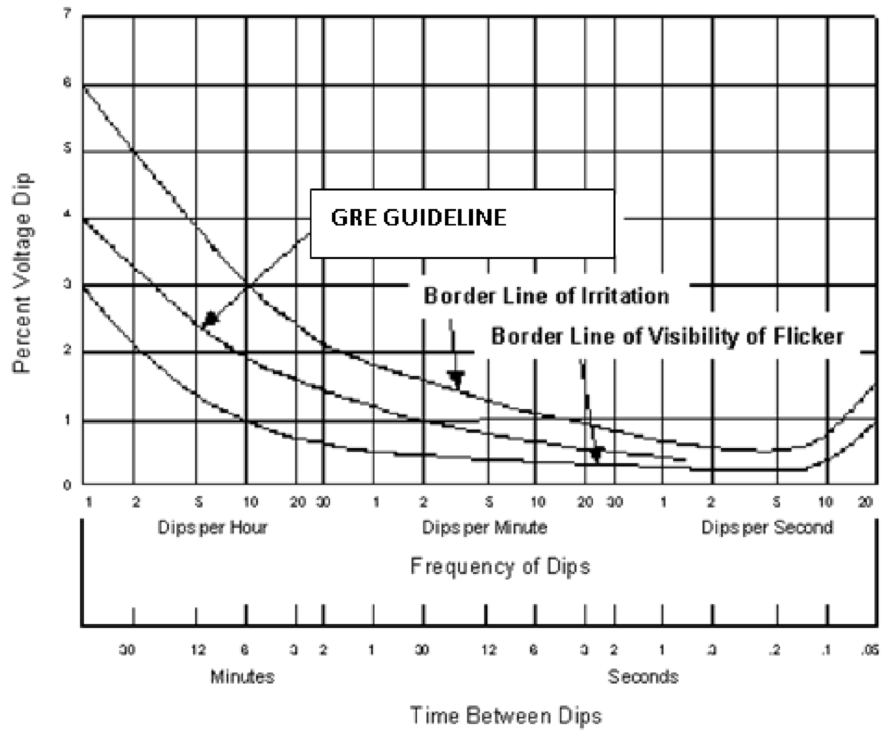
If the limits defined below are exceeded under intact or outage conditions, the flicker producing source must be operated in a manner that does not adversely affect other loads. Planned outages can be dealt with by coordinating transmission and flicker producing load outages. Because operating restrictions during unplanned outages may be severe, it would be prudent for the owner of the harmonic producing source to study the effect of known critical or long-term outages before they occur so that remedial actions or operating restrictions can be designed before an outage occurs.

All GRE buses are required to adhere to the following two criteria.

- Relative steady state voltage change is limited to 3 percent of the nominal voltage for intact system condition simulations. The relative steady state voltage change is the difference in voltage before and after an event, such as capacitor switching or large motor starting.
- Relative steady state voltage change is limited to 5 percent of the nominal voltage for contingency condition simulations.

GRE uses the following flicker curve found in IEEE Standard 1453-2015 (commonly referred to as "The GE Flicker Curve") to determine the acceptability of single frequency flicker. Please refer to the most recent version of the IEEE-1453 standard for more information.

Figure 2
GRE Voltage Flicker Guideline



8.4 Harmonic voltage distortion
GRE advises the interconnecting customer to account for harmonics during the early planning and design stages. The interconnected customer's equipment shall not introduce excessive distortion to the transmission system voltage and current waveforms per IEEE 519-2014. Please refer to the recommended harmonic voltage limits in section 5.1 of the IEEE-519-2014 standard for more information.

Additionally, a special study will be required for situations when the fault to load ratio is less than 1.0.

9.0 Remedial action schemes

GRE does not permit the addition of new, permanent Remedial Action Schemes (RAS).

9.1 A Temporary RAS can be installed provided the following is met
The installed RAS must be temporary and its use will only be valid for a maximum of five (5) years to allow for planned transmission upgrades to be completed while serving new load or generation. The transmission resolution must be placed into the MISO Transmission Expansion Plan (MTEP) process, a scope and schedule must be

approved by GRE prior to the installation and granting of the RAS. An extension of the RAS will be granted unless transmission cascading, 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 Regional Entity, Planning Coordinator or Reliability Coordinator.

9.2 Legacy RAS

A legacy RAS may be maintained if there is a significant reliability benefit such as preventing cascading, system collapse or large loss of load.

All RASs 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.

References

- GRE TDOG-108, Transmission Planning Procedures and Planning Criteria
- GRE TDOG-202: Generator Interconnection Guidelines
- GRE TDOG-204: Tie Line and Substation Interconnection Guide
- North America Electric Reliability Corporation, NERC Standards web page
- NERC Reliability Standards Complete Set: Reliability Standards for the Bulk Electric Systems of North America
- IEEE 1453-2015, “IEEE Recommended Practice for the Analysis of Fluctuating Installations on Power Systems”
- IEEE 519-2014, “IEEE Recommended Practice and Requirements for Harmonic Control in Electric power Systems”