

Transmission System Guidelines



Xcel Energy Operating Companies

Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW

Version:16.0

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1.0 PURPOSE

- This guideline describes the requirements for connecting new generation of greater than 20 megawatts (MW) to an electric transmission line or a substation owned and operated by one of the Xcel Energy operating companies: Northern States Power Company (Minnesota) and Northern States Power Company (Wisconsin) (jointly NSP); Public Service Company of Colorado (PSCo); and Southwestern Public Service Company (SPS).
- Note: NSP and NSPW are members of the Midcontinent ISO, and interconnection of new generation is subject to the Midcontinent ISO Tariff on file with FERC. SPS is a member of the Southwest Power Pool, and interconnection of new generation is subject to the SPP Tariff. Interconnection of new generation to PSCo is subject to the Xcel Energy Operating Companies Tariff. The applicable Tariff should be reviewed in addition to these Guidelines.

2.0 APPLICABILITY AND RESPONSIBILITIES

- Xcel Energy Services Inc., the service company for the Xcel Energy Inc. holding company system.
- Xcel Energy Operating Companies.

3.0 APPROVERS

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4.0 VERSION HISTORY

Date	Version Number	Supersedes	Change
07/31/2008	3.0	N/A	Initial ProjectWise Document. Original document version is 3.0—ProjectWise version.
04/15/2010	4.0	3.0	Annual review and update.
4/26/2010	4.01	4.0	Corrected OATT link, page 8.
09/30/2011	6.0	4.01	Review and update. Based document on the 4.01 version. Version 5.0 was a working copy. Updated language on AGC. Updated Interconnection diagram.
08/31/2014	7.0	6.0	General review. Updated Interconnection diagram.
08/31/2015	8.0	7.0	Annual review and update.
08/31/2016	9.0	8.0	Annual review and update.
8/31/2017	10.0	9.0	Annual review and update.
8/31/2018	11.0	10.0	Annual review and update.
8/31/2019	12.0	11.0	Annual review and update.
8/31/2020	13.0	12.0	Annual review and update.
11/3/2022	14.0	13.0	Annual review and update.
1/30/2023	15.0	14.0	Changes to industry standards and NERC updates.
8/31/2023	16.0	15.0	Annual review and update.



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I. INTRODUCTION AND GENERAL POLICY

A. INTRODUCTION

The Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation (**Guidelines**) describe the requirements for connecting new generation to an electric transmission line or a substation owned and operated by any of the following Xcel Energy operating companies: Public Service Company of Colorado (**PSCo**), Southwestern Public Service Company (**SPS**), or Northern States Power Company (Minnesota) or Northern States Power Company (Wisconsin) (jointly **NSP**). For the balance of this document, the Xcel Energy operating companies will be jointly referred to as **Xcel Energy** or the **Xcel Energy Operating Companies**.

These Interconnection Guidelines are to comply with the requirements of NERC reliability standard FAC-001, Facility Interconnection Requirements, by maintaining and publishing facility interconnection requirements.


One purpose of these Interconnection Guidelines is to implement the final Generation Interconnection Rules (**Final Rules**) adopted by the Federal Energy Regulatory Commission (**FERC**) on August 19, 2003 in FERC Order No. 2003.¹ The Final Rules require all FERC-jurisdictional electric utilities, including the Xcel Energy Operating Companies, to use standardized generation interconnection procedures and agreements for all pending or new requests to interconnect a generator at transmission voltage (in general at or greater than 69kV in SPS, 44kV in PSCo and 34.5kV in NSP) subject to certain regional differences.²

The Final Rules establish a pro forma Large Generation Interconnection Procedure (**LGIP**) and Large Generation Interconnection Agreement (**LGIA**). The LGIP and LGIA will be incorporated in the Open Access Transmission Tariffs (**OATTs**) applicable to each Xcel Energy Operating Company are described in section B.3. Another purpose of these Guidelines is to document the detailed technical requirements for interconnection not included in the

¹ *Standardization of Generation Interconnection Agreements and Procedures*, Order No. 2003, Fed. Reg. Vol. 68, No. 160 (August 19, 2003).

² These Interconnection Standards thus do not apply to generation interconnections to the Distribution system of an Xcel Energy Operating Company and in PSCo to new generators sized 20 MW or less connecting at Transmission voltage. NSP is a member of the Midcontinent Independent System Operator (MISO) whose Tariff and therefore these guidelines apply to all generation regardless of size. SPS is a member of the Southwest Power Pool (SPP) and therefore these guidelines apply to all generation regardless of size. Please contact Xcel Energy for information regarding the processes for Distribution and small generator interconnections. Contact information by operating company can be found at the Xcel Energy web site http://www.xcelenergy.com/Company/Transmission/Transmission_Organizations/Interconnections_for_Transmission.

In addition, various generation units were connected to the Xcel Energy transmission systems prior to publication of these Guidelines and the Final Rules. These were installed under prior guidelines published by New Century Energies, Inc. or Northern States Power Company. In most cases, the system, regulatory, or safety requirements have not changed sufficiently to require these units to update their interconnection or generation to comply specifically with this document. In some cases, compliance with certain updated requirements may be required. These will be handled on a case-by-case basis.

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LGIP or LGIA, as allowed by the Final Rules. To the extent there is a conflict between these Guidelines and the applicable OATT, the applicable OATT will control unless FERC has accepted the Xcel Energy Guideline as consistent with the Final Rules.

These Guidelines should thus be considered a "User's Guide" to the interconnection process for generators and Xcel Energy employees under the Final Rules. To the extent possible, the Guidelines provide a universal set of requirements for all Xcel Energy Operating Company transmission systems. However, there are some technical requirements specific to a state, Xcel Energy operating company, North American Electric Reliability Corporation (**NERC**), applicable **NERC Regional Entity (RE)**, or applicable **Regional Transmission Organization (RTO)** tariff, as allowed by the Final Rules. The specific requirements are discussed in more detail below, where applicable. Each such requirement is labeled with the Operating Company, **RTO**, or Reliability Region to which it applies.

In this document, certain words and abbreviations are identified as having specific meanings. These words and abbreviations are given in **bold face** type when initially defined. These words and abbreviations can also be found in the **GLOSSARY** section of this document.

For example, for purposes of these Guidelines, the term **Interconnection Customer** will be used to refer to transmission connected co-generators, qualifying facilities (**QFs**), independent power producers (**IPPs**) small power producers, non-utility generators (**NUGs**), and other producer-owned generators. To the extent any of the Xcel Energy operating companies or affiliates construct and own generation and propose to interconnect to the Xcel Energy transmission system, the Xcel Energy operating company or affiliate will be treated comparably to an Interconnection Customer with regards to the new generation project and subject to these Guidelines.

B. THE XCEL ENERGY SYSTEMS

1. Description of Xcel Energy Operating Companies

The Xcel Energy Operating Companies own and operate electric transmission systems in portions of 10 states. The applicable states are:

- **PSCo** - Colorado
- **NSP** - Minnesota, North Dakota, South Dakota, Wisconsin, Michigan
- **SPS** - Texas, New Mexico, Kansas, Oklahoma

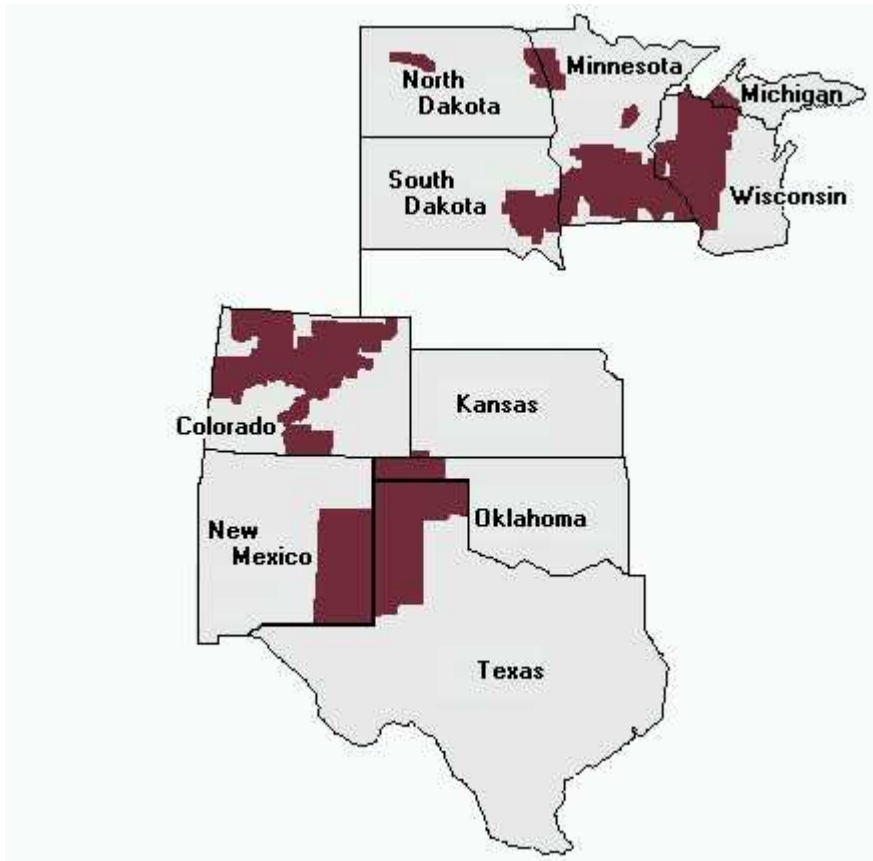
The following is a simple map showing the location of the transmission systems of each Xcel Energy Operating Company.

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Other electric utilities also serve these states, and in some areas the utilities operate highly interconnected networks. An Interconnection Customer must determine if the proposed generator will in fact interconnect to a transmission facility owned by an Xcel Energy operating company at the proposed location. If the generator will interconnect to a transmission facility owned by another utility, these Guidelines are not applicable.

2. NERC and Regional Entities

The Xcel Energy Operating Company transmission systems are located in two **NERC Reliability Regions**. Each Reliability Region has certain requirements that are specific to that region. NERC has delegated authority for Reliability Standard enforcement to the Regional Entities overseeing the various Reliability Regions. The two Regional Entities applicable to Xcel Energy are the Midwest Reliability Organization (**MRO**), and the Western Electricity Coordinating Council (**WECC**). The applicable Reliability Regions for each of the Xcel Energy Operating Companies are as follows:

- NSP - MRO <https://www.mro.net/>
- PSCO - WECC www.wecc.org

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3. Open Access Transmission Tariffs

The Xcel Energy transmission systems are also subject to three different **OATTs** on file with the FERC. The NSP system is a member of the Midcontinent Independent System Operator, Inc. (MISO or Midcontinent ISO) regional transmission organization (RTO). The SPS system is a member of the SPP RTO. Each RTO has an OATT on file with FERC.

The Applicable OATT, and the web site address, are as follows:

PSCo - the Xcel Energy Operating Companies Joint OATT, is available at the Xcel Energy web site (www.xcelenergy.com); Xcel Energy > Transmission > Open Access Transmission Tariff

NSP - the MISO regional OATT, the MISO Open Access Transmission, Energy, and Operating Reserves Market Tariff (MISO OATT) available at www.misoenergy.org (click on "Tariff" Quick Link)


SPS - SPP regional OATT (**SPP OATT**), available at http://www.spp.org/publications/SPP_Tariff.pdf (click on "Regional Tariff" in the matrix of selections)

Each OATT has been amended to include the LGIP and LGIA required by the Final Rules, and new generators will be subject to the processes in the OATTs. Specifically:

- Generation interconnections to the PSCo transmission systems are subject to the procedures set forth in the Xcel Energy Joint OATT and the technical requirements defined in these Guidelines.
- Generation interconnections to the NSP transmission system are subject to the procedures set forth in the MISO Tariff and the technical requirements defined in these Guidelines.
- Generation interconnections to the SPS transmission system are subject to the procedures in the SPP OATT and the technical requirements defined in these Guidelines.
- As indicated above, these Guidelines should be considered supplemental technical requirements to the procedures and requirements set forth in the applicable OATT. To the extent there is a conflict between these Guidelines and the applicable OATT, the applicable OATT will control unless FERC has accepted the Xcel Energy Guideline as consistent with the Final Rules.

C. GUIDELINE AUTHORITY

Several federal and state regulatory agencies have authority over the electric services provided by the Xcel Energy operating companies. The requirements set forth by this document are intended to comply with these requirements, including the Federal Power Act (**FPA**), the Public Utility Regulatory Policies Act (**PURPA**), the FERC Final Rules, all local, state and federal regulatory agency requirements, and the applicable requirements of other entities related to owners and operators of electric systems and associated interconnected generation, such as NERC or the Regional Entity. The Interconnection Customer should keep abreast of changes in regulatory requirements and comply with them as they develop. Specifically, FERC has authority over any interconnection to

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an Xcel Energy electric transmission system at transmission voltage under the FPA and the Final Rules. The Final Rules, and the individual OATTs implementing them (listed above), are subject to change from time-to-time. The Interconnection Customer should consult the applicable OATT to ensure that the most up to date OATT requirements are used in the project design, operation, and maintenance requirements.

NERC has established standards and practices for the reliable design and operation of the electric transmission system. NERC and the individual Reliability Regions modify and update their requirements from time to time. The Interconnection Customer should also consult the websites of NERC (www.nerc.com) and the applicable Reliability Region (see above) to ensure that the most up-to-date requirements are used in the project design, operation and maintenance requirements. This Guideline is periodically updated, but the Guideline may not reflect the most up-to-date information.

Various American National Standards Institute (**ANSI**) and Institute of Electrical and Electronic Engineers (**IEEE**) standards also affect interconnection of generation and are mentioned in this Guideline. ANSI and IEEE update and revise these standards from time to time. The Interconnection Customer should plan its generation project using the latest revision of referenced ANSI/IEEE standards because Xcel Energy considers them to be automatically incorporated into this Guideline.

The NSP and SPS transmission systems are part of the MISO and SPP **RTOs**, respectively. For the purposes of this document, the term **RTO**, unless specified otherwise, will be used to refer to such regional transmission entities. As such changes occur, the requirements imposed on Xcel Energy by the applicable RTO will affect generation interconnections. Xcel Energy plans to update these Guidelines from time-to-time to incorporate the changing RTO requirements that become applicable, but the Interconnection Customer should consult the ISO for any applicable RTO requirements.


However, these Guidelines are not intended to modify any existing OATT or agreements that establish the rights and obligations of Xcel Energy or the Interconnection Customer. This document also is not intended to override or change any statutes, regulations or other applicable authority. In cases where federal, NERC, Regional Entity, or state or local codes or regulations are in conflict with the provisions of these Guidelines, the national, state or local code may take precedence.

Since these Guidelines are subject to these various regulatory authorities, which are subject to change, Xcel Energy reserves the right to revise these Guidelines from time-to-time without advanced notice.

D. GUIDELINE OBJECTIVES AND LIMITATIONS

These Guidelines serve as a reference for establishing the interconnection between Xcel Energy and the Interconnection Customer to operate Generation in parallel with an Xcel Energy electric transmission system (**Xcel Energy System**). The technical terms used in this guide are defined in the **GLOSSARY**.

- **Generation** is defined as any device producing (or releasing from storage) electrical energy. The guidelines apply to both rotating machines and inverter-based systems.

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- **Parallel Operation** is defined as the operation of Interconnection Customer-owned generation with output terminals connected directly to or through an intermediary's system to Xcel Energy's System. Parallel Operation may be long term, or momentary ("make before break", "hot", or "closed" transition).

Pursuant to the applicable OATT, Xcel Energy will permit any eligible Interconnection Customer to operate generating equipment in parallel with the Xcel Energy System. The OATT and these Guidelines state the minimum requirements for Interconnection Customer owned generation to safely and effectively interconnect to Xcel Energy's electric transmission system.

These Guidelines are formulated to provide the Interconnection Customer with a reliable interconnection that minimizes scheduling conflicts and other restrictions that could result in output restrictions while providing Xcel Energy with the flexibility and authority necessary to preserve reliability. All of the elements necessary for Xcel Energy to achieve this flexibility will be under the control of Xcel Energy. All of the elements necessary for the Interconnection Customer to control, operate, and maintain its generation facility will be under the control of the Interconnection Customer. The objective is a clear line or point of demarcation between the Xcel Energy and the Interconnection Customer's equipment, maintenance, and operating responsibilities.

Any responsibilities and liabilities between Xcel Energy and the Interconnection Customer will be detailed in the generation interconnection agreement between Xcel Energy and the Interconnection Customer (or between the applicable RTO, Xcel Energy Operating Company and the Interconnection Customer). The terms "approve", "approved", and "approval" used throughout this document mean acceptance. "Approval" by Xcel Energy does not mean that Xcel Energy endorses or is held responsible for the safety or reliability of an Interconnection Customer's design and facility.


E. INTERCONNECTION PROCESS

The following process applies to an Interconnection Customer that proposes to (a) interconnect a generating unit to the Xcel Energy System or (b) increase the capacity of a generating unit interconnected with the System. These procedures only apply to generation interconnections and establish the facility and facility cost estimates associated with such interconnections.

Interconnection requests will only be considered on existing transmission facilities or transmission facilities that have been identified as committed to in a state filing, OASIS posting, or Regional Transmission Organization (RTO) approved transmission plan (ex. MISO MTEP appendix A or B only, SPP Integrated Transmission Plan).

If the proposed generation facility is to be interconnected to the NSP Transmission System:

This location is governed by MISO Open Access Transmission, Energy, and Operating Reserve Tariff (MISO OATT) and the interconnection process is administered by MISO. The specific written process is titled "Attachment X" to the MISO OATT, available from the MISO Website. To access, go to www.misoenergy.org, open the "Planning" tab, open "Generator Interconnection" tab, and locate Attachment X. In addition, MISO augments the procedures with a Business Practice Manual (BPM 015 - Generation Interconnection). To access, go to www.misoenergy.org, open the "Planning" tab, open the "Generation Interconnection" tab, and locate BPM 015. If you would like more information about the MISO, contact 317-249-5400 or email webmaster@misoenergy.org.

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Coordination of generator interconnection studies and plans is achieved through the MISO tariff interconnection process under Attachment X and through the study procedures identified in the Business Practice Manual (BPM 015 - Generation Interconnection). All transmission projects are coordinated through the MISO Transmission Expansion Plan (MTEP) process as specified in the MISO Business Practice Manual (BPM 020 - Transmission Planning). These processes assure coordination with other transmission study process.

Other transmission owners and stakeholders will be notified of the proposed interconnection and new or modified facilities via the MISO queue posting, the MISO Oasis posting of the facility study and the submittal of the generation interconnection projects into the MISO MTEP process which includes providing its draft MTEP report to stakeholders for comment. In addition, affected transmission owners are informed of and invited to participate in the Generation interconnection studies by MISO under the procedures identified in the Business Practice Manual (BPM 015 - Generation Interconnection).

If the proposed generation facility is to be interconnected to the PSCo Transmission System:

These locations are governed by Xcel Energy’s OATT and the interconnection process is administered by Xcel Energy’s Transmission Department. If you would like more information about the Xcel Energy OATT contact the Transmission Account Representative at (303) 273-4726 or email Jennifer.L.Bass@xcelenergy.com.

If the proposed generation facility is to be interconnected to the SPS Transmission System:

This location is governed by the SPP OATT and the interconnection process is administered by the SPP. The specific written process is found at this webpage <http://spooasis.spp.org/documents/swpp/transmission/GENInterPAGE.cfm> and is “Interconnection Guidelines for Posting”. If you would like more information you can also contact SPP at 501-664-0146.

Limitation: As determined by FERC, a request for interconnection of a generator **does not** constitute a request for transmission service. The process described in these Guidelines is not sufficient, nor intended, to determine the capability of the transmission network to deliver the Interconnection Customer’s power and energy to loads. An Interconnection Customer desiring transmission service from Xcel Energy or the appropriate RTO, including a System Impact Study if one is necessary, must follow the procedures of the Xcel Energy OATT or the appropriate RTO OATT in requesting transmission service.

F. FINANCIAL OBLIGATION OF THE INTERCONNECTION CUSTOMER

The Interconnection Customer will reimburse Xcel Energy fully for the costs to interconnect the generator to the extent allowed by the Final Rules and applicable OATT.

The following are examples (but not a complete list) of the Interconnection Costs that may be the responsibility of the Interconnection Customer:

1. Study analyses and related expenses to determine:
 - a. The feasibility to interconnect includes but not limited to dynamic, and transient studies);

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- b. The transmission facilities required for interconnection;
 - c. The Xcel Energy System network upgrades required for the interconnection;
 - d. Construction and project schedules; and
 - e. Cost estimates and other related information.
2. Preparation of and presentation of study results to appropriate regional oversight committees or planning groups.
 3. Land and rights-of-way, including any required licensing or permitting.
 4. The Interconnection Customer's Interconnection Facilities.
 5. Meter installation, testing, and maintenance, including all parts and other related labor.
 6. Meter reading and scheduling.
 7. Telemetry installation, testing, and maintenance, including all parts and other related labor.
 8. Operating expenses, including communication circuits.
 9. Xcel Energy protective device installation, testing, equipment cost, and related labor.
 10. Interconnection Customer's protective device and interlock review of design, inspection, and test witnessing.
 11. Programming costs to incorporate generation data into Xcel Energy's Energy Management System (EMS).
 12. Facilities that are radial to the Xcel Energy as shown in Appendix A, Figure 1. These are the facilities that are built and owned by Xcel Energy for the purpose of bringing Producer generated power into the Xcel Energy network transmission system.


Any cost responsibilities detailed in the generation interconnection agreement between Xcel Energy and the Interconnection Customer that conflict with this section will take precedence over these Guidelines.

G. OWNERSHIP, OPERATION

Xcel Energy shall own and operate all transmission facilities constructed for the interconnection of an Interconnection Customer's generation to the Xcel Energy System that are determined to be part of the transmission system Network Facilities, as defined in the Final Rules. Xcel Energy shall own all Xcel Energy Interconnection Facilities and System Upgrades that Xcel Energy 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. Xcel Energy may, at its option, contract with the Interconnection Customer or a third party for construction of any or all of these facilities.

The Interconnection Customer will normally construct and own, operate and maintain at a minimum all Interconnection Customer Interconnection Facilities, unless the parties agree in the generation interconnection agreement that Xcel Energy will construct, own, operate or maintain these facilities.

If the Interconnection Customer desires to contract with Xcel Energy to operate or maintain the Interconnection Customer's Interconnection Facilities, specific design considerations may be required that go beyond the minimum technical requirements described in this document. To ensure the safety of Xcel Energy personnel and to minimize the opportunity for human error, the Interconnection Customer may be required to use certain Xcel Energy design standards or certain approved equipment manufacturers which may include but are not limited to control panel layouts, ground grid designs, personal ground attachments placed in approved locations, electrical clearances,

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and lighting of the electrical equipment for night operating. The Interconnection Customer will pay for the training of Xcel Energy personnel, if required, to operate and maintain this Interconnection Customer-owned equipment. The Interconnection Customer will be required to maintain their own stock of any necessary spare/emergency parts and make them available to Xcel Energy maintenance personnel or contract employees.

All equipment, whether provided by Xcel Energy or the Interconnection Customer, whose operation or failure can result in the separation of an Xcel Energy System, must conform to the technical specifications of this Guideline.

H. OPERATION SUBJECT TO BALANCING AUTHORITY/TRANSMISSION OPERATOR

Operation of all interconnected transmission equipment must be under the direction of a NERC-certified **Balancing Authority/Transmission Operator (BA/TOP)**. PSCo is a NERC-certified BA/TOP for the transmission and generation within its BA/TOP area. NSP is the TOP and the Local Balancing Authority (**LBA**) operator for the NSP system; MISO is the BA for the NSP system. SPS is the TOP in the SPS operating system; SPP is the BA for the SPS system. SPS unregistered as a BA on March 11, 2014.

However, the Xcel Energy BA/TOP areas are not contiguous with the Xcel Energy Systems. In some cases, Xcel Energy owns transmission facilities in the BA/TOP Area operated by another entity. Similarly, other utilities own transmission facilities within the Xcel Energy BA/TO Areas. Xcel Energy will operate (switch) all equipment that Xcel Energy owns or which is considered integral to the Xcel Energy System and is within an Xcel Energy BA/TOP Area. At its option, Xcel Energy may contract with another BA/TOP Area Operator to provide for any or all of its operation requirements for transmission lines or other facilities that Xcel Energy owns but are located outside of an Xcel Energy BA/TOP Area.


I. GENERATOR CERTIFICATION AND ACCREDITATION

1. MRO RELIABILITY REGION GENERATION UNITS

All interconnected generator installations on the NSP system in the MRO Reliability Region must meet the applicable regional and NERC Standards and the requirements of MISO acting as an RTO for the NSP system. In addition, Producers intending to qualify as a Capacity Resource under the MISO OATT must demonstrate reliable generating capacity capability. This is accomplished through the generation testing and reporting process established by the MRO and MISO. Producers adding generation will be responsible for the cost of all study work required to meet these requirements.

a. MISO Generation Testing

A Generation Resource wishing to qualify as a Capacity Resource for a MISO Market Participant is required to demonstrate Generation Verification Testing Capability on an annual basis. This is required under Module E - Resource Adequacy, Section 69.3.1a of the MISO OATT. The detailed testing requirements and procedures are found in the MISO Resource Adequacy Business Practices Manual (BPM-11-r7 Section

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4 - Qualifying and Quantifying Planning Resources and Appendix L - MISO Generator Testing requirements. These can be accessed from the MISO website under Library.

b. MRO Generator Testing

The MRO has established the MRO Generator Testing Guidelines for Generators within the MRO region. The Guidelines are designed to comply with a variety of mandatory NERC standards applicable to Generation Owners. The Testing Guidelines are available from the Midwest Reliability Organization Website www.midwestreliability.org under the MRO manual, tab "Supporting Documents".

2. SPP RELIABILITY REGION GENERATION UNITS

There are no specific certification or accreditation requirements for new Interconnection Customers in the SPP Reliability Region. However, as an RTO and operator of the SPP generation reserve sharing pool, SPP may impose additional obligations in the future. An Interconnection Customer proposing to construct generation on the SPS system should keep up to date with applicable SPP requirements. New SPP requirements, if adopted, will apply.

3. WECC RELIABILITY REGION GENERATION UNITS

All transmission-connected generators are required to perform testing on initial startup consistent with the requirements of WECC to obtain certification. See Sections II.J.2 and V.H.2 for further discussion.


J. NERC AND REGIONAL ENTITY POLICIES AND STANDARDS COMPLIANCE

As discussed in Section II.D., all generators and other Interconnection Customer owned facilities up to the Point of Interconnection (**POI**), operated normally in long term parallel with the Xcel Energy System must satisfy NERC standards and the applicable Regional Entity's (MRO or WECC) system design standards for generation including providing data and other information.

All generators must satisfy all NERC and Regional Entity mandatory reliability standards. The Generator is responsible to register with NERC for all required reliability functions and ensure compliance to all applicable mandatory reliability standards. The Interconnection Customer will be solely responsible for compliance to all requirements for registered functions. Unless explicitly documented in a written agreement, Xcel Energy will assume no reliability standards compliance functions on behalf of the Interconnection Customer. Interconnection Customer and Xcel Energy agree to cooperate and provide timely response to data, compliance documentation requests.

All generators must provide evidence that they have agreement with entities that identify the generator's NERC defined Generator Owner, Generator Operator, Balancing Authority, Transmission Operator, Transmission Planner, Resource Planner, Transmission Owner (if applicable) and Planning Coordinator.

Upon notification of interconnection request Xcel Energy will confirm with the applicable Transmission Operations group that the new or qualified change to the transmission facilities is within the NSP, PSC or SPS Balancing

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Authority Area. If the new or qualified change to the transmission facilities is not within the NSP, PSC or SPS Balancing Authority Area, Xcel Energy will notify the Interconnection Customer.

Information about NERC reliability standards registration and compliance is available at the NERC web site at: www.nerc.com.

K. REGULATORY APPROVALS AND PERMITS

The schedule for interconnection and commercial operation of a new generation plant depends on obtaining regulatory approvals and permits for construction of required facilities. Interconnection facilities and system upgrades typically require several permits and regulatory approvals.

The Interconnection Customer is responsible for obtaining all required permits and regulatory approvals for its interconnection facilities. Xcel Energy is responsible for obtaining approval for the permits and regulatory approvals necessary for any Xcel Energy Interconnection Facilities or Network Upgrades. The Interconnection Customer's responsibility for the cost of Xcel Energy's permits and regulatory approvals will be determined by the applicable OATT.

In addition, regulatory approvals may be required to be obtained by neighboring systems if interconnection of the Interconnection Customer's generator will make it necessary for system upgrades to be constructed on these systems.


The lead-time for obtaining these regulatory approvals and permits is often lengthy. This lead-time should not be underestimated.

II. INTERCONNECTION TECHNICAL REQUIREMENTS

The requirements in this document apply to all generating equipment greater than 20 MW (for NSP and SPS, all generation) operated in long-term parallel operation with the Xcel Energy Transmission System. This applies to all rotating generators and inverter-based resource (IBR) installations. If you have questions, please contact Xcel Energy. Contact information by operating company can be found at the Xcel Energy web site http://www.xcelenergy.com/Company/Transmission/Transmission_Organizations/Interconnections_for_Transmission.

A. GENERATION INTERCONNECTION SUBSTATION CONFIGURATION

An interconnecting Interconnection Customer may interconnect at an existing Xcel Energy station or via a tap with breakers into an existing Xcel Energy transmission line. The configuration requirements of the interconnection depend on where the physical interconnection is to occur and the performance of the system with the proposed interconnection.

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Xcel Energy uses various standard substation configurations in various parts of its system: Single Bus, Straight Bus, Ring Bus, Main & Transfer Bus, Double-Bus, and Breaker-and-a-half Bus design. If the Interconnection Customer interconnects to an existing Xcel Energy substation, the interconnection must conform, at a minimum, to the original designed configuration of the substation. Generally, Xcel Energy will not allow a Ring Bus of greater than five breakers. Adding a sixth breaker will require conversion of the station into a Breaker-and-half Bus design. Xcel Energy, at its sole discretion, may consider different configurations due to physical limitations at the site.


Typical interconnection configuration diagrams can be found in **APPENDIX A**. The figures represent generic installations. Circumstances unique to each installation may cause the final configurations to differ significantly from the examples shown. No transmission configuration will be allowed for the addition of generation if it creates a three terminal transmission line configuration. In any case, the Facilities Study will determine final configuration of the Interconnecting Facilities.

The Interconnection Facilities configuration will be allowed only if it does not jeopardize the transmission system’s ability to operate reliably and safely during generation unit trips (except during a local breaker failure backup operation) and generator maintenance activities. Any circuit breaker that can directly impact the reliability and the security of the Xcel Energy System will be under the sole ownership and control of Xcel Energy. In some cases, this will require the installation of an additional breaker in the facility of the Interconnection Customer in order for the Interconnection Customer to exercise maintenance control, ongoing operational control, and personnel safety.

If the Interconnection Customer interconnects into an existing Xcel Energy substation or transmission line, Xcel Energy requires the Customer to have a breaker on the high voltage side of their generator step-up transformer.

B. MODELING INFORMATION

All generator (exciter/governor/power system stabilizer, electromagnetic transient black box model for IBRs, turbines and inverters, etc.), transmission line, and main step-up transformer manufacturers’ data sheets must be available for modeling in steady state, transient/voltage stability, short circuit, and relay setting calculation programs. This includes detailed one-line of the generation facility, generator reactive capability curves, exciter saturation curves, transmission facilities on the customer’s side of the Point of Interconnection and model of any additional var support devices. The Interconnection Customer shall provide to the Transmission Provider and the transmission owner, at the time of application for interconnection, the model data for the proposed generation and any associated power conversion equipment and controls. If a suitable user model does not exist, the Interconnection Customer shall provide the IEEE standard model for use with dynamic and transient stability simulations of their equipment. The load flow modeling data must be provided in either General Electric’s PSLF or Siemens PSSE format, as instructed by the entity doing the studies. The Interconnection Customer shall provide, upon request, the model data for the proposed generation and any associated power conversion equipment and protective devices for use with a PSCAD program. Any model data not covered by a Non-Disclosure Agreement may be publicly released by Xcel Energy to meet NERC model development requirements, other NERC standards or other regulatory requirements.

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Any time there is a new/updated inverter protection and/or control strategy implemented in the facilities, dynamic models, particularly transient models will need to be re-submitted. This is required for Xcel to maintain compliance with all applicable NERC Reliability standards

([https://www.nerc.com/comm/RSTC Reliability Guidelines/White Paper Odessa Disturbance Follow-Up.pdf](https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_Odessa_Disturbance_Follow-Up.pdf))

The Interconnection Customer will annually forecast the firm MW and Mvar usage on each plant Reserve Station auxiliary system for when the generator is on-line, off-line, and starting/stopping, and provide this information annually to Xcel Energy. Station Power for use when the Interconnection Customer is off-line, if needed, must be provided for in accordance with FERC, NERC, NERC Regional Entities, RTOs and/or local state requirements. In some instances, this power may need to be arranged for with the local electric distribution provider, if the Interconnection Customer's facility is not located within the retail service area of the applicable Xcel Energy operating company.

Upon completion of all testing procedures and prior to declare commercial, the Interconnection Customer shall provide to the Transmission Provider and the Transmission Owner the actual/tested data for all equipment connected up to the point of interconnection and any as-built one-line or relaying diagrams as required.


C. SEPARATE SYSTEMS

A separate system is defined as one in which there is no possibility of connecting an Interconnection Customer's generating equipment in parallel with Xcel Energy's System. This can be accomplished by either an electrically or a mechanically interlocked switching arrangement which prevents the two power sources (Xcel Energy and Interconnection Customer) from serving a power load simultaneously. If an Interconnection Customer has a separate system, Xcel Energy will require verification that the system meets the non-parallel requirements. This will be accomplished by the approval of drawings by Xcel Energy in writing and, if Xcel Energy so elects, by field inspection of the transfer scheme. Xcel Energy requires that the final design prints be sealed by a Professional Engineer (**P.E.**) with a brief description of the non-parallel scheme documented on the prints. Generating systems that exceed 20 MW or any system that connects directly to Xcel Energy's System may require backup relaying (besides the generator protection relaying) to protect Xcel Energy's System from adverse impacts from accidental paralleling. Xcel Energy will make these determinations on a case-by-case basis.

D. PARALLEL OPERATION

A parallel system or parallel generation is defined as one in which the generation of an Interconnection Customer can be connected to Xcel Energy's System. A transfer of power between the two systems is a direct and often desired result. The parallel can be by direct connection to Xcel Energy's System or via the internal electrical system of an entity to which the Interconnection Customer is connected such as in an industrial plant. Regardless of the connection means, Xcel Energy's parallel operation requirements still apply to that Interconnection Customer.

E. PROTECTIVE DEVICES

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The Interconnection Customer is responsible for the overall safe and effective operation of their generating facility. Certain protective devices (relays, circuit breakers, etc.) that are specified by Xcel Energy must be installed at the location where an Interconnection Customer desires to operate generation in parallel with the Xcel Energy System. The purpose of these devices is to promptly disconnect an Interconnection Customer's generating equipment from Xcel Energy's System whenever faults or abnormal operating conditions occur. Other modifications to the electrical system configuration or protective relays may be required in order to accommodate parallel generation.

Xcel Energy will not be responsible for primary protection of equipment in the Interconnection Customer's substation or Generating Facility. Protective devices (e.g. relays, circuit breakers) must be installed by the Interconnection Customer to the full extent required by all applicable standards to disconnect the Interconnection Customer's generation from the Xcel Energy System whenever a fault or abnormality occurs (including local breaker-failure tripping whenever the normal relaying does not work). Such equipment must coordinate with existing Xcel Energy equipment and provide comparable levels of protection as practiced on Xcel Energy's System. The protective devices differ with the size of the installation. The specific requirements will be determined in the Interconnection and Facilities Studies. Major factors generally determining the type of protective devices required include:

1. The type and size of the Interconnection Customer's generating equipment.
2. The location and system voltage level of the Interconnection Customer's connection to Xcel Energy's System.
3. The manner in which the installation will operate (one-way versus two-way power flow).

However, this Guideline does not address all of the nuances and complexities involved in designing a protection scheme or for integrating a generation unit into an interconnected electric transmission system. The Interconnection Customer is responsible for designing their own protection scheme and should consult an expert in the field of system protection, generation controls, etc.


Specific protective device requirements are described in Section III below.

F. INTERFERENCE

Operation of the generator by the Interconnection Customer must not cause unusual fluctuation or disturbance on, or inductive interference with an Xcel Energy System, other generators or loads connected to the Xcel Energy System. If such fluctuations or disturbance occur, the Interconnection Customer will be disconnected and required to install suitable apparatus to reasonably correct or limit such fluctuation, disturbance, or interference at no expense to Xcel Energy or Xcel Energy's other Interconnection Customers or other customers.

G. VOLTAGE, HARMONICS, AND FLICKER

The interconnection of an Interconnection Customer's generating equipment with Xcel Energy's System shall not cause any reduction in the quality of service on the Xcel Energy System. No abnormal voltages, frequencies, or interruptions will be permitted. If high or low voltage complaints, transient voltage complaints, and/or harmonic (voltage distortion) complaints result from operation of an Interconnection Customer's generation, Interconnection Customer's generating equipment shall be disconnected from Xcel Energy's System until the Interconnection Customer resolves the problem. The Interconnection Customer is responsible for the expense of

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keeping the generator(s) in good working order so that the voltage, harmonics, power factor (PF), and reactive power (var) requirements are always met. Variable output machines (wind), with fluctuations in plant MW output, may cause fluctuation in power system voltage. To achieve adequate speed of response to such variations, plants relying on switched shunt capacitors to control such variations must have the capacitor banks equipped with "rapid discharge" circuits capable of rendering the capacitors available for re-insertion within 5 minutes of de-energization.

Control systems for any energy conversion equipment(s) employed shall be designed to preclude excitation of the sub-synchronous modes of oscillation of existing turbine-generators, during either steady-state or dynamic conditions, including converter restart attempts or repeated commutation failures. Similarly, excitation of existing or new power system resonances (whether sub- or super-synchronous) due to non-fundamental current injection shall be effectively prevented.

1. STEADY STATE VOLTAGE RANGE

The Interconnection Customer should expect a normal transmission operating voltage range of +/- 5% from nominal. The Interconnection Customer should contact Xcel Energy to determine the expected normal operating voltage at their point of interconnection. The plant should be capable of start-up whenever the voltage at the point of interconnection is within this range. If the auxiliary equipment within the generator cannot operate within the above range, the Interconnection Customer will need to provide regulation equipment to limit the station service voltage-level excursions. During system contingency or emergency operation, operating voltages may vary up to +/- 10% from nominal, depending on the planning criteria for PSCo, NSP, and SPS. Each operating company's planning criteria should be consulted for further information.

2. DYNAMIC VOLTAGE RANGE

All generators must comply with the most recent version of NERC Standard PRC-024.

a. MRO Region

The NSP transmission system is designed to avoid dynamic voltage dips below 0.7 p.u. voltage due to external faults or other disturbance initiators to meet MRO requirements. Dynamic voltage excursions within this range can be expected. Dropout of control contactors associated with any essential generator auxiliaries should not occur during dynamic-power system voltage-swings to levels as low as 0.7 p.u. If contactor dropout does occur, and this causes a further voltage excursion, the Interconnection Customer is required to resolve this problem in a timely manner.

Power conversion or conditioning equipment, either for conversion of output or other reasons such as excitation supply to the rotor circuits of wound-rotor induction machines and protective devices, should also be capable of satisfactory performance (no trip-out, commutation failures or blocking) during voltage swings. Successful commutation and continued power generation should be possible during dynamic voltage swings to levels as low as 0.7 p.u. The low-voltage-withstand capability of this equipment should be able to tolerate a duration of 0.7 p.u. voltage of 0.5 seconds and a total time during which the voltage

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is below 0.9 p.u. of 2.0 seconds per occurrence. Due to power system dynamic-response characteristics, such dynamic under-voltage occurrences may be experienced repetitively in a back-to-back manner.

The Voltage Control Response Rate (for synchronous generators, the exciter response ratio) is the speed with which the voltage-controlling device reacts to changes in the system voltage. The minimum response rate for a static excitation system shall have the exciter attain 95% of the exciter's ceiling (maximum) voltage in 0.1 seconds. The exciter ceiling voltage shall be at least two times the exciter voltage at the rated full load value. For rotary exciters, the exciter response ratio shall be at least 2.0. The response ratio, ceiling voltage, and speed of response are defined in IEEE 421A. Non-synchronous generators should be designed to meet a similar Voltage Response Rate. However, excitation system capabilities less than the ones stated above may be considered for a wind generation where those capabilities will not negatively impact the NSP System.

b. WECC Region

WECC criteria TPL-001-WECC-CRT-3 WR1.2-WR1.6 state the dynamic voltage requirements for applicable BES buses.

c. SPP Region


SPP does not have any dynamic voltage performance criteria. The requirements for each generator will be assessed on a case-by-case and location specific evaluation by SPP under Part V to the SPP OATT. SPP is currently reviewing the addition of dynamic voltage performance criteria. New rules if adopted, will apply.

3. VOLTAGE FLUCTUATIONS AND OTHER VOLTAGE VARIATIONS

Interconnection Customers are not allowed to produce voltage fluctuations, as defined and discussed in IEEE 519 and IEEE 1453, that adversely impact adjacent customers and generators or that exceeds the following limits:

Fluctuations Per Hour	Maximum Allowable Voltage Fluctuation
Fewer than 2	3.0%
2 to 10	2.0%
11 to 100	1.0%
More than 100	0.5%

In some cases, for Interconnection Customers producing fewer than two (2) fluctuations per hour and depending on the proximity of sensitive loads, it may be necessary to restrict the maximum allowable voltage fluctuation to no more than 2%. The Interconnection Customer will be responsible for corrections if their facility is the cause of objectionable voltage fluctuations. In addition, where starting or energizing Interconnection Customer equipment will have an adverse impact on Xcel Energy's System voltage, corrective measures may be required on the part of the Customer to limit the voltage changes.

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4. HARMONICS

The equipment of the Interconnection Customer must include protective equipment so the Interconnection Customer does not introduce excessive distortion to Xcel Energy’s System voltage and current waveforms as defined by IEEE 519. Total harmonic distortion (**THD**) from the facility will be measured at the FERC defined term Point of Interconnection (POI). The point of common connection (**PCC**), as used in IEEE 519, is considered synonymous with POI for this Guideline. The harmonic distortion measurements are made at the point of interconnection between the Interconnection Customer and the Xcel Energy System. The measured results must be within the limits specified in IEEE 519. The Interconnection Customer is encouraged to ensure that the facility as designed will comply with these requirements early in the design process. The Interconnection Customer is responsible for the elimination of any objectionable interference (whether conducted, induced, or radiated) to communication or signaling circuits or systems, or any miss-operation, failure, or overloading of power system devices or equipment (protective relays, capacitor banks, metering, etc.) arising from non-fundamental current injections into the Xcel Energy System from the Interconnection Customer’s facilities.

Output energy present at any frequency (harmonic or non-harmonic) in the range 220-420 Hz is limited to 1.0% of the fundamental current. This additional requirement is for ensuring that no harmful interference occurs to existing ripple-based load control systems in use by adjacent interconnected power suppliers. Note that the fifth through seventh harmonics of 60 Hz fall within the ripple-system protection range. Any power conversion equipment employing six-pulse configurations may require special power-quality measures to satisfy this requirement. Any reference to “load current” in IEEE 519 should be interpreted as referring to output current of the interconnecting facility, as measured at the point of interconnection.

Since inverters can be a significant harmonic source, IEEE 519 shall be followed explicitly. Interconnection Customers that utilize inverters with their generators shall adhere to the guidelines for inverters.

H. FREQUENCY AND FREQUENCY CONTROL

All generators must comply with the most recent version of NERC Standard PRC-024. The energy delivered to Xcel Energy’s System must be 60 Hz sinusoidal alternating current at a standard voltage and phase rotation. Xcel Energy’s phase rotation is ABC counterclockwise in most areas. The Interconnection Customer should verify rotation with Xcel Energy before purchasing any equipment.

1. GOVERNOR OPERATION

All generating equipment must be designed to continuously operate between 59.5 and 60.5 hertz. The Interconnection Customer will operate its generator consistent with Xcel Energy’s guidelines and requirements concerning frequency control. Governors must be maintained and tested in accordance with the manufacturers’ specifications to maintain the performance stated in this section. The Interconnection Customer must, at its sole expense, be responsible for this maintenance and testing of the generating equipment.

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- a. Generators shall be equipped with governors that sense frequency (unless exempt under MRO/SPP/WECC and NERC rules due to prime mover or regulatory limitations).
- b. Governors shall provide a zero to ten percent (0-10%) adjustable setting nominally set at a three percent (3%) droop characteristic (MRO) and 5% (SPP and WECC) and a ± 0.036 hertz or less dead band unless agreed otherwise by Xcel Energy.
- c. The generator must begin increasing or decreasing output at frequency set points of 59.964 hertz or 60.036 hertz respectively.
- d. The change in output must begin occurring within 0.5 seconds of a detected frequency disturbance.

2. MRO REGION OVER/UNDER-FREQUENCY GENERATION TRIPPING

All transmission connected generators, if installed with over/under frequency tripping relays, must be set to coordinate with the under-frequency load shedding program in MRO region.

The Interconnection Customer is required to report their generator off-nominal frequency tripping relay settings to Xcel Energy.

3. SPP REGION OVER/UNDER-FREQUENCY GENERATOR TRIPPING

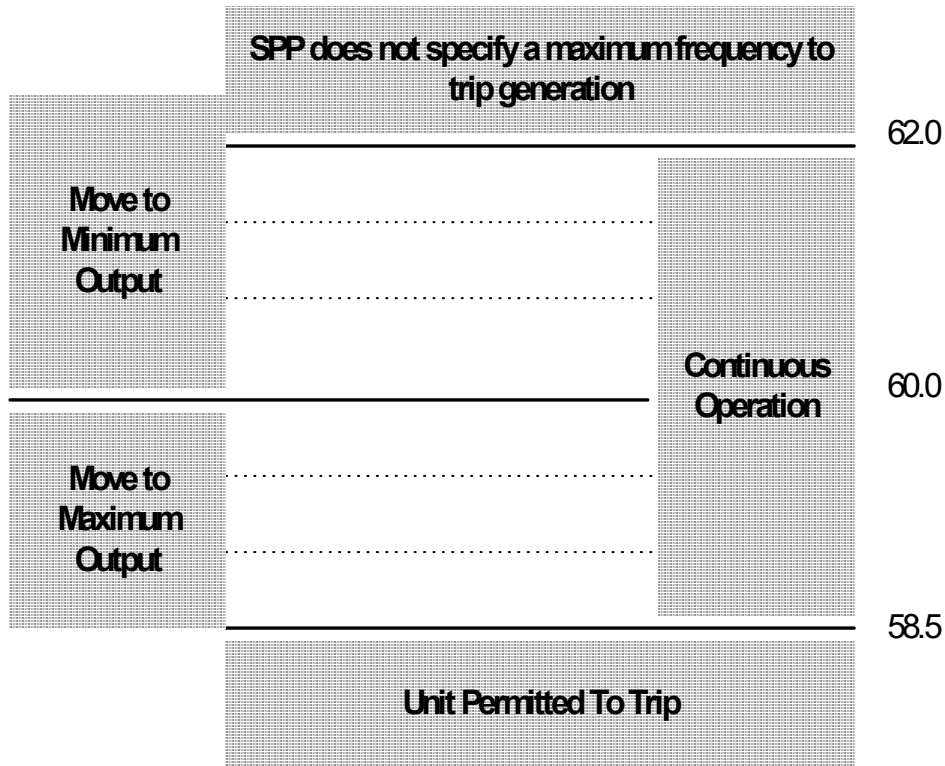
SPP Criteria (Sec. 7.3) requires that the generator under-frequency tripping be coordinated with its load shedding. Specific generator setting constraints are not provided by SPP. The SPP has three mandatory under-frequency load shedding levels: 59.3 Hz, 59.0 Hz, and 58.7 Hz. SPS has elected to have a fourth level, as permitted under SPP criteria, to automatically trip generators. Due to the structure of the under-frequency load-shedding plan, it is necessary that generators be able to sustain frequencies to at least 58.5 Hz. Any generator that must trip off-line prior to the system frequency declining to 58.5 Hz must have a block of load connected to the generator and equal to the generator's output capability tripped at the same frequency as the generating unit. To fulfill this requirement, coordination with Xcel Energy is required during the under-frequency relay-setting phase for the generator plant. The Interconnection Customer is required to report their generator off-nominal frequency tripping relay settings to SPP and SPS.

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4. WECC REGION OVER/UNDER-FREQUENCY GENERATOR TRIPPING

All transmission-connected Generation units’ over/under-frequency protective (device 81 O/U) relaying, if installed, must be set to coordinate with the area automatic load shedding program. The following settings are in accordance with the WECC Coordinated Off-Nominal Frequency Load-Shedding and Restoration Plan. All Interconnection Customers must provide the off-nominal generator frequency relay settings for their units to the WECC and Xcel Energy. Any change in settings must also be reported.

Only solid state and/or microprocessor frequency relays will be allowed on generators to provide off-nominal frequency protection in the range of 57.9-61.0 Hz. All generators connected to the transmission system should be no more restrictive than the specifications defined within the most current version of NERC Standard PRC-024 (including generators connected to the non-BES transmission system).

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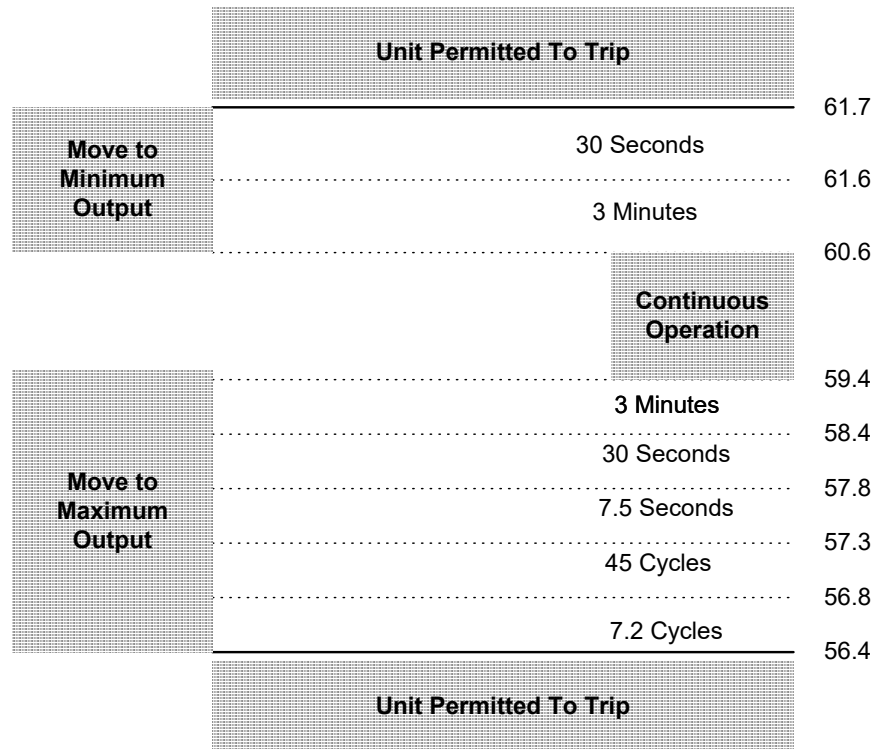
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The Interconnection Customer is responsible for protecting their generation units. The manufacturer’s recommendations for some units may be more restrictive than PRC-024-2. In such cases, the Interconnection Customer should follow the manufacturer’s recommendations. Interconnection Customers who have units that violate PRC-024-2 must contract with Xcel Energy or another entity to trip an equivalent amount of additional load for off-frequency excursions in accordance with the WECC Coordinated Off-Nominal Frequency Load-Shedding and Restoration Plan.

I. GENERATOR REACTIVE CAPABILITY

1. INDUCTION GENERATORS AND INVERTERS

Induction generator installations must provide power factor control within a range of 0.95 leading to 0.95 lagging at the system operating voltage at the POI. The Interconnection Customer must provide any capacitors or other devices needed to achieve this power factor performance level. Under lagging reactive power facility conditions, the Interconnection Customer is responsible for ensuring that self-excitation of the induction generators does not occur, including under the various outage combinations that might occur in the local Xcel Energy System. The Interconnection Customer is responsible for ensuring that high voltages from self-excitation are not applied to the Xcel Energy System.

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All IBRs shall comply with the requirements specified in the most recent version of IEEE 2800. Reactive power supply requirements for inverter systems can be similar to those for induction generators. Self-commutated inverters must meet the same requirements as synchronous generators, and line commutated inverters must meet the same requirements as induction generators.

2. MINIMUM POWER FACTOR REQUIREMENTS

Generators generally must provide for their own reactive power needs, including the reactive power needs of their Generator Step-Up transformer (GSU). Interconnection Customers who self-provide station service will be expected to provide sufficient facilities and controls to operate their combined generation and load within a range of 0.95 leading to 0.95 lagging power factor of the load or be subject to the power factor penalties associated with the service rate. All other generators are required to provide reactive power, upon the request of the system dispatchers, within a range of 0.95 leading to 0.95 lagging at the system operating voltage, as measured at the POI (unless a greater range is specified under an ancillary services contract). Generators will be expected to meet the following criteria:


- Generator operating at less than or equal to 10 % - operate at unity.
- Generator operating greater than 10% - must meet ± 0.95 leading and lagging.

The Interconnection Customer must respond dynamically to meet system performance requirements unless exempted. The Interconnection Customer is expected to provide reactive power up to the generation unit's reactive power capability curve (a.k.a. "D" Curve, see typical diagram below) during system emergency conditions.

Some portions of the Xcel Energy System (the NSP system) are located in or adjacent to balancing authorities where other load serving entities (municipals or cooperatives) 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 customer-site load-management devices. The 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 by shunting to ground the ripple signal through the capacitor bank(s). To prevent such degradation, appropriate tuned blocking filters may be required.

3. VOLTAGE CONTROL BY GENERATION RESOURCES

Voltage Control is a FERC defined ancillary service under the applicable OATT. These are Xcel Energy's present minimum requirements for such service. However, the final requirements will be based on any mandated MRO/SPP/WECC, NERC, ISO, or RTO interconnection requirements. Any generator providing this service to the Control Area Operator must be able to automatically control the voltage level by adjusting the machine's power factor within a continuous range of between + 0.90 to - 0.90 power factor based on the station's sum total name plate generating capability as measured at the transmission system's point of interconnection. The voltage or var set point that the generator needs to maintain will be established and dispatched as necessary by Xcel Energy's Control Centers.

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4. GENERATOR STEP-UP (GSU) TRANSFORMER SPECIFICATIONS

The Generator Step-Up (**GSU**) Transformer specifications (including taps if applicable) will be determined by the Interconnection Customer to insure proper coordination of voltages and regulator action. Interconnection Customer may contact Xcel Energy for information on the transmission systems as needed to determine generator transformer specifications. The ANSI Standards require that generators be capable of delivering rated power capability when operated within +/-5% of its rated terminal voltage. The generators of the Interconnection Customer shall operate to fulfill this requirement by selecting the appropriate GSU Transformer tap ratio setting. In some cases, such as facilities with a high-impedance GSU Transformer, a voltage regulator (or tap changing under load) will need to be installed at the expense of the Interconnection Customer. Furthermore, the final GSU Transformer winding (fixed) tap ratio is often selected so as to provide a voltage boost over the nominal generator terminal operating voltage (e.g., 13.2kV GSU LV tap for 13.8kV generator terminal nominal voltage). This provides compensation for var absorbed by the GSU Transformer, needed to be accounted for in the HV side POI power factor requirements.

The high voltage winding configuration of the GSU transformer shall be designed such that the high voltage system is effectively grounded, as defined by IEEE 142, with Xcel Energy's system disconnected. Typical and accepted winding configurations are wye-delta, auto wye-delta, wye-wye-delta and wye-delta-delta.

5. GENERATOR CAPABILITY CURVES

A copy of the generator capability curves supplied by the generator manufacturer must be provided to Xcel Energy for each generator at the Interconnection Customer's facility as soon as the information is available. These curves, along with related electrical impedance data on the generator and step-up transformers, must be supplied prior to the final On-Line Testing, including the var capability testing, required before a facility can be declared commercial.

Either stator or rotor winding heating limits the allowable reactive power. The generator reactive capability is greatly affected by cooling. The figure below illustrates the impact of different hydrogen pressures. Many generators are air-cooled and ambient air temperatures have a major impact on generator output ability. The Interconnection Customer is required to operate the cooling at full rated hydrogen pressures and to ensure full machine capability is maintained under normal conditions.

The portion of the capability curve above the horizontal MW line represents the vars that can be supplied to the system. This region is referred to as "lagging" or "overexcited". The curve below the MW line represents the vars that can be absorbed from the system by the generator. This region is referred to as "leading" or "under excited". When Xcel Energy's transmission voltage is running in a high voltage condition (typically under "lightly loaded" conditions), the Interconnection Customer may be required to absorb vars from Xcel Energy's System to help bring the voltage down. Note that the vars shown on the gen. capability ("D") curve reflect the var output at the generator terminals, and do not reflect the vars and power factor as measured at the POI (typically the HV side of the GSU transformer). The generator

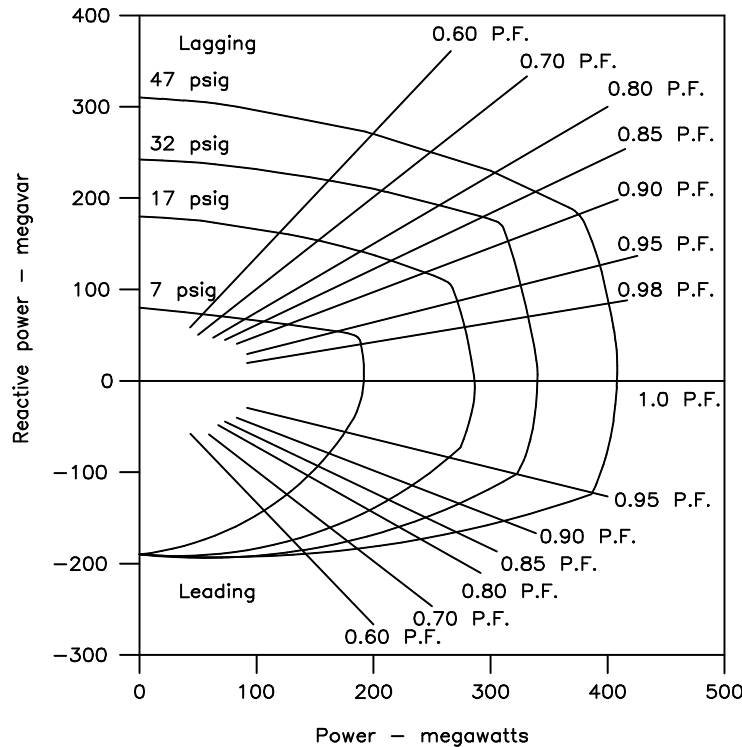
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may be required to operate at a significantly lower power factor value in order to meet the +/- p.f. values as measured at the POI, largely due to the vars absorbed by the GSU transformer.



J. POWER SYSTEM STABILIZERS GENERATOR CAPABILITY CURVES

1. MRO POWER SYSTEM STABILIZERS

Power System Stabilizers (PSS) or equivalent devices shall be applied to all units larger than 70 MVA where results from field tests and dynamic and/or small signal stability studies have determined the potential for unit or system instability and where the condition can be improved or corrected by the application of such devices.

The MRO-S2 Criteria requires power system stabilizers or equivalent devices shall be designed and tuned to have a positive damping effect on local generator oscillations as well as inter-plant and inter-area oscillations without deteriorating turbine/generator shaft torsional oscillation damping. The power system stabilizer shall be designed to ensure system performance as defined in Categories A, B, and C of Table I.A. Standards on Transmission Systems, and the MRO Disturbance-Performance Table.

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The Interconnection Customer and the Transmission Provider must work jointly and provide results, prior to the generator's in-service date and as required by changes in system conditions, which clearly show whether or not power system stabilizers or equivalent devices are required on the generator(s) in question. The Interconnection Customer must provide results from field tests, such as Automatic Voltage Regulator (**AVR**) open circuit 2% and 5% step response tests). The Transmission Provider shall provide dynamic stability and/or small signal stability study results. These results should provide evidence of high generator relative participation (relative participation factors greater than 0.1 or 10%) in a range of local, inter-plant and inter-area modes (0.1 to 2.0 Hz).

Interconnection Customers and the Transmission Provider must work jointly and provide results, prior to the Generator's in-service date and as required by changes in system conditions, that demonstrate compliance with the system performance requirements as defined in Categories A, B, and C in Table I of Standard I.A. and the MRO Disturbance-Performance Table. The Interconnection Customer must provide results from field tests such as a frequency response test to verify the power system stabilizer linear characteristics. (Detailed information about generator test data can be found in the MRO Generator Testing Requirements.) The Transmission Provider shall provide dynamic stability and/or small signal stability study results. Any non-compliance shall be documented, including a plan for achieving compliance.

Documentation of these assessments shall be provided to the Regional Reliability Council and those entities responsible for the reliability of the interconnected transmission systems upon request.

2. WECC POWER SYSTEM STABILIZERS

- a. The following criteria shall be used to determine when a PSS must be installed on a synchronous generator, regardless of ownership, that is connected to the transmission system (by generator step-up transformer to 60 kV or higher voltage):
 - i. A PSS shall be installed on every existing synchronous generator that is larger than 75 MVA and is equipped with a suitable excitation system as defined in the report "Criteria to Determine Excitation System Suitability for PSS", dated December 1992 (available on WECC website, www.wecc.org).
 - ii. A PSS shall be installed on every existing synchronous generator that is larger than 30 MVA or is part of a complex that has an aggregate capacity larger than 75 MVA, if the excitation system is updated so that it becomes a suitable excitation system as defined in the report mentioned in 1a above. This section applies to all machines whose excitation system is updated at any time after November 18, 1993.
 - iii. A PSS shall be installed on every synchronous generator that is larger than 30 MVA or is part of a complex that has an aggregate capacity larger than 75 MVA and is equipped with suitable excitation systems as defined in paragraph 1a and is commissioned after November 18, 1993.
 - iv. A PSS is not required on a station service generator.

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- b. When a generator that is equipped with a functional PSS is online, the PSS shall be in operation except for the following reasons:
 - i. Maintenance and testing.
 - ii. PSS exhibits instability due to nonstandard transmission line configuration.
 - iii. PSS does not operate properly due to a failed component.
 - iv. Unit is operating in the synchronous condenser mode (very near zero power level).
 - v. When a unit is generating less power than its design limit for effective PSS operation.
 - vi. When a unit is passing through a range of output that is a known "rough zone".


The aggregate MVA of the synchronous machines that are online and equipped with a functioning PSS shall not fall below the level identified in the most recent power system stabilizer study commissioned by the WECC.

- c. When a synchronous generator that is equipped with a PSS is operating in the pump mode (P/G unit) and is connected to a transmission system such that the PSS does not produce negative damping, the PSS should be in service.
- d. PSS equipment must be tested and calibrated in conjunction with AVR testing and calibration. This will be done as often as is necessary to maintain reliable PSS performance in accordance with the "WECC PSS Tuning Criteria" (available on WECC website, www.wecc.org). PSS recalibration must be performed if AVR response parameters are modified. When a PSS is taken out of service because of a failed component, the party responsible will be expected to perform the needed repairs (or replacement) in a responsible and timely manner.
- e. A PSS is not required for a synchronous condenser.

It is the responsibility of the Interconnection Customer to arrange for any and all design modeling, settings, testing, and field adjustments necessary to incorporate the PSS as an operational part of the generator's control system. Xcel Energy must be given the opportunity to review the PSS setting data and test procedures, and to witness the testing and operation of the generator's PSS. Whenever the generator is connected to the Xcel Energy System, the generator's PSS must be operated in-service. An exception is allowed for testing. The PSS should be tested periodically.

The WECC has established settings, modeling, and testing guidelines for PSS systems, per the WECC Planning Coordination Committee document of March 21, 1997 on "Testing of Synchronous Unit Reactive Limits and Dynamic Testing/Model Validation". The Interconnection Customer must provide complete documentation of PSS related settings and test data to Xcel Energy prior to the Interconnection Customer's facility being declared ready for "Commercial Operation." This documentation must be in compliance with the WECC test/data forms included with the aforementioned WECC 1997 document.

In addition to the PSS, the generator's AVR shall be an integral part of the excitation control system. All generators 10 MVA and larger must be equipped with automatic voltage control equipment. All generating units with automatic voltage control equipment must normally be operated in a voltage control mode. These generating units must not be operating in any other mode (e.g. constant

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power factor control) unless authorized to do so by the Control Area Operator. The AVR must be properly tuned and tested in accordance with IEEE 421 for continuously acting AVRs. All AVRs must be in-service at all times that the Interconnection Customer’s generator is connected to Xcel Energy. The generator’s AVR must be able to ride through reactive element switching on the Xcel Energy System. An exception is allowed for testing.

3. SPP POWER SYSTEM STABILIZERS

SPP does not require power system stabilizers at this time, however, the inclusion of a PSS is preferred. SPP is currently reviewing the policy for PSS. New rules for PSS, if adopted, will apply.

K. FAULT CURRENT


Xcel Energy’s protective equipment fault current capability is based on the use of equipment with greater capability than the maximum fault current available at a location. The Interconnection Customer’s equipment capability must exceed the maximum fault current available. On the Xcel Energy System, this value may be over 63,000 amps. The exact value of available fault current depends upon location and circuit configuration and will be determined in the Interconnection Facilities studies. The Interconnection Customer must work closely with Xcel Energy at the time of the interconnection design to determine the available fault current at the specific location of interconnection. In addition this value may increase over time due to growth and changes in the interconnected power system. Therefore, the Interconnection Customer should make accommodations for reasonable increases in fault current in designing its Facility.

L. SYSTEM RESTORATION AND BLACK START CAPABILITY

Under an extreme emergency, large portions of the U. S. electric power grid may shut down. The Xcel Energy BA/TO Areas, in conjunction with MRO, SPP, and WECC, have developed a process for restoring the Xcel Energy BA/TO Areas and, by request, adjacent BA/TO Areas. Xcel Energy may need to obtain more black start capability from time to time. If the Interconnection Customer is interested in pursuing this service, indicate so on your application to get the specific details and requirements.

M. DISCONNECT DEVICE/POINT OF DEMARCATION

A disconnect device must be installed to isolate Xcel Energy’s System from the Interconnection Customer’s generation. This disconnect shall be installed and owned by the Interconnection Customer and shall provide a visible air gap and lock to establish required clearances for maintenance and repair work of the Xcel Energy System. Xcel Energy does not consider the integral switch available on some circuit-switchers as an acceptable way to meet this requirement. Xcel Energy may require the design to allow the application of personnel safety grounds on Xcel Energy’s side of the disconnect device. OSHA lockout/tag requirements must be followed.

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The disconnecting device must be accessible at all times to Xcel Energy personnel. The Disconnects should allow being padlocked in the open position with a standard Xcel Energy padlock. The Interconnection Customer shall not remove any padlocks or Xcel Energy safety tags. The Interconnection Customer must provide access to disconnect at all times (24 hours a day telephone number, guard desk, etc.). The disconnecting equipment must be clearly labeled. The disconnecting equipment shall be approved for the specific application and location.

N. EFFECTIVE GROUNDING

Xcel Energy maintains effective grounding on its transmission systems, as defined by IEEE 142. All Interconnection Customer facilities connected to Xcel Energy's System must be effectively grounded per the IEEE 142 requirement. These calculations should be made as if the Xcel Energy system was disconnected from the Interconnection Customer (The Interconnection Customer must meet the effective grounded system criterion independent of the Xcel Energy system).

IEEE 142 requires that: The positive sequence reactance is greater than the zero-sequence resistance ($X_1 > R_0$); and the zero-sequence reactance is less than three times the positive sequence reactance ($X_0 < 3X_1$).

III. EQUIPMENT, PROTECTION AND CONTROL REQUIREMENTS

This section indicates the minimum Xcel Energy design requirements for the major components of generating facilities interconnecting to the Xcel Energy transmission system. In accordance with FERC Order 2003, any facilities constructed by the interconnection customer that will be ultimately owned by Xcel Energy shall be designed using Xcel Energy substation and transmission design and material standards, which will be made available upon request. The interconnecting party must communicate and coordinate its system protection design and settings with the Xcel Energy system protection engineering staff.

A. FAULT CLEARING AND BREAKER DUTY

1. A circuit breaker is required to be installed by the Interconnection Customer on the HV side of the Interconnection Customer's GSU transformer. Circuit breakers must be capable of interrupting present and future available fault current at the location at which they are being installed. Fault currents will change on the Xcel Energy system over time. The Interconnection Customer needs to periodically check fault levels to ensure their breaker meets these ever-changing values. This device will be installed and owned by the Interconnection Customer. Sync-check relay(s) must be installed with the circuit breaker to ensure synchronous closing. Breaker failure relaying shall also be included. Circuit breakers shall meet the latest applicable ANSI and IEEE standards and shall be suitable for the local environment and system operating conditions. It is presumed that the installation meets the NEC/NESC certified by appropriate authorities to ensure safety of Xcel Energy personnel.
2. Application of ground-switches to trigger remote tripping is not an acceptable practice.
3. The Interconnection Customer's and Generator's internal auxiliary equipment, generator, or generator step-up transformer must not trip existing transmission lines as a primary protection method.

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4. The Interconnection Customer immediately and automatically isolates any faulted or failed equipment from the Xcel Energy System. This automatic equipment must be compatible with the existing transmission protection equipment.

Xcel Energy will require approval only for those portions of the Interconnection Customer's design that pertain directly to the protection of Xcel Energy System. Xcel Energy may make suggestions or comment on other areas; however, the Interconnection Customer is responsible for the design of protection schemes associated with their generating facility.

B. UTILITY GRADE RELAYS

Utility grade protective and control relays are required for all generation facilities interconnected to the Xcel Energy System. The applicable relays are described in the next section (C. Minimum Protection Requirements) or as designated by the Facilities Study. The relays must:


1. Meet or exceed ANSI/IEEE Standards for protective relays (i.e., C37.90, C37.90.1, C37.90.2 and C37.90.3).
2. Have documentation covering application, testing, maintenance, and service.
3. Give positive indication of what caused a trip (Targets).
4. FT-1 or equivalent switches are required to facilitate testing.

The Interconnection Customer is strongly encouraged to use microprocessor-based protective relays. The self-diagnostic abilities, the sequence of events capabilities, and the increased flexibility of application are highly desirable. Xcel Energy may require that microprocessor style relays be utilized for certain interface relay applications.

C. MINIMUM PROTECTION REQUIREMENTS

The following functions are required as a minimum to protect Xcel Energy's equipment. The Facilities Study will determine specific protective requirements for the transmission line.

- a. Over-voltage (59).
- b. Under-voltage (27).
- c. Over/Under Frequency (81O/81U).
- d. Two zone Distance, Phase and Ground, (21). On short transmission lines current differential relay(s) and fully redundant communication assisted schemes are required per current Xcel Energy philosophy. On installations where the Interconnection Customer step up transformer is directly adjacent to Xcel Energy's substation redundant bus differential relays are required.
- e. Ground Overcurrent Relay (51N).
- f. Transformer Differential Relay (87T).
- g. Breaker Failure Relay (50BF).
- h. Breaker Failure Initiate from all appropriate protective relays.
- i. Reverse Power (32).

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- j. Synchronizing Check (25X).
- k. Speed-Matching (15) for induction generators.

The following additional protection functions may be suggested or required depending upon the size of the generator, nature of interconnection and coordination requirements with the Xcel Energy Protective Systems:

- a. Out-of-Step (68).
- b. Voltage Balance (60).
- c. Phase Sequence (47).
- d. Transfer-Trip (TT).
- e. Directional Overcurrent (67).
- f. Additional Surge Arresters.
- g. Disturbance Recorder.
- h. Power Quality Meter

The plant must follow the requirement of IEEE 2800 to ensure that the protective functions of the plant coordinate with those of the transmission systems and shall not limit the ability of the plant to meet the ride-through performance requirements.

The plant must also follow the recommendations identified in the NERC 2022 Odessa Disturbance report, chapter 1 and chapter 2 (pg 16-17).


D. REDUNDANT/BACKUP PROTECTION

Relays protecting the Xcel Energy system shall be designed to ensure that the failure of a single protective relay will not result in failure to clear the fault. 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 design shall provide the necessary backup that will meet the Xcel Energy standards and regional protection requirements.

E. SYNCHRONIZATION OF GENERATION

The Interconnection Customer is responsible for synchronization of the Interconnection Customer's generation to the Xcel Energy System. Xcel Energy is not responsible for the design of the Interconnection Customer's synchronization relaying. It is highly recommended that the Interconnection Customer consult with the equipment manufacturers when setting relays associated with the protection of their equipment.

The Interconnection Customer is responsible for ensuring that their generators separate before an out-of-step condition can occur. Depending on the system topography in the area, this may require arranging for Xcel Energy to install transfer-trip or some other supplementary measures.

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1. SYNC-CHECK RELAYS

Xcel Energy requires sync-check relays to be installed on all circuit breakers interconnecting the generation facility to its transmission system. These relays, with additional voltage monitoring functions, will supervise the closing of the circuit breaker. If this is also the point of generator synchronization, it is highly recommended to install additional automatic synchronizing equipment. However, Xcel Energy will be responsible for reviewing only the settings and operation of the sync-check relay that will be supervising the automatic synchronizer. The sync-check relay to be used shall be pre-approved by Xcel Energy. The relay shall contain the manufacturer’s optional voltage monitoring functions. Automatic re-closing after tripping due to a transmission system fault is not allowed unless the generation is disconnected from the system.

2. INDUCTION GENERATOR SYNCHRONIZING

Speed matching may be by any means such that voltage regulation and voltage flicker at the Point of Interconnection (POI) is held within the tolerances described in IEEE 519 and IEEE 1453.


F. STATION POWER/STATION SERVICES

The Interconnection Customer is responsible for securing a source of AC Station Power for the Generation Facility in accordance with FERC, regional ISO and/or local state requirements. If applicable, Xcel Energy may provide the AC Station Power also pursuant to corresponding regulatory requirements and the Retail Tariff of the local Xcel Energy Operating Company. If the Interconnection Customer is located outside the retail service area of the applicable Xcel Energy Operating Company, the Interconnection Customer is required to secure Station Power from the Load Serving Entity serving that geographic location in accordance with FERC, regional ISO and/or local state requirements.

If the Interconnection Customer does provide for its own source of AC Station Power and is constructed such that it is adjacent to the Xcel Energy facility, Xcel Energy may require **AC Station Services** for its facility be supplied from the generating facility. In this case the Interconnection Customer will be expected to match the regional Station Service voltage in use by Xcel Energy. The three most common voltages are: 1) 120/240 VAC single phase, three wire; 2) 120/208 VAC three phase, four wire; and 3) 120/240 VAC three phase, four wire.

G. GROUNDING SYSTEM

The Interconnection Customer is responsible for the appropriate safety grounding of their equipment and facility. At the point of interconnection, the Interconnection Customer’s grounding equipment must be compatible with Xcel Energy’s grounding equipment. The Interconnection Customer shall submit the grounding system study and design for Xcel Energy review prior to construction. The ground grid design must comply with IEEE 80 and properly address site extremes. Site tests should be completed to determine soil resistivity prior to ground grid design. Interconnections, if any, between Xcel Energy and Customer grounding

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systems must protect from damage all copper control, relaying, and/or communication circuits passing between the facilities under all operating conditions.

H. CONTROL, PROTECTION, AND COMMUNICATION INTERCONNECTIONS

The design and installation of all copper, fiber, and other signals, if any, passing between adjacent Xcel Energy and Customer facilities shall be coordinated with Xcel Energy. A point of demarcation shall be identified for raceway, cabling, and other interfaces for the delineation of the scope of responsibility between the parties.

I. TRANSMISSION LINE INTERCONNECTIONS

Any customer-owned tie line will be designed, procured, installed, owned, operated, and maintained by the Customer. Xcel Energy will design, procure, install, own, and maintain the substation dead-end structure, the first structure away from the dead-end and the span between. The attachments for the customer-provided spans terminating on the first structure will be coordinated between the parties.

J. COMMUNICATION CHANNEL(S)

Xcel Energy may require that a communication channel and associated communication equipment be installed as part of the protective scheme. This channel may consist of power line carrier, fiber optic cable, radio, or other means. Communication channels may be needed for telemetry, generation control, monitoring, or protection/control purposes. The Facilities Study will determine the specific communication channel requirements.

K. METERING AND TELEMETRY

1. REVENUE METERING

All generating units are required to have metering installed such that the delivery of power and energy to or from the Interconnection Customer and the Xcel Energy System can be determined. The metering installation shall be of billing accuracy. The standard installation will be located at the Point of Interconnection and possibly in a suitable location for metering the generator gross output, when applicable per specified local requirements. Each operating company (NSP, PSCo, SPS) may have specific requirements for the metering configuration and will be evaluated on a site-specific basis. The metering installation normally will be owned and maintained by Xcel Energy. The metering installation includes the CTs, VTs, meter, recorder, remote communication unit (usually a modem), and any auxiliaries required. Additional detail on revenue class metering, telemetry to the Xcel Energy System Control Center, and Load Frequency Control/Automatic Generator Control is provided in Appendix B.

2. INTERCONNECTION CUSTOMER FACILITY NET GENERATOR OUTPUT TELEMETRY AND CONTROL

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- a. Automatic Generator Control (AGC) is the changing of the plant or unit output (remote control) based on a signal generated by either the Transmission Owner's Energy Management System, or in response to a signal generated by another Energy Management System. The hardware and operational requirements of the control will be specified in the interconnect agreement. The requirements can vary depending on the type of plant, the destination of the plant output, any contractual terms in the Power Purchase Agreement, and the telemetry hardware required to interface the appropriate Energy Management System. The remote control will be implemented through the telemetry equipment. For most applications requiring AGC control, separate signals and telemetry will be employed for each individual generator. AGC will not be required if the unit or plant is exempt from RRO or NERC rules due to prime mover or regulatory limitations. See Appendix B for additional requirements.

- b. Regardless of AGC requirements, an interconnected generator(s) may be required to be staffed or have the ability to be operated remotely at the direction of the Xcel Energy Control Center operators. If required for the reliable operation of the bulk electric system, this control requirement will be specified in the interconnection agreement. Xcel Energy reserves the right to require an existing facility to meet the requirements to be staffed or operated remotely at a later date if system conditions change if this requirement is not identified in the original interconnection agreement.

- c. Regardless of AGC requirements, additional (non-revenue) facility net MW and Mvar output telemetry is typically installed at the POI, utilizing the same CTs and VTs as the Revenue metering. This information is sent to the applicable XE control center for indication of the Interconnection Customer Facility's net generation output to XE.

- d. All new or expanding renewable (wind, solar, and BESS) generation plants with output equal to or greater than 20MW may be required to provide the equipment necessary to facilitate data point monitoring and remote control for AGC. Data points to be supplied may include but are not limited to the table listing below. Specific data point requirements for any new generation will be identified in the Power Purchase Agreement and/or the Generation Interconnection Agreement. Renewable energy generation plants located within the MISO or SPP operating footprint are subject to any AGC requirements of those organizations. Any discrepancy regarding renewable energy AGC between these Guidelines and the requirements of MISO or SPP will be governed by those of the controlling RTO.

DATA POINT	GENERATION TYPE (Solar, Wind, Fossil Fuel, and BESS)
Real Power (MW)-POI	All four
Reactive Power (MVAR)-POI	All three
Real Power (MW)--Generator Collector	All four
Reactive Power (MVAR)--Generator Collector	All four
Line Voltage (kV)--POI	All four
Line Voltage (kV)--Generator Collector	All four
Line Current (Amperes)--POI	All four
Neutral Line Current (Amperes)--POI	All four
Turbine Generation (kW)	Wind

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Panel Generation (kW)	Solar
Wind Speed (mph)	Wind
Wind Direction (NESW)	Wind
Solar Concentration (irradiance)	Solar
Turbines Generating (#)	Wind
Turbines Available (#)	Wind
Total Turbines (#)	Wind
Panels Producing (#)	Solar
Panels Available (#)	Solar
Total Panels (#)	Solar
Ambient Temperature	All four
Air Pressure (mb)	Wind
Air Density (kg/m3)	Wind
Breaker Status (#)	All four
MW Setpoint (MW)	All four
Park Potential (#)	Wind
Farm Potential (#)	Solar
Remote/Local (bit)	All four
VAR Setpoint/Voltage Setpoint (MVAR/kV)	All four
MW Setpoint Echo (MW)	All four
VAR Setpoint/Voltage Setpoint Echo (MVAR/kV)	All four
Power Factor Setpoint (#)	All four
High Wind Cutoff (MW?)	Wind
Maximum VAR Output Available (MVAR)	All four
Maximum VAR Intake Available (MVAR)	All four
Slew Rate (MW/second)	Solar and Wind
AGC control on/off	All four
Regulation up/down	All four
Ramp rate up/down	All four
Battery ramp rate	BESS
Battery discharge rate and time	BESS
Battery charging rate and time	BESS
Battery emergency discharge rate	BESS
Battery emergency charge rate	BESS
Control Mode (MVAR, MW, or Power Factor)	All four
Status of Reactive Devices	All four
High Side Total Harmonic Distortion Va (THDV.a)	All four
High Side Total Harmonic Distortion Vb (THDV.b)	All four
High Side Total Harmonic Distortion Vc (THDV.c)	All four
High Side Total Harmonic Distortion Ia (THDI.a)	All four
High Side Total Harmonic Distortion Ib (THDI.b)	All four

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High Side Total Harmonic Distortion Ic (THDI.c)	All four
Specific order harmonic data (dependent on inverter type)	All four

J. SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

Certain Interconnection Customer substations with a 69 kV or greater voltage circuit breaker must provide remote control of the circuit breaker to the applicable Xcel Energy BA/TO operators. The equipment data and statuses, which are to be provided, as applicable, include, but are not limited to what may be provided:

- a. Breaker position.
- b. Motor-operated disconnect position.
- c. Bus voltage and alarming.
- d. Loss of AC and DC voltage alarms.
- e. GSU Transformer MW and Mvar values.
- f. Lockout relay status.
- g. Other points as necessary to provide comparable control and indication to Xcel
- h. Energy control standard.
- i. Digital Fault (Transient)/Dynamic recorder trouble alarm.
- j. Protective Relay malfunction alarms.
- k. Energy accumulator or integrator.

K. VOLTAGE AND BIL VALUES

The Interconnection Customer must ensure that all equipment is adequately protected from excessive system over-voltages. This includes selection of equipment Basic Impulse Insulation Level (BIL) and protective devices (e.g. surge arresters) to achieve proper insulation coordination with Xcel Energy's system and protection of equipment. The addition of new generation to Xcel Energy's System in general should be modeled, hardware in-loop (RTDS, Opal RT) or Electromagnetic Transients Program (EMTP) studies may be required. The Facilities study will identify whether these detailed studies are required. If so, these studies should be completed before other major engineering work on the project commences. The following table indicates voltage and BIL levels found on most of the Xcel Energy transmission system.

Customer may need to determine, through their studies, the appropriate BIL, SA MCOV and energy requirements for their equipment.

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VOLTAGE AND BIL LEVELS CURRENTLY IN USE IN TYPICAL XCEL ENERGY SUBSTATIONS:


Transmission Substation Standard BILs and Surge Arrester Ratings			
Voltage (kV)	BIL (kV)⁽¹⁾	MCOV(kV)⁽²⁾	Duty-Cycle (kV)
13.2	150	8.4	10
13.8 ⁽³⁾⁽⁴⁾	150	8.4	10
34.5 ⁽³⁾⁽⁴⁾⁽⁵⁾	200	22	27
46	250		
69	350	48	60
88	450	57	72
115	550	76	96
138	650	84	108
161	750	106	132
230	900	152	192
345	1300	230	288
500	1550	335	420

⁽¹⁾The standard BIL refers to external equipment and bus work BIL ratings. Transformers and other equipment sometimes use lower or higher internal BIL levels.
⁽²⁾This is the Maximum Continuous Operating Voltage for Metal Oxide Surge Arrester Applications. The standard surge arrester rating may not be correct for all locations. Engineering must verify the rating to use for each substation.
⁽³⁾Where surge arresters are installed for transformer delta tertiary windings rated for 13.8kV or 13.2kV, the surge arresters shall be rated for 15.3kV MCOV and 18kV duty-cycle. Where surge arresters are installed for transformer delta tertiary windings rated for 34.5kV, the surge arresters shall be rated for 39kV MCOV and 48kV duty-cycle.
⁽⁴⁾ Due to overvoltage during 3I₀ faults, arresters used on network feeders must have a nominal voltage rating of greater than phase-to-phase voltage (13.8kV)
⁽⁵⁾At elevations of 10,000 ft. and above, a 250kV BIL rating should be assumed.

Table 1

L. INTERCONNECTION FACILITY RATINGS

The facility rating for the interconnection between the interconnection customer and the Xcel Energy transmission facility will be based on the most limiting equipment rating of each party's equipment. The Xcel Energy facility rating methodology will be applied to all Xcel Energy-owned equipment. The Customer's facility rating methodology will be applied to Customer-owned equipment. The overall rating, and publication thereof, of any composite facilities will be coordinated with Xcel Energy's facility rating group. All ratings and related procedures will consider ratings methodologies of the interconnection customer and Xcel Energy, as well as any applicable NERC, RRO, or RTO requirements.

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M. REMEDIAL ACTION SCHEME

The use of a Remedial Action Scheme (formally called a Special Protection System) within the NSP service territory is addressed in the Transmission Planning Criteria Manual for the NSPM and NSPW Transmission System. The Transmission Planning Criteria Manual for the NSPM and NSPW Transmission System can be found on MISO's [Policy, Procedure, Standards Template \(misoenergy.org\)](http://misoenergy.org)

The application of a Remedial Action Scheme (RAS) on the SPS transmission system is permitted only if the RAS is temporary. The Southwest Power Pool (SPP) Planning Criteria identifies the requirements for a Temporary RAS installation along with the RAS Sponsor's NERC compliance obligations associated with the Temporary RAS. The addition of an Extended Use RAS is not permitted on the SPS transmission system. The [SPP Planning Criteria](https://www.spp.org/spp-documents-filings/?id=18162) document can be found on the SPP website www.spp.org (<https://www.spp.org/spp-documents-filings/?id=18162>).

IV. VARIABLE ENERGY RESOURCE (VER) INTERCONNECTIONS


The following Variable Energy Resource (VER) interconnections are subject to specific interconnection requirements due to the operational characteristics of the VER generator technology.

A. INVERTER CONNECTED VER (PV SOLAR, TYPE 4 WIND, BESS GENERATOR)

Inverter Connected VER Generation is normally energy supplied by photovoltaic sources, fuel cells, wind, battery, or other energy supply, which requires a conversion from DC to AC to connect to the Xcel Energy transmission system. These systems must adhere to the standards for harmonics, flicker, and voltage. The protection and design for Photovoltaic Systems must meet IEEE Standards 2800, C37.90, C37.90.2, C37.90.3 and ANSI/IEEE Standard 519, ANSI/IEEE Standard 929 and the NEC. A good companion book to the NEC is the "Photovoltaic Power Systems and National Electric Code" booklet published by the Photovoltaic Design Assistance Center. Another booklet, "Interim Qualification Tests and Procedures for Terrestrial Photovoltaic Thin-Film Flat-Plate Modules" (ANSI/IEEE 928), is also available from the Photovoltaic Design Assistance Center.

B. ASYNCHRONOUS (INDUCTION) MACHINE CONNECTED VER (TYPE 1, 2, 3 WIND GENERATORS)

Wind generation systems typically use induction generators. Reactive power supplies for induction generators may pose difficult problems. The installation of capacitors or dynamic voltage control devices to mitigate reactive power problems and allow higher power factor operation must be studied on an individual basis. In general, the wind energy plant cannot trip off-line for faults remote from the point of interconnection. Nor

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can the behavior of the wind energy plant cause other generating units to trip off-line. There may be specific Reliability Council requirements that must also be met for wind generation.

Trip-out, commutation failure, short circuit, or other malfunction at one turbine, on the Interconnection Customer's or Xcel Energy's collector system serving a set of turbines, or at a point of interconnection, shall not cause cascading or sympathetic trip-out of other generating units within Interconnection Customer's development – either local or remote – unless required to prevent damage to electrical facilities, or to isolate faulty devices, equipment or circuits.

Wind energy plants sometimes will cause a significant voltage variation as the MW output of the plant changes in response to varying wind input conditions. However, protective systems must be installed so this variation is not passed on to the Xcel Energy transmission system. In general, the voltage variation at the point of interconnection should not vary more than 1.5% for voltage oscillations with periods of 15 seconds to 5 minutes.

C. FERC APPROVED INTERCONNECTION REQUIREMENTS FOR A VER GENERATION PLANT

The following requirements set forth requirements and provisions specific to VER generation plants as approved by FERC. These requirements were designated as Appendix G to the Large Generation Interconnection Agreement (LGIA).

1. LOW VOLTAGE RIDE-THROUGH (LVRT) CAPABILITY

All generation facilities that fall under the ambit of PRC-024 and IEEE 2800 (whichever is more restrictive) shall be required to achieve the LVRT requirements stated within this standard. Generation facilities must notify Xcel Energy if it cannot achieve the required performance.

A VER generating plant shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below. The LVRT requirement provides for a transition period requirement and a post-transition period requirement.

A. TRANSITION PERIOD LVRT REQUIREMENTS

The transition period standard applies to VER generating plants subject to FERC Order 661 that have either: (1) interconnection agreements signed and filed with the FERC, filed with the FERC in unexecuted form, or filed with the FERC as non-conforming agreements between January 1, 2006 and December 31, 2006, with a scheduled in-service date no later than December 31, 2007, or (2) wind generating turbines subject to a wind turbine procurement contract executed prior to December 31, 2005, for delivery through 2007.

- i. VER generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to pre-fault voltage unless clearing the fault

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effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the transmission provider. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles at a voltage as low as 0.15 p.u., as measured at the high side of the VER generating plant step-up transformer (*i.e.* the transformer that steps the voltage up to the transmission interconnection voltage or "GSU"), after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system.

- ii. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU or to faults that would result in a voltage lower than 0.15 per unit on the high side of the GSU serving the facility.
- iii. VER generating plants may be tripped after the fault period if this action is intended as part of a Remedial Action Scheme (formally called a Special Protection System).
- iv. VER generating plants may meet the LVRT requirements by the performance of the generators or by installing additional equipment (*e.g.*, Static VAR Compensator, etc.) within the wind generating plant or by a combination of generator performance and additional equipment.
- v. Existing individual generator units that are, or have been, interconnected to the network at the same location at the effective date of the LGIA Appendix G LVRT Standard are exempt from meeting these requirements for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the post transition period LVRT requirements.

B. POST TRANSITION PERIOD LVRT REQUIREMENTS

All wind generating plants subject to FERC Order No. 661 and not covered by the transition period described above must meet the following requirements:

- i. Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to pre-fault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the transmission provider. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system. A wind generating plant shall remain interconnected during such a fault on the transmission system for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU.
- ii. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.

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- iii. VER generating plants may be tripped after the fault period if this action is intended as part of a Remedial Action Scheme (formally called a Special Protection System).
- iv. VER generating plants may meet the LVRT requirements by the performance of the generators or by installing additional equipment (e.g., Static VAR Compensator, STATCOM, etc.) within the VER generating plant or by a combination of generator performance and additional equipment.
- v. Existing individual generator units that are, or have been, interconnected to the network at the same location at the effective date of the LGIA Appendix G LVRT Standard are exempt from meeting these requirements for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the post transition period LVRT requirements.

2. POWER FACTOR RANGE DESIGN CRITERIA (REACTIVE POWER CAPABILITY)

A VER generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection, if the Transmission Provider’s System Impact Study shows that such a requirement is necessary to ensure safety or reliability. The power factor range standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors if agreed to by the Transmission Provider, or a combination of the two. The Interconnection Customer shall not disable power factor equipment while the VER plant is in operation. VER plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the System Impact Study shows this to be required for system safety or reliability.

3. SYSTEM IMPACT STUDIES

A. ON THE PSCo SYSTEM

The System Impact Study will evaluate the need for the VER Generating Customer to supply additional reactive power to the system because of the addition of the proposed VER generating facility. The System Impact Study will recommend network upgrades for bus voltage violations and transformer flows outside emergency ratings.

Power Flow Study Criteria (PSCo Criteria): The system impact study will use the following study criteria for power flow and transient stability analysis.

PSCo adheres to NERC Reliability Standards³ and WECC Criteria⁴ as well as internal company criteria for planning studies. WECC criteria TPL-001-WECC-CRT-3 states the performance requirements used for studies.

Transient Stability Study Criteria (PSCo Criteria): Transient stability analyses for system intact initial conditions are performed at the appropriate dispatch and demand scenario(s). The NERC Standards for

³ Specifically NERC TPL-001-4

⁴ April 2008 TPL –001– WECC – 1 – CR – System Performance Criteria

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transient stability criteria require that all machines remain in synchronism and all voltage swings should be damped. In addition, the WECC Criteria for and voltage performance is stated within TPL-001-WECC-CRT-3 WR1.2-WR1.6.

Energy Resource and Network Resource Issues (PSCo Criteria): The System Impact Study report must address the concepts of "Energy Resource" and "Network Resource". The System Impact Study report will include the following information.

The System Impact Study report should include the following statement pertaining to Energy Resource (ER) if applicable:


"Energy Resource Interconnection Service (ER) is an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service".

"The study has determined that the Customer may interconnect as a Network Resource after the required Network Upgrades for Delivery are completed. Interconnection as an Energy Resource will require the same Network Upgrades to deliver the requested generation level on a firm basis. Some non-firm transmission capability may be available depending upon generation dispatch levels, demand levels, import path levels (TOT3, etc.), and the operational status of transmission facilities".

The System Impact Study report will include the results of study work that determined any Network Resource (NR) additions required to support the wind generating facility. The power flow simulations will determine the network upgrades (on PSCo's transmission system or on another utility's transmission system) necessary to designate a proposed wind generator facility as a network resource. The principles that PSCo follows in determining if network upgrades are needed are as follows:

Power flow studies conducted by PSCo are deterministic and require study cases to be created that represent the extreme operating conditions that the system could encounter under extreme demand and/or transfer conditions (on-peak or off-peak seasonal demand conditions with high transfer path flows). Deterministic planning assumes that if a system is studied and found to be reliable under extreme operating conditions, it is reliable under normal or less extreme operating conditions.

PSCo will create a study case (or cases) that reflects these deterministic conditions prior to the addition of a proposed larger generator facility. This case (or cases) represents the benchmark case(s). The power flow studies will consider on-peak and off-peak conditions with the wind generating facility at full and minimum output. Contingency simulations will be performed on the benchmark case(s) to calculate the flows on transmission branches and voltages on transmission buses on neighboring systems and determine if these flows or voltages are outside the power flow criteria of PSCo or the neighboring system, recognizing that

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neighboring systems may have a different criterion for branch flows and bus voltages⁵. Branch flows and bus voltages on neighboring systems in the study area are monitored and those branch flows or bus voltages outside the criteria ranges are flagged.

The proposed generating facility is added at full output to the benchmark case and generation in the PSCo area re-dispatched to accommodate the increase in generation in the PSCo balancing authority.

Contingency simulations are conducted and branch flow or bus voltage violations on neighboring systems in the study area are noted. Network upgrades will be identified if the addition of the generating facility results in a branch flow or bus voltage criteria violation on the PSCo system or a neighboring system that was not present in the benchmark case.

Reactive Power Requirements at the Point of Interconnection (PSCo Criteria): Interconnecting to the PSCo bulk transmission system requires the Customer to adhere to certain interconnection requirements. Many of these requirements are contained in this document. The Interconnection Guidelines make reference to interconnection requirements resulting from FERC Order 661A and 827. FERC Order 661A and 827 describes the interconnection requirements for wind generation plants. PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a Customer’s facilities.


The Customer must adhere to the following:

VER Facilities

A VER generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI. The Transmission Provider’s System Impact Study is needed to demonstrate that such a power factor requirement is necessary to ensure safety or reliability.

Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the high-side of the generator substation at a power factor within the range of 0.95 leading to 0.95 lagging, unless the Transmission Provider has established a different power factor range that applies to all non-synchronous generators in the Control Area on a comparable basis. This power factor range standard shall be dynamic and can be met using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two. This requirement shall only apply to newly interconnecting non-synchronous generators that have not yet executed a Facilities Study Agreement as of the effective date of the Final Rule establishing this requirement (Order No. 827). This requirement also applies to existing non-synchronous generators making upgrades that require a new Generator Interconnection Agreement where the System Impact Study shows the need for reactive power as a result of an upgrade.

⁵ Platte River Power Authority under Category B disturbances (loss of generator, line, or transformer) requires voltages on their system to remain within 0.92 p.u. to 1.07 p.u.

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The voltage at a Point of Interconnection shall be maintained in the ideal voltage range for the appropriate Colorado region and bus type (regulating⁶ or non-regulating) as determined in the Rocky Mountain Area Voltage Coordination Guidelines⁷. The System Impact Study will investigate pertinent demand (on-peak or off-peak), season (summer or winter), dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).

The POI for a VER generating facility cannot be designated a “regulating bus” unless system studies demonstrate that the designation of the POI as a regulating bus is needed for system reliability or safety.

The impact of the VER generating facility on the reactive power schedules of nearby generation units may need to be mitigated by the Customer if system studies demonstrate that the proposed VER generating facility causes nearby generating units to generate or absorb reactive power for voltage control. It is understood that sufficient power reserve must be maintained on existing generating units to allow them to them to dynamically regulate voltage for extreme system conditions.

Affected Parties (PSCo Criteria):


The additions of VER generating facilities may impact neighboring utilities. PSCo will recommend network upgrades to address branch overloads greater than 100% of the nominal rating of the line that are the result of the addition of the wind generating facility. Network upgrades will be recommended for bus voltage violations and transformer flows outside PSCo’s emergency ratings that are the direct result of the addition of the wind generating facility. Feasibility and System Impact study results will be shared with affected parties through the study reports. PSCo will consult with the affected parties during the study process if additional information is needed from the affected parties.

Low MW Output MVAR requirements:

If a VER generating facility is interconnected to the bulk transmission system but is operating with its generation off-line and receiving power from the bulk transmission system for its station service requirements, that facility is acting as a load and will be required to maintain the power factor at the POI within 98% lagging or leading (when the station service load is greater than 85% of maximum) per the Xcel Energy document titled Interconnection Guidelines For Transmission Interconnected Customer Loads.

⁶ A regulating bus is defined in the Rocky Mountain Area Voltage Coordination Guidelines as any transmission or generation bus with controllable var’s. This implies that the bus has a voltage schedule that is being regulated by a generating facility. Generating facilities include Static VAR Compensators (SVC’s), synchronous generators, or synchronous condensers that can supply fast-acting reactive power (var) compensation to dynamically regulate voltage at a power system bus along with switchable capacitors, switchable reactors, and load tap changing transformers..

⁷ The Voltage Coordination Guidelines Subcommittee (VCGS) of the Colorado Coordinated Planning Group developed the guidelines. The subcommittee consisted of representatives from major Colorado utilities including Colorado Springs Utilities, Platte River Power Authority, Tri-State Generation and Transmission, Public Service Company of Colorado, and Western Area Power Administration-Rocky Mountain Region. Other major utilities outside of Colorado were also involved in the development of these guidelines.

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If the inherent design of the facility makes controlling the power factor at the POI impractical during low (<10% of the rated output) or zero MW output conditions, the generating facility shall be required to achieve a leading tolerance (MVAR ≤ 0) at the POI. The level of leading MVAR tolerance allowed during these conditions shall be determined by PSCo Operations and dependent on system conditions at the POI. The default leading MVAR tolerance at the POI during low wind conditions shall be ≤ 0. The reactive devices installed to achieve this tolerance shall have the capability to operate via manual and automatic control.

Operational Tests:

PSCo System Operations will require the Customer to perform operational tests prior to commercial operation that would verify that the equipment installed by the Customer meets operational requirements.

It is the responsibility of the Customer to determine what type of equipment (DVAR, added switched capacitors, SVC, STATCOMS, reactors, etc.), the ratings (MVAR, voltage--34.5 kV or 230 kV), and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.

PSCo requires the Customer to provide a single point of contact to coordinate compliance with the power factor and voltage regulation at the POI. The reactive flow at the end of the line near the POI will need to be controlled according to the Interconnection Guidelines.

B. SYSTEM IMPACT STUDIES ON THE NSP SYSTEM

Per MISO Guidelines.

C. SYSTEM IMPACT STUDIES ON THE SPS SYSTEM

Per SPP Guidelines.


Transmission owner may require the plant to produce more than the minimum positive and negative sequence reactive current injection as required per IEEE 2800.

3. SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) CAPABILITY

The wind plant shall provide SCADA capability to transmit data and receive instructions from the Transmission Provider to protect system reliability. The Transmission Provider and the wind plant Interconnection Customer shall determine what SCADA information is essential for the proposed wind plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.

These are suggested SCADA requirements for large wind generators because of high penetration of wind generation within the power system:

- a. Wind velocity and wind direction data shall be continuously provided to Xcel Energy from the main Interconnection Customer owned substation.

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- b. High Wind Cut Out data shall be continuously provided to Xcel Energy from the wind plant. This requirement will be met typically by providing the number of turbines currently online, and/or the number of turbines with High Wind Cut Out alarm asserted.
- c. PSCo requirement based on the RMRG (Rocky Mountain Reserve Group). If the reserve group loses a 200 MW generator or larger, the group is required to active their reserves. Wind Producers equal to or greater than 200 MW shall provide status indication of any transmission breaker that branches out to feed a portion of the overall wind farm.

The Facilities Study and associated Interconnection Agreement may indicate additional SCADA requirements.

V. ACCEPTANCE TESTING AND INSPECTION REQUIREMENTS

Xcel Energy requires all Interconnection Customers proposing to interconnect to the Xcel Energy System be in compliance with the applicable testing and/or performance requirements.

A. GENERAL

Prior to the actual operation of Interconnection Customer-owned generation with the Xcel Energy System, all pertinent contracts must be signed and all equipment modifications must be complete. Interconnection Customers are required to demonstrate the correct operation of all interface protective and control devices to Xcel Energy. Xcel Energy shall define and witness but is not responsible for performing this demonstration.

The Interconnection Customer must provide detailed information on the protective relaying, metering, and control (including sync-check) equipment that will interface with the Xcel Energy System. This is usually provided on a relaying and metering one-line (and possibly a three-line) diagram. Basic proposed AC and DC schematics or specification of logic might also be provided at this time. This information is required 120 days before the Interconnection Customer in-service date, along with a listing of the specific relays, etc., including information on the manufacturer, model number, relay ranges, etc. Xcel Energy requires at least two sets of any design documentation packages sent. If any subsequent changes are made, the Interconnection Customer shall provide Xcel Energy a set of revised one-lines, schematics, construction drawings, etc. Based on this information, Xcel Energy will develop and deliver to the Interconnection Customer the required demonstration test details within 30 days after receipt of information from Interconnection Customer. A coordination meeting shall be held with Xcel Energy and the Interconnection Customer to clarify any questions that may exist before testing begins. The Interconnection Customer is also required to hold a coordination meeting with the Xcel Energy Transmission Control Center to establish a specific switching sequence for the initial energizing of the Interconnection Facilities. The switching procedure will include a sign-off provision for the Interconnection Customer.

Scheduling of demonstration testing should be coordinated through Xcel Energy with a minimum of three (3) business days' notice. All testing shall be completed at least seven (7) days prior to the planned in-service date to provide time to resolve problems identified during testing. If no problems are identified then the equipment can be placed in service without delay. Based on the amount of generation and the type of

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generation at the site, Xcel Energy may, at Xcel Energy's sole discretion, require only a design and relay settings review and not require a site visit. Interconnection Customers shall be responsible for determining their own relay settings. At least 90 days before startup testing, the Interconnection Customer must supply the proposed settings for the relays, including support documentation (e.g. PRC-027/PRC-025 documentation, calculations, fault studies, time over-current relay coordination curves, etc.) for approval by Xcel Energy.

The Interconnection Customer shall supply certified test reports for Xcel Energy's required protective relaying, interlocks, and any equipment directly connected to Xcel Energy's System (Interconnection Customer's transformers and/or breakers). Certified test reports shall be sealed by a registered Professional Engineer (P.E.). Xcel Energy's personnel may require witnessing some or all of the tests, calibrations, and the relay setting applications. The final "as-built" documentation, including all drawings and final "as left" relay settings, must be provided by the Interconnection Customer to Xcel Energy no later than 90 days after commercial operation.

Xcel Energy document TCS-4 "Testing Criteria" provides the specific criteria that Xcel Energy uses for ensuring its electrical equipment is properly tested and checked out. Xcel Energy requires that the Interconnection Customer's facilities that are an integral part of the Xcel Energy System or may disrupt the Xcel Energy system due to miss-operation or failure, must undergo a similar level of testing and checkout. The demonstration testing indicated above is employed to ensure that the Interconnection Customer has completed the appropriate testing and checkout. Specific regional requirements may apply and may be obtained from the regional Xcel Energy representative by request.

The Interconnection Customer must assign one qualified and proficient protection and controls person to be the main point of contact throughout the commissioning phase of the project. This person should have adequate field experience as appropriate to the system they are working on (46 kV and above). This person's experience should include, but not be limited to polarity checks, phase-outs, relay calibration, and trip testing for multiple large projects. This person will also insure adherence to these Guidelines. The Interconnection Customer must also provide qualified electricians, technicians, and operators to perform the demonstration testing. The Interconnection Customer must supply all personal protective equipment and designate any procedures necessary to assure that safety precautions are taken while working near energized equipment.

Inspection and approval by Xcel Energy does not constitute a warranty or relieve the Interconnection Customer of responsibility for the operating condition or installation of the equipment and may not be relied upon by the Interconnection Customer for that purpose. Once the facility is interconnected, Xcel Energy will retain the right to inspect the facility if the operation is suspected of causing problems for other Xcel Energy Interconnection Customers or customers and retains the right to inspect the facilities of the Interconnection Customer at Xcel Energy's discretion.

B. DEMONSTRATION

The Interconnection Customer and Xcel Energy shall follow the following steps in assuring that the new facilities have been adequately tested prior to energization.

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1. CONSTRUCTION TESTING DOCUMENTATION REVIEW

The Interconnection Customer must complete field-testing of all their electrical equipment prior to commissioning and energization. This includes physical testing of equipment such as transformers and circuit breakers per the manufacturers' recommendations. This testing also includes setting and testing of relays and control systems per the manufacturers' recommendations, as well as verifying Xcel Energy approved relay settings. The extent of testing shall be consistent with the level of testing specified in the International Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) and good utility practice. These tests shall be completed prior to demonstration testing as outlined in the following paragraph. Xcel Energy may require being a witness to some of these testing activities. Xcel Energy will notify the Interconnection Customer prior to the start of testing if witness testing is required. In some cases, review of these test reports shall constitute sufficient demonstration that proper testing has been completed.

The Interconnection Customer must submit reports for all tests performed for approval by Xcel Energy. All revisions and changes found on field drawings shall be shown on the Interconnection Customer drawing and copies provided to Xcel Energy for approval by Xcel Energy. A written record must be kept of all tests showing date, personnel performing test, signature or initial of person completing tests, equipment or material tested, as-left results, and type of testing equipment used by manufacturer, model type, and model serial number. The test sheets must show all equipment nameplate data (including for all bushings and surge arresters).

The requirements of this paragraph apply to equipment that will be owned by Xcel Energy. Two copies of the final test reports must be submitted. Three copies of application software and instruction books are to be supplied to Xcel Energy along with the test reports.

The Interconnection Customer must download settings and programs from each relay and programmable logic controller after testing to retrieve all as-left-in-service settings, and shall copy these files onto a CD-ROM, or e-mail the data to Xcel Energy. For non-microprocessor-based relays, test sheets or reports for each device are to be completely filled out. All relay setting sheets are to be checked against as-left settings on the corresponding relay device and signed as being complete by the responsible technical person. The disks, test sheets, reports, and settings are to be labeled with equipment identification numbers, relay type numbers, and relay device numbers and returned to Xcel Energy with the test reports. The address is provided in Section II. of these Guidelines.

2. DEMONSTRATION TESTS

Demonstration tests must be employed to ensure that each of the required protection systems and protective devices operate correctly. These tests are used to verify that the Interconnection Customer has completed testing as indicated in the preceding paragraph. These tests also verify synchronizing equipment and the proper operation of the Xcel Energy – Interconnection Customer interface protective relays. Xcel Energy will produce the demonstration test requirements and deliver them to the Interconnection Customer. Upon performance and certification of the Demonstration, the Interconnection Customer will be granted approval for operation of their generating equipment in parallel with Xcel

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Energy's System. Unsuccessful demonstration may lead to delays in the Interconnection Customer facility in-service date. Xcel Energy and the Interconnection Customer will develop an initial energization procedure at least two weeks prior to energization. If deemed necessary by Xcel Energy, a meeting will be held on site within one week of the energization date to discuss any particulars of the initial energization.

The actual demonstration requirements will depend upon the final, approved AC/DC schematics, relay settings, etc. This demonstration is intended to be non-destructive. However, Xcel Energy will not be liable for any equipment damage or injury resulting from the use of these guidelines. It is the responsibility of the Interconnection Customer to demonstrate the operation of all protective devices in a safe manner and in a manner that does not adversely affect the Interconnection Customer's generator or any equipment on the Xcel Energy System. Xcel Energy recommends that similar tests be performed for the Interconnection Customer's other relays to insure the adequacy of their generator's protective relaying.

3. POST IN-SERVICE TESTS


These tests are employed for verification of correct relay connections under actual load conditions. This is commonly known as "load checking". These checks are completed by directly measuring actual operating quantities in differential, distance, and overcurrent relays. This also includes spot-checking of metering and SCADA systems. Post in-service tests may also include online tests of substation equipment including insulating oil tests of power transformers and infrared-thermography testing.

C. FUTURE CHANGES IN REQUIREMENTS

From time-to-time new requirements for testing, reporting, equipment and/or performance are established by MRO, SPP, WECC, NERC, etc., for interconnected generation. The Interconnection Customer should take steps so it is notified of any changes by the applicable entity. If an Interconnection Customer fails to comply with these requirements, Xcel Energy is required to pay monetary penalties assessed to Xcel Energy as the Balancing Authority entity responsible for regional interconnected system reliability. Xcel Energy will bill the Interconnection Customer for any monetary penalty resulting from the non-performance of the Interconnection Customer.

D. PERFORMANCE OF TESTS

The Interconnection Customer must test all wire, cable, electrical equipment, and systems installed by the Interconnection Customer or connected by the Interconnection Customer to assure proper installation, adjustment, setting, connection, and functioning. The Interconnection Customer must inform Xcel Energy of any equipment or system that fails testing or that is deficient in any matter. The extent of testing where modifications are made to existing circuits shall be sufficient to check the entire trip/control/CT/VT path as if it were new. Xcel Energy will not be responsible for any damage to equipment or material due to Interconnection Customer's inadequate, substandard, improper test procedures or test apparatus handling.

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Xcel Energy reserves the option to assign its personnel to assist the Interconnection Customer in checking out certain control schemes where Xcel Energy concludes such assistance is necessary to meet the project schedule. If Xcel Energy should exercise this option, the Interconnection Customer will be notified in advance of the extent of Xcel Energy's involvement.

Xcel Energy also reserves the right to shut down testing activities if, in Xcel Energy's opinion or the opinion of Xcel Energy's designated representative, the Interconnection Customer is using unsafe practices or is in violation of applicable local, state, or federal safety regulations. Xcel Energy requires compliance with the most conservative of the safety practices as provided by OSHA, NESC, or Xcel Energy's safety practices whenever work is being performed in an energized facility.

E . PSCO OPERATIONAL TESTS

PSCo System Operations will require the Customer to perform operational tests prior to commercial operation that would verify that the equipment installed by the Customer meets operational requirements.

It is the responsibility of the Customer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings (Mvar, voltage--34.5 kV or 230 kV), and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.

PSCo requires the Customer to provide a single point of contact to coordinate compliance with the power factor and voltage regulation at the POI. The reactive flow at the end of the line near the POI will need to be controlled according to the Interconnection Guidelines.


Refer to Appendix C for the PSCo Voltage Control and Frequency Response Testing Procedures.

F. TESTING EQUIPMENT

The Interconnection Customer must provide all equipment necessary to perform the tests required by Xcel Energy. A list of testing equipment shall be submitted to Xcel Energy for approval prior to the beginning of the testing. Test instrument type (manufacturer, type, serial number) and associated calibration certifications shall be submitted to Xcel Energy prior to the commencement of any testing. The equipment certification shall be renewed at least annually and shall be traceable to the National Bureau of Standards. Xcel Energy will review the list and notify the Interconnection Customer of any testing items that are not acceptable or are missing from the list. The Interconnection Customer shall correct this deficiency prior to the start of testing.

G. XCEL ENERGY SUPPLIED EQUIPMENT

Any Xcel Energy supplied equipment that is factory calibrated (transducers, pressure switches, tuners, etc.) shall be tested to verify calibration. The Interconnection Customer may not modify calibration settings without authorization from Xcel Energy. If equipment does not meet specifications, the Interconnection Customer

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should notify Xcel Energy of the problem immediately. Xcel Energy will then direct the Interconnection Customer on how to proceed. If the Interconnection Customer modifies factory settings without authorization, Xcel Energy will not be responsible for any costs associated with repair, replacement, or re-calibration of the Interconnection Customer's equipment.

H. FINAL DESIGN/AS-BUILT DOCUMENTS

The Interconnection Customer must at the time of demonstration testing have a complete set of construction drawings and documentation available. These documents should represent a complete set of information showing exactly how the facility has been built and the logic behind how the control systems will operate. The documents shall include but are not limited to one-line diagrams, meter and relaying diagrams (**M&R**), AC and DC elementary diagrams (schematic drawings), circuit lists, Programmable Logic Controller (PLC) and relay logic, and any other appropriate or necessary information. Xcel Energy should be provided a duplicate copy of this documentation at least two weeks prior to demonstration testing. A coordination meeting with Xcel Energy should be held to clarify any questions on documentation or testing requirements before demonstration testing begins.

I. GENERATOR PARAMETER DATA

1. SPP AND MRO


The Interconnection Customer must provide to Xcel Energy the results of unit testing which will include, but not be limited to the generator gross and net dependable capability, gross and net reactive power capability, performance of voltage regulator controls, performance of speed/load regulator controls, and excitation systems. This testing is a NERC requirement and should be conducted once the generator has attained commercial status and the test schedule has been mutually agreed upon with Xcel Energy. MRO also requires the annual URGE test, referred to in Section I.11. Periodic updated testing may be required per the individual regional requirements.

2. WECC

All transmission-connected generators must perform testing on initial startup consistent with the WECC 2006 Generator Test Policy. This document is available on the WECC website at www.wecc.org under Publications and Documents. A copy is also available from Xcel Energy upon request. Other applicable documents include the NERC/WECC Planning Standards (Revisions 8/9/02, or latest), sections II.B, III.B, and III.C.

The testing shall provide:

- a. Verification of reactive limits (5 years)
- b. Proper performance of the dynamic control systems (5 years)
- c. Computer model data used for transient stability analysis, including excitation systems, voltage regulators, turbine-governor systems, power system stabilizers, and other associated generation equipment (5 years).

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- d. Verification of real power output (MW) capability (annually).

Generator Owners must perform these tests, at their cost, every year or 5 years as specified and must provide this data to Xcel Energy and WECC. These tests result in WECC Generator Certification.

VI. OPERATION AND MAINTENANCE GUIDELINES

The Interconnection Customer may be connecting to the Xcel Energy system for one of five different reasons, which are listed below:

- a. The Interconnection Customer is selling the plant output to Xcel Energy Commercial Operations (XEM) and the plant will be dispatchable by XEM.
- b. The Interconnection Customer is selling the output to XEM and the plant is not dispatchable by XEM (wind energy, run of river hydro, etc.)
- c. The Interconnection Customer is selling the output on the open market (a merchant plant) and the output of the plant is scheduled to other entities outside Xcel Energy's transmission control area.
- d. The Interconnection Customer is selling the output on the open market (a merchant plant) and the output of the plant is controlled or dispatched by another control area.
- e. The Interconnection Customer is selling the output on the open market (a merchant plant) and the Interconnection Customer will be its own control area, as defined by NERC.


Each of the unique situations described above has its own operating and maintenance guidelines. General guidelines will be stated below, but any specific guidelines will be defined in the Interconnection Agreement between the Xcel Energy operating companies and the Interconnection Customer.

The guidelines listed below apply only to the situations described in (a) and (b) above. The Operation and Maintenance Guidelines for (c) through (e) above will have to be defined in the Interconnect Agreement for that generator interconnection. The Interconnection Customer shall operate within the applicable guidelines of this document and any other specific requirements as stated in the Interconnect Agreement, the Power Purchase Agreement, or the Ancillary Services Agreement.

A. NORMAL CONDITIONS

The Interconnection Customer must operate according to the instructions and approval given by the Xcel Energy Transmission Control Center personnel:

1. All schedules must be pre-approved prior to implementation. Usually the implementation notification will occur at specified intervals.
2. All generators operating in manual or automatic mode as requested.
3. The Interconnection Customer has twenty-four-hour support available.

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B. ABNORMAL CONDITIONS

Xcel Energy reserves the right to open the interconnection for any of the following reasons:

1. Xcel Energy line maintenance work on Xcel Energy System.
2. Xcel Energy System emergency.
3. Inspection of an Interconnection Customer's generating equipment and protective equipment reveals a hazardous condition.
4. Failure of the Interconnection Customer to provide maintenance and testing reports when required.
5. Interconnection Customer's generating equipment interferes with other Xcel Energy customers or producers or with the operation of Xcel Energy System.
6. Interconnection Customer has modified the generating equipment that affects Xcel equipment without the knowledge and approval of Xcel Energy or has not installed Xcel required protective devices.
7. Parallel operation of any unapproved Interconnection Customer generating equipment.
8. Personnel or public safety are threatened.
9. Interconnection Customer fails to comply with applicable OSHA Safety Tagging and Lockout requirements.
10. To address abnormal frequency or voltage conditions or power quality conditions determined by Xcel Energy to be adversely impacting the network transmission system.

Changes to the Xcel Energy System or the addition of other producers with generation in the vicinity may require modifications to the interconnection protective devices. If such changes are required, the Interconnection Customer may be subject to future charges for these modifications.

C. ENERGIZATION OF XCEL ENERGY EQUIPMENT BY THE INTERCONNECTION CUSTOMER

The Interconnection Customer must not energize a de-energized Xcel Energy circuit (unless specifically authorized and requested by Xcel Energy). The Interconnection Customer must install the necessary control devices on the facility's equipment to prevent the energization of a de-energized Xcel Energy circuit by the Interconnection Customer. Connection may be accomplished only by synchronization with the Xcel Energy System via synchronizing relays installed by the Interconnection Customer. Failure to observe this requirement will result in the immediate disconnection of the generator.

D. DISCONTINUATION OF OPERATION

Interconnection Customers must discontinue parallel operation when requested by Xcel Energy:

1. To facilitate maintenance, test, or repair of Xcel Energy's facilities. Xcel Energy will coordinate this with each Interconnection Customer;
2. During system emergencies;

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3. When a generator is interfering with other Xcel Energy customers or producers on the system;
4. When an inspection of a generator reveals either a condition hazardous to Xcel Energy's System or personnel or a lack of scheduled maintenance or maintenance records for equipment necessary to protect Xcel Energy's System.

E. MAINTENANCE NOTIFICATION

The Interconnection Customer must notify Xcel Energy or the ISO as provided for in the applicable OATT of any unusual conditions including, but not limited to the following:

1. Partial operating capability due equipment limitations and fuel shortages.
2. Scheduled outage periods and return to service expectations. Return to service notification must be updated daily to reflect the recent progress or the lack of progress.

F. MAINTENANCE


Interconnection protective devices owned by the Interconnection Customer should be maintained and inspected according to manufacturer recommendations, NERC, and/or industry standards. Procedures must be established for visual and operational inspections. Provisions should be established for equipment maintenance and testing. Equipment should include, but not be limited to:

1. Circuit Breakers
2. Protective Relays
3. Control Batteries

Xcel Energy maintains the right to review the maintenance, calibration, and operation data of all protective equipment for protecting Xcel Energy facilities, customers, and other producers. The Interconnection Customer is responsible for providing the necessary test accessories (such as relay test plugs, instruction manuals, wiring diagrams, etc.) required to test these protective devices. Verification testing may include the tripping of the intertie breaker. If Xcel Energy performs work on the premises of the Interconnection Customer, Xcel Energy operating personnel may make an inspection of the work area. If hazardous working conditions are detected, the Interconnection Customer must correct the unsafe conditions before Xcel Energy personnel will perform their work.

G. DESIGN CHANGES AFTER COMMERCIAL OPERATION

Any modifications to the generator requiring Xcel Energy protective relaying and interlocks after the date of commercial operation must be reviewed and approved by Xcel Energy prior to implementing any changes. Demonstration of Relay Calibration, Trip Tests, and On-Line Tests may be required depending on the extent of the design change. Xcel Energy must approve the setting changes of any interconnection protection or synchronizing device, and a hard copy of the changes must be forwarded to the designated Xcel Energy representative. Any "Field Modification" or "As Built" AC/DC protection and synchronizing schematics

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associated with any Xcel Energy required interconnection device must be forwarded to the designated Xcel Energy representative.

H. OPERATING DATA SUBMITTALS

The Interconnection Customer must provide operating data and equipment modeling to Xcel Energy and/or the appropriate regional reliability organization to support the following:

1. NERC compliance program(s).
2. Regional Reliability Organization compliance program(s).
3. Federal, state and local regulatory programs.

I. OPERATIONAL LOG

Interconnection Customers must maintain an operating log at each generating facility indicating changes in operating status (available or unavailable), maintenance outages, trip indications, or other unusual conditions found upon inspection.

J. COMMUNICATION WITH XCEL ENERGY OPERATIONS

Customer will provide and maintain a dedicated, ring-down voice communication circuit between the Transmission Provider's Control Center and the Large Generating Facility Operator. The Large Generating Facility Operator is a 24/7 operator with full visibility and control of the entire Large Generating Facility. The Large Generating Facility Operator will have sufficient training and authority to operate the plant independently, and as directed by the Transmission Provider's System Operator to maintain transmission system reliability.

The Xcel Energy representative will provide the Producer with the names and telephone numbers of the Xcel Energy Control Center and Operations Coordination personnel responsible for Xcel Energy System at the interconnection. The Producer will provide Xcel Energy with the names and telephone numbers of the personnel with responsibility for operating the generator.

The contact(s) of the Interconnection Customer should include at least one 24/7-telephone number. Contacts should be able to provide information on equipment status, explanation of events on the Interconnection Customer's equipment, and relay target and alarm information when asked to do so by Xcel Energy personnel. Xcel Energy may choose to waive some of the communications requirements for smaller generating facilities. In addition, the Interconnection Customer should contact Xcel Energy whenever:

1. Problems with the generator are detected that could result in mis-operation of generator protection or other generator equipment.
2. The generator has tripped off-line during parallel operation with the Xcel Energy System.
3. Generator equipment problems result in an outage to a portion of the Xcel Energy System.

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4. The Interconnection Customer intends to initiate switching to parallel the generator(s) and the Xcel Energy System.
5. The Interconnection Customer intends to initiate switching to break the parallel interconnection between generator(s) and the Xcel Energy System.

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VII. GLOSSARY

AGC (Automatic Generation Control): An EMS based system that sends raise and lower instructions to the governors of the generators in the control area for the purpose of matching the generation output to the area load. This is also known as Load Frequency Control (LFC).

Accredited: Generating capability recognized as meeting MRO requirements to satisfy a portion of an MRO member's generating capacity obligation.

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

Ampere: The unit of current flow of electricity. It is to electricity as the number of gallons per minute is to the flow of water. One-ampere (**A**) flow of current is equal to one coulomb per second flow.

ANSI: American National Standards Institute.

Apparent Power: For single-phase power, the current in amperes multiplied by the voltage equals the apparent power in volt-amperes (**VA**). Apparent power for 3-phase power equals the phase to neutral voltage multiplied by the line current multiplied by 3.

ATP (Alternate Transients Program): A digital computer modeling program that is typically utilized for performing high frequency lightning and/or switching induced transient power system studies. This is similar to EMTP and is not supported by the Electric Power Research Institute (EPRI).

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.

AVR (Automatic Voltage Regulator): A control system component associated with a generator's field excitation system and is used to automatically regulate and control the generator terminal voltage.

Balancing Authority (BA): 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.

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

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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. The interrupting ability of the device is normally rated or sized such that it exceeds the maximum fault current that is available at the location of application.

Control Area: A control area is an electrical system bound by interconnect (tie-line) metering and telemetry and which regulates its generation in order to maintain its interchange schedule with other systems, contributes to frequency regulation of the Interconnection, and fulfills its obligations and responsibilities in accordance with NERC and reliability region (such as MRO, SPP, or WECC) requirements.

Control Contactors: Switching devices utilized to start or stop power system equipment, normally large motors.

Current: A flow of electric charge measured in amperes (**A**).

CT (Current Transformer): A transformer intended for metering, protective, or control purposes and 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 reduces current magnitudes to levels which can be handled by control, protection, and metering equipment. A CT secondary circuit must never be open circuited while energized.

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

Disconnect: A device used to isolate a piece of equipment and which has a minimal ability or no ability to interrupt current. 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 the Xcel Energy Power System Operator. The adjustment normally includes the capability to start up and shutdown generating units.

Dynamic Voltage Excursion: Transient change in system voltage magnitude, typically associated with a condition following clearing a system short-circuit or fault.

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 Xcel Energy uses to provide real-time status and remote control of its electrical transmission system.

EMTP (Electromagnetic Transients Program): A digital computer modeling program that permits the analysis of the transient behavior of electrical networks. This program is presently supported by Electric Power Research Institute (EPRI).

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ERO (Electric Reliability Organization): New electric reliability organization formed as prescribed in the Energy Policy Act of 2005. Expected to establish reliability standards and provide for enforcement of those standards.

FERC (Federal Energy Regulatory Commission): (Formerly the Federal Power Commission, or FPC.) FERC is an independent body within the Department of Energy (DOE) regulating interstate transmission and the prices of electricity and natural gas. It also licenses hydroelectric projects and regulates interconnections, construction work in progress, rates for wholesale Producers, utility accounting practices, and procedures.

Frequency: The number of alternating cycles occurring in a given interval of time (usually one second) in an electric current or voltage. Frequency is commonly expressed in hertz (**Hz**).

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

Generator Capability Curves: The curves showing the real power output of a generator in relation to the reactive power output (also known as "D" curves).

Ground: A term used in electrical work in referring to the earth as the zero potential conductor or reference plain. 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.

GSU (Generator Step-Up Transformer): A special purpose transformer that raises the voltage from the Interconnection Customer's generator up to the voltage of the interconnected system.

Hertz (Hz): The term denoting frequency. Historically, frequency was referred to as cycles per second.

IEEE: Institute of Electrical and Electronics Engineers, Inc.

Incoming Breaker: The Interconnection Customer-owned breaker that connects the Xcel Energy source of power to the bus of the Interconnection Customer.

Interconnection Customer: Party requesting to interconnect a generator to the Xcel Energy System.

Interconnection Facilities: The facilities required to make the physical connection between the Interconnection Customer's generation facility and the Xcel Energy transmission system. This may include new substation and transmission facilities as well as other system upgrades to be owned by Xcel Energy.

Interconnection Facilities Study: A study conducted by the Transmission Provider or a third-party consultant for the Interconnection Customer to determine a list of facilities, the cost of those facilities, and the time required to interconnect the Generating Facility with the Transmission Provider's Transmission System.

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

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IPP (Independent Power Producer): An organization that is not a utility and that operates a power plant that produces energy and sells it to a utility.

Island: A part of an interconnected system that may become isolated from the rest of the system during a system disturbance and start operating as a subsystem with its own generation, transmission, and distribution capability. The islanded system and the main interconnected system may operate at different frequencies and voltages.

ISO (Independent System Operator): Entities corporately separate from the owners of transmission and other power market participants approved by FERC to direct the operation of the transmission system.

ITC (Independent Transmission Company): Entities corporately separate from the owners of transmission and other power market participants approved by FERC to direct the operation of the transmission system.

Kilovolt (kV): One thousand volts.

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

Kilowatt (kW): An electric unit of power that equals 1,000 Watts.

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

LBA (Local Balancing Authority) Within MRO, scheduling areas and entities that are not LBA's must designate an LBA that is responsible for controlling the group's load and for all scheduling errors that are made. MRO will only deal with LBA's and holds the LBA responsible for all problems within that LBA.

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.


Load Frequency Control (LFC): An EMS based system that sends raise and lower instructions to the governors of the generators in the control area for the purpose of matching the generation output to the area load. This is also known as Automatic Generation Control.

MISO (Midcontinent Independent System Operator, Inc.): A FERC-approved RTO to whom Xcel Energy has turned over the functional control of the NSP transmission system. The MISO operate the transmission system in a fifteen-state area, including Minnesota, Wisconsin, North Dakota, South Dakota, Michigan and Iowa, plus portions of Illinois, Pennsylvania, Kentucky, and Missouri and other states.

MRO (Midwest Reliability Organization): A NERC reliability region.

Megavolt-Ampere (MVA): One-million-volt ampere. See definition for Apparent Power.

Megawatt (MW): An electrical unit of power that equals one million watts.

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NERC (North American Electric Reliability Corporation): NERC is a national organization responsible for establishing the operating and planning standards to assure the reliability of the electric grid. NERC is the ERO designated by FERC. NERC Regional Entities (SPP, WECC, MRO) are expected to be replaced by Regional Entities (RE).

Non-Spinning Reserve: All unloaded generating capability not meeting the Spinning Reserve criteria but that can be made fully effective in 10 minutes. This may include generation that shall be made available within 10 minutes by interrupting or curtailing loads or changing schedules.

OATT (Open Access Transmission Tariff): The FERC approved tariff for provision of transmission service to the Interconnection Customer.

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.

On-Line Testing: Testing typically performed as part of commissioning a new generation facility, specifically as it pertains to energized equipment ultimately operating in parallel / interconnected with the power system.

Parallel Operation: The operation of an Interconnection Customer-owned generator while connected to the utility's grid. Parallel operation may be required solely for the operating convenience of the customer or producer, or for the intentional interchange of power with the utility's grid.

Peak Load: The maximum electric power consumed in a stated period.

Point of Change of Ownership (PCO): The point where the Interconnection Customer's Interconnection Facilities connect to Xcel Energy's Interconnection Facilities.


Programmable Logic Controller (PLC): A special form of micro-processor-based controller that uses a programmable memory to store instructions ("ladder logic"), and to implement functions such as logic sequencing, timing, and arithmetic in order to control machines and processes.

Point of Delivery (POD): See Point of Energy Exchange.

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 Xcel Energy and the Interconnection Customer. It is usually the point where facility ownership changes. For transmission-connected producers, this is usually at a location at the transmission voltage level. This is often referred to as the POI or POD.

Point of Interchange: See Point of Energy Exchange.

Point of Interconnection (POI): The point where the Interconnection Facilities connect to the Transmission Provider's Transmission System.

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Point of Metering: The point where metering equipment (meters, transducers, current transformers, voltage transformers, etc.) is or will be installed to measure the power flow and energy exchange between Xcel Energy and the Interconnection Customer.

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 or out of the facility of the Interconnection Customer. Two-way power flow is the condition where the net flow of power may be either into or out of the facility depending on the operation of the generator and other Interconnection Customer load.

Professional Engineer (P.E.): A licensed professional engineer registered with the appropriate state agency.

Programmable Logic Controller (PLC): A special form of micro-processor-based controller that uses a programmable memory to store instructions ("ladder logic"), and to implement functions such as logic sequencing, timing, and arithmetic in order to control machines and processes.

PSCAD: A transient analysis software program, similar to ATP and EMTP.

PSCAD - is a simulation program similar to EMTP and ATP programs. PSCAD is a registered trademark of Manitoba HVDC research center Inc.

PSS (Power System Stabilizer): Supplemental generator excitation device for the purpose of dampening low-frequency system oscillations.


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

QF (Qualifying Facility): An IPP that has met the criteria to be certified by FERC as a Qualifying Facility and that has rights established by the PURPA of 1978.

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 that are required to perform useful work in AC systems.

Relay: A device that is operated 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.

Remote Terminal Unit (RTU): A device installed at a substation or generation facility, and at an XE Operations Control Center, and is used to provide communication for remote control and indication of substation or generation facility equipment from the XE Operations Control Center.

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RTO (Regional Transmission Organization): Entities such as MISO and SPP that are corporately separate from the owners of transmission and other power market participants approved by FERC to direct the operation of the transmission system.

Scheduling Area: For MRO area entities, a scheduling area is similar to a control area in that a utility schedules energy and provides capacity for a defined area. The utility operates a 24-hour control center and is recognized as a MRO Scheduling Area. Unlike a control area, a scheduling area does not have generators that can follow the load in their area and are completely captured within one or more control areas. They must contract for load following services. Within MRO, a scheduling area must identify a Host Control Area.

Spinning Reserve: The amount of unloaded generating capability of a participant connected to and synchronized with the interconnected system of the participants and ready to take load. The Spinning Reserve allocated to any generator shall not exceed the amount of generation increase that can be realized in 10 minutes by that machine.

SPP (Southwest Power Pool, Inc.): SPP operates as an RTO. The SPP RTO performs the independent transmission functions required of that entity. The SPP RTO has a Pool-Wide Tariff under which Xcel Energy has placed the SPS operating area. This tariff governs generator interconnection requests and provides network and point-to-point transmission service. SPP Operates in portions of Texas, New Mexico, Oklahoma, Kansas, Nebraska, Missouri, Arkansas, Louisiana, Iowa, Colorado, Utah, Arizona, Wyoming, and Montana.

Station Power: The electric power used for the heating, lighting, air-conditioning, and office equipment needs of the buildings on a Generation Facility's site, and for operating the electric equipment that is on the Generating Facility's site.

Station Service: The electric energy needs of the Transmission Provider's substation equipment.

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


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

THD (Total Harmonic Distortion): A measure of the amount of the non-fundamental content that an electrical waveform contains. The non-fundamental (60 Hz) part consists of frequency components that are integer multiples of the fundamental.

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

Transient Network Analysis (TNA): A digital computer modeling program that permits the analysis of the transient behavior of electrical networks.

Transmission Operator (TOP): The entity responsible for the reliability of its "local" transmission system, and that operates or directs the operations of the transmission Facilities.

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Transmission Owner (TO): An entity that owns, leases, or otherwise possesses an interest in the portion of the Transmission System at the Point of Interconnection and may be a Party to the Interconnection Agreement to the extent necessary.

Transmission Provider: The public utility (or its designated agent) that owns, controls, or operates transmission or distribution facilities used for the transmission of electricity in interstate commerce and provides transmission service under the OATT. The Transmission Provider includes the Transmission Owner when the Transmission Owner is separate from the Transmission Provider.

URGE (Uniform Rating of Generation Equipment) Test: An MRO area set of tests to confirm the abilities and ratings of a generator located in the MRO area.

Utility Grade Relays: Relays that meet IEEE C37.90, C37.90.1, C37.90.2, and C37.90.3.

var: Volt-ampere reactive, see Reactive Power.

var Capability Testing: Testing performed with a generation facility interconnected with the XE power system in order to verify or determine the generation facility's net reactive power (var) output and corresponding power factor, typically as measured at the POI.

Voltage: Electric potential or potential difference expressed in volts (**V**).


Volt-Ampere: A unit of apparent power (**VA**) in an alternating-current circuit.

VT (Voltage Transformer): A transformer intended for metering, protective, or control purposes and which is designed to have its primary winding connected either between the primary conductors to be measured or between a conductor and ground. A voltage transformer normally reduces voltage magnitudes to levels which can be handled by control, protection, and metering equipment. The historic term for a VT is potential transformer.

Watt-Hour: A unit of work or energy equivalent to the power of one Watt operating for one hour (**Wh**).

WECC (Western Electricity Coordination Council): a NERC reliability region. An organization of power suppliers in the Western States that plans for power availability by coordinating power exchanges between members. WECC's current members include investor-owned companies such as Xcel Energy, municipal systems, rural cooperatives, the Western Area Power Administration, Bonneville Power Administration, and the US Bureau of Reclamation.

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

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VIII. REFERENCES

The following list of references has been utilized in preparation of this document and/or should be consulted for further information/clarification. When the following publications/standards are superseded by an approved revision, the latest revision shall apply.

ANSI C2-2002, National Electrical Safety Code.

ANSI C84.1-1995 (R2005), Electric Power Systems and Equipment - Voltage Ratings (60HZ).

IEEE Std. C37.106™ –2003, IEEE Guide for Abnormal Frequency Protection for Power Generating Plants,

ANSI/ IEEE C37.90-1989, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.90.1-2002™ – 2002, IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.90.2™-2004, IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

IEEE Std C37.90.3-2001, IEEE Standard Electrostatic Discharge Tests for Protective Relays.

IEEE Std C37.95™ – 2002, IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.

IEEE Std 80-2000, IEEE Guide for Safety in AC Substation Grounding.

IEEE Std-142-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems – IEEE Green Book (Color Book Series).


IEEE Std-242-2001, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems – IEEE Buff Book (Color Book Series).

IEEE Std-446-1995, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications – IEEE Orange Book (Color Book Series).

IEEE 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

IEEE 1453™-2004, IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems

IEEE Std-1100-1999, IEEE Recommended Practice for Powering and Grounding Electronic Equipment – IEEE Emerald Book (Color Book Series).

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NERC Reference Document, Reliability Considerations for Integrating Non-Utility Generating Facilities with the Bulk Electric Systems, April 1987, North American Electric Reliability Council, Princeton, NJ 08540.

NERC Document, Integrating Non-Utility Generators - Reliability Considerations for Integrating Non-Utility Generating Facilities with the Bulk Electric Systems, January 1992, North American Electric Reliability Council, Princeton, NJ 08540.

NERC/WECC Planning Standards September 1997.

NFPA 70- 2005, National Electrical Code

OSHA Safety Tagging and Lockout Procedures.

Standardization of Generation Interconnection Agreements and Procedures," Order No. 2003, Fed. Reg. Vol. 68, No. 160 (August 19, 2003).

WSCC Coordinated Off-nominal Frequency Load Shedding and Restoration Plan (Final Report November 25, 1970), prepared by the Under-frequency Issues Workgroup, WSCC Technical Studies Subcommittee.

Xcel Energy document "Physical Design Criteria for Substations"

Xcel Energy document TCS-3 "Transmission Criteria for Substations: Protective Relaying and Control"

Xcel Energy document TCS-4 "Testing Criteria"

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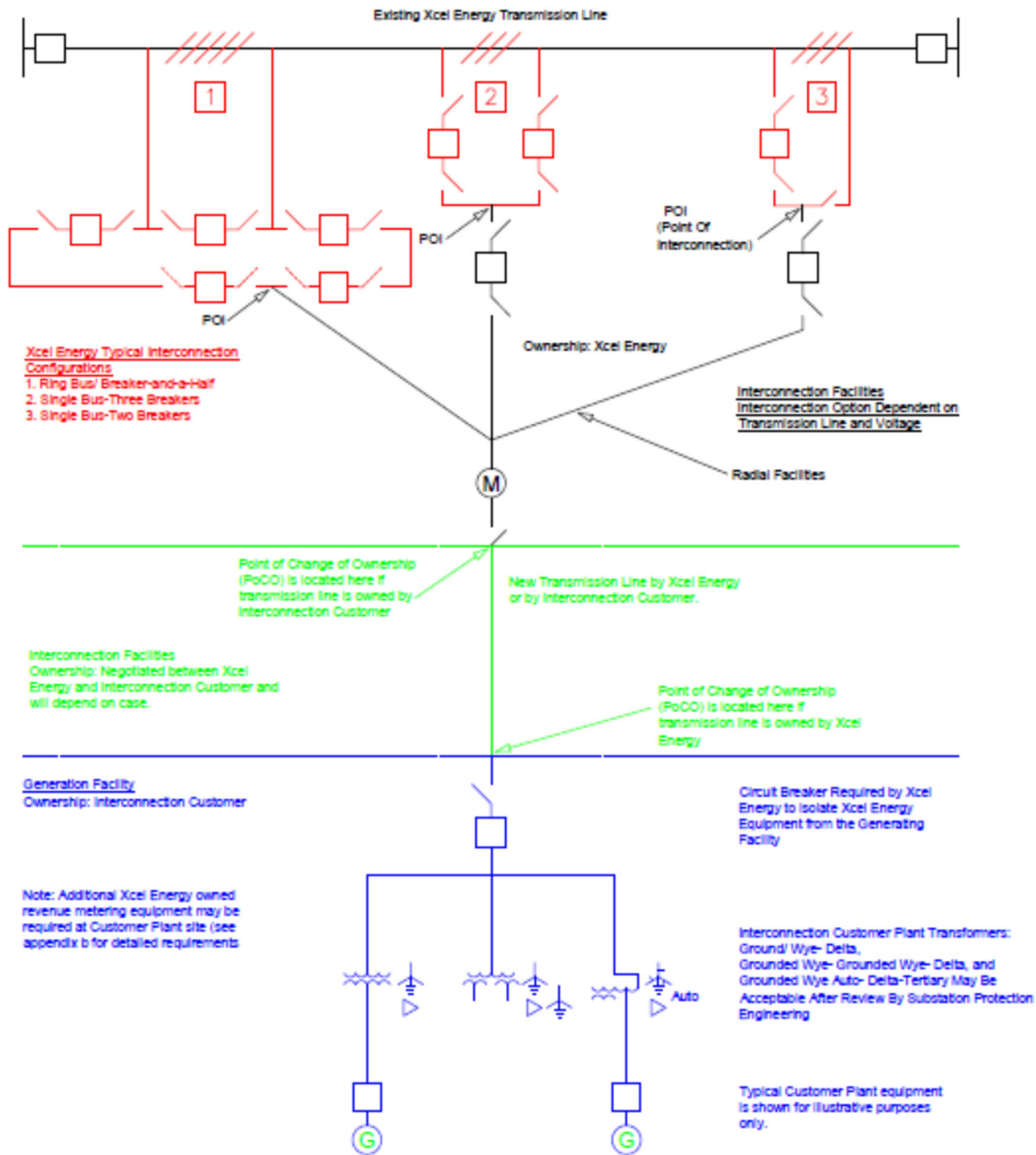
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APPENDIX A: Typical Interconnection Diagram

Figure 1: Typical Interconnection To Existing Transmission Line



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APPENDIX B: Xcel Energy Metering and Telemetry Requirements

1. GENERAL

The information in Appendix B outlines the requirements that shall apply for interconnecting the Interconnection Customer to the Xcel Energy System. In those cases where the Power Purchase Agreement, Interconnection Agreement, or Ancillary Services Agreement provisions differ from these requirements, the contract provisions shall take precedence.


The meter installation will be capable of measuring Real Energy (Watts, kW, or MW), Reactive Energy (vars, Kvars, or Mvars), Voltage (V or kV), Current (A), Watt-hours (Whr, kWhr, or MWhr), and var-hours (var-hours, kvar-hours, or Mvar-hours). The metering shall have memory capable of a minimum of 4-channel, hourly data recording for 60 days. Additional channels for data recording may be required at the discretion of Xcel Energy. High side or low side metering (with either a fixed billing Transformer Loss Compensation (TLC), a Meter Programmed or MV90 software calculated TLC) will be used when a Interconnection Customer owns the facility transformer. Low side metering may be required when the unit of the Interconnection Customer is embedded into another entity's electric system such as in an industrial plant. In this case, there may be a "Transformer Loss Compensation" adjustment within the metering. The metering installation shall have remote dial-up data-retrieval capability. The XE required billing (revenue) meter, net generation metering, gross generation metering, and associated transducers, instrument transformers (CTs, VTs) will be specified and owned by Xcel Energy but could be purchased and installed by the Interconnection Customer or XE, as identified during the project design phases, and determined on a case-by-case basis. Xcel Energy will furnish meter and programs according to Xcel Energy specifications.

2. METERING ACCURACY, TESTING, AND REPAIR

A. METERING ACCURACY – REVENUE METERING

The metering shall have an accuracy of + or – 0.5%. Any current or voltage transformers that are used for metering will adhere to the "Accuracy Classifications for Metering" listed in ANSI C57.13 Xcel Energy requires 3-element metering accuracy for all circuits; however, 2-element metering may be acceptable where necessary. The Voltage Transformers (VT) and Current Transformers (CT) must be metering accuracy class devices. Metering CTs and VTs are required to be independent of the protection system CTs. As long as the burden is not determined by Xcel Energy to be excessive, additional secondary windings on the VTs can be used for other purposes such as protective relaying. All of these VT secondary supplies used for non-revenue metering purposes (e.g. relaying) shall be separately fused from the metering VT secondary supplies.

All voltage and current transformers used for interconnect metering with continuous flows less than 20% of full-scale nameplate rating of the current transformers shall conform to $\pm 0.15\%$ metering accuracy class or better. All current transformers shall conform to ANSI metering accuracy class $\pm 0.3\%$ for Burdens B0.1 thru B1.8 and shall have a continuous current thermal rating factor (TRF) sized appropriately for the application. All voltage transformers shall meet ANSI metering accuracy class $\pm 0.3\%$ for all standard burdens. The current transformers and voltage transformers used to meter bi-directional power flow shall meet ANSI

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C57.13 requirements for instrument transformers. MW and Mvar transducers shall be 3-element transducers with an accuracy of $\pm 0.2\%$ or better. Note that the metering used for local (panel) and remote (SCADA) indication and monitoring purposes does not typically need to conform to the higher accuracy requirements of the revenue metering, and are typically supplied off of the relaying accuracy CTs (bushing CTs), CVTs, etc.

B. PERIODIC TESTING

The metering equipment shall be tested periodically, and re-calibrated to maintain the required accuracy. The meter testing frequency shall at a minimum be based on current Xcel Energy Practices. Xcel Energy’s present testing practices are based on the type of metering situation and the jointly agreed to requirements of both parties involved. Typically, the metering equipment at non-Xcel Energy generation sites is tested annually. The Interconnection Customer, at its option, may participate in the periodic testing. The party performing the testing must notify the witnessing party at least a week in advance, preferably more. If the proposed date is not acceptable, then an alternative time acceptable to both parties must be worked out. The owner of the meter shall analyze and distribute any maintenance, repair, and test results to all parties receiving the meter readings per the request of such parties.

C. METER AND TELEMTRY EQUIPMENT REPAIR

The owner of the metering and telemetry equipment is responsible for ensuring that the equipment is adequately maintained and is repaired within a reasonable time after a failure is detected. The repair or replacement of a bad meter must be completed within 24 hours after it has been detected. If the metering cannot be repaired within that time, Xcel Energy may require that the Interconnection Customer cease all generation until the meter has been repaired. All changes, repairs, and replacements of the meter must be coordinated with the Xcel Energy Meter Department.


3. METERING AND TELEMTRY FUNCTION REQUIREMENTS

The meter and telemetry requirements define Xcel Energy’s required functionality for meters, metering related equipment (telephone lines, current transformers, voltage transformers, etc.), and telemetry equipment (Remote Terminal Units [RTUs], transmitters, receivers, etc.). Three major factors generally determine the type of metering and telemetry required:

- a. The type and size of the customer’s generating equipment.
- b. The location of the customer on the Xcel Energy System.
- c. The manner in which the installation will operate (one-way vs. two-way power flow).

Each request will be handled individually, and Xcel Energy will solely determine the metering and telemetry modifications and/or additions required. Xcel Energy will work with the customer to achieve an installation that meets the requirements of both the customer and Xcel Energy. The metering requirements and cost responsibility will be stated in the Interconnection Agreement.

If the generating facility is outside Xcel Energy’s control area, the utility within whose control area the generator resides may have specific metering and telemetry requirements to which the Interconnection Customer must

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adhere. Upon the start of the Facilities Study, Xcel Energy will notify the customer of any other utility who may need to be involved in the metering and telemetry design and approval. If the generator is not within either Xcel Energy’s service territory or Xcel Energy’s control area, the following metering and telemetry requirements may not apply.

A. MEASURED VALUES AND METERING REQUIRED FOR GENERATING STATIONS WITH A NET OUTPUT CAPACITY GREATER THAN OR EQUAL TO 20 MW

- Real Power Flow (Watts, kW, or MW).
- Reactive Power Flow (vars, kvars, or Mvars).
- Voltage at the point of connection to the Xcel Energy System at Xcel Energy’s discretion.
- Amps at the point of connection with the Xcel Energy System.
- Remote Terminal Unit or Data Link to telemeter all measured values to Xcel Energy’s Energy Management System. Recording and communication of the data to Xcel Energy’s EMS through a dedicated communication medium. If the customer participates in the ancillary services market, recording and communicating every six seconds or less is required.

B. METERING CONFIGURATION

The meter installation will be capable of measuring Real Energy (Watts), Reactive Energy (VArS), Voltage (V), Current (A), Watt-hours, and var-hours. The metering shall have memory capable of a minimum of 4-channel, hourly data recording for 60 days. Additional channels for data recording may be required at the discretion of Xcel Energy.

The Typical Metering Installation (see Figure B-1) will be used when Xcel Energy serves the load requirements of the Interconnection Customer directly. At least two meters will be utilized; one meter will be used to measure the total power into or out of the facility. The Net meter will typically be on the high side of the generator step up transformer at the point of interconnection (Net facility POI). The other meter(s) will be located on each of the generator(s). The Generation meters will be totalized to give the total output of the generation (Gross Generation). The difference in the Net Facility POI meter and the Gross Generation metering is the load of the facility (house power load, all other loads and losses not associated with the power production process). The load of the facility will be billed using the current billing rates on file with PUC or PSC.

When Xcel Energy is not the retail supplier, the metering for the load requirements for the Interconnection Customer will be determined by the retail service provider (see Figure B-2).

Each specific situation will be evaluated for cost effective metering.

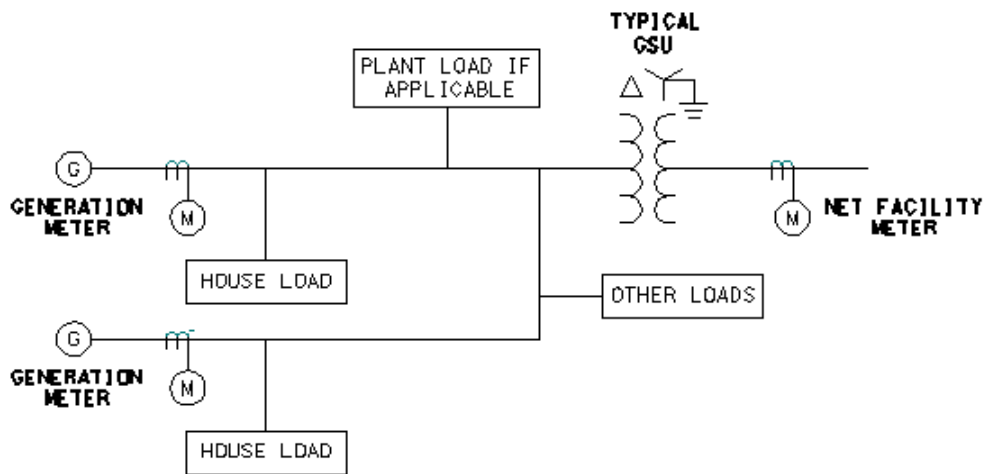
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**FIGURE B-1
TYPICAL METERING INSTALLATION – LOAD REQUIREMENTS SERVED BY XCEL ENERGY**



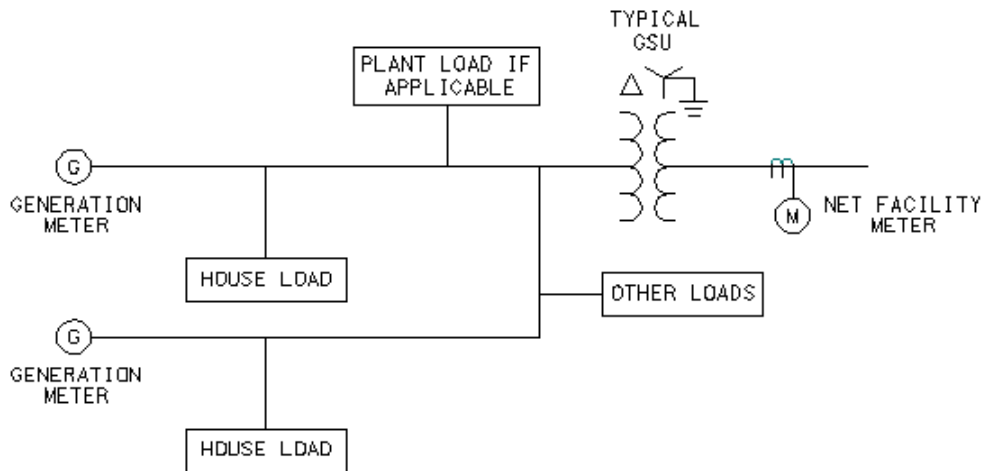
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**FIGURE B-2
TYPICAL METERING INSTALLATION – LOAD REQUIREMENTS SERVED BY ANOTHER RETAIL SERVICE SUPPLIER**



C. ENERGY LOSSES

If the energy is not measured at the point where the energy exchange between Xcel Energy and the Interconnection Customer has been defined by contract, energy losses must be determined. Accounting for the losses may be done either by attributing losses to the monthly accounting of exchanged energy or by attributing losses directly to the energy registered on the meter. Should a loss compensated meter be used, power transformer performance test results and/or line impedances must be supplied to Xcel Energy's Meter Engineering Department prior to installation. Transmission System Losses may not be applied through a compensated meter; only Transformation Losses and/or specific Line Losses may be applied through a compensated meter.

D. METER READING

General practice is to perform meter readings at midnight on the first day of the month. For most cases, the meter read day will be the last day of the month. All Interconnection metering points will have recording devices that are required to be interrogated by remote communication. Xcel Energy has the ability to share an existing telephone line with the Interconnection Customer, but it may be necessary to install a new communications line. The communications circuit cost (telephone lines, telephone charges, etc.) to allow

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remote reading of the meter at a non-Xcel Energy facility is the responsibility of the Interconnection Customer. Other communications options may be available for meter data retrieval, depending on service territory.

4. VOICE DISPATCH CIRCUIT

There shall be a voice communications circuit between the Interconnection Customer's facility and/or Interconnection Customer's dispatch center and the Xcel Energy System Control Center. If the facility plant operators are not located on the plant site, then the circuit must be terminated at the actual location of the plant operators. The circuit may be a leased line or may be a dialup circuit. If the circuit is a leased circuit, this circuit is to be ordered by the Interconnection Customer. This circuit will be a type 428 non-dialable pair, also known as an OSPA two-wire circuit.

5. PRODUCER FACILITY NET GENERATION OUTPUT TELEMETRY AND CONTROL

The design, purchase, installation, testing, maintenance, and replacement of the remote generation control and telemetry equipment and circuits from an Interconnection Customer's facility to Xcel Energy's EMS Dispatch Center will be the responsibility of Xcel Energy or their designated representative. The direct costs will be charged to the Interconnection Customer.

A. GENERATION TELEMETERING

All Interconnection Customers will have telemetering equipment installed at the Interconnection Customer's facility and receiving equipment at Xcel Energy's Operations Control Center (EMS Dispatch). This will typically include a telemetry Remote Terminal Unit (RTU) and meters (or transducers) that utilize the same Xcel Energy-supplied CTs and VTs used for the separate revenue meters. A separate dedicated communication circuit (e.g., leased line, etc.) will be required with this telemetry equipment.

B. XCEL ENERGY REQUIRED TELEMETRY POINTS

The table below provides the general telemetry and LFC/AGC requirements. As each installation is unique, the requirements may differ slightly depending on the type of generator interconnection as stated in Section VII. The Interconnect Agreement, Power Purchase Agreement, or Ancillary Services Agreement may contain certain requirements that must be met in addition to or in place of the typical ones listed below.

Xcel Energy's Typical Control Outputs to Interconnection Customer's Generation Control System Per Generator	
Raise Pulse MW	Pulse width range 50 ms-2 s
Lower Pulse MW	Pulse width range 50 ms-2 s
Voltage Reg. Raise	Pulse width range 50 ms-2 s
Voltage Reg. Lower	Pulse width range 50 ms-2 s
Go Max Generation	Normally Open Dry Contact
Go Min Generation	Normally Open Dry Contact

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Auto Stop	Normally Open Dry Contact
Auto Start	Normally Open Dry Contact

Interconnection Customer's Typical Control Outputs to Xcel Energy's LFC/AGC per Generator

Remote/Local status	Normally Open Dry Contact
Gen Run Mode Status	Normally Open Dry Contact
Acknowledge Go Max/Go Min	Normally Open Dry Contact
Raise Block	Normally Open Dry Contact
Lower Block	Normally Open Dry Contact

Xcel Energy's Typical Analog Outputs to Interconnection Customer's Generation Control System per Generator

(1) Desired MW	4/20 mA or 0-5 V Analog Signal
(1) Desired Mvar	4/20 mA or 0-5 V Analog Signal

Interconnection Customer's Typical Analog Outputs to Xcel Energy's LF/AGC per Generator

High Reg. Limit MW	4/20 mA or 0-5 V Analog Signal
Low Reg. Limit MW	4/20 mA or 0-5 V Analog Signal
Ramp Rate MW	4/20 mA or 0-5 V Analog Signal
High Reg. Limit Voltage	4/20 mA or 0-5 V Analog Signal
Low Reg. Limit Voltage	4/20 mA or 0-5 V Analog Signal

- (1) The units may be dispatched on either a net or gross basis depending on the AGC/LFC requirements of the specific AGC/LFC software in the SPS, NSP, or PSCo control centers. Xcel Energy's EMS Dispatch Center will typically send one set of pulses for control of each of the Interconnection Customer's generation units but may also provide a set of pulses to control the total plant output in lieu of controlling each unit.

C. LOAD CONTROL/RELAYING/COMMUNICATION CABINETS REQUIREMENTS

For most installations, Xcel Energy will provide cabinets that contain equipment for load control, telemetry, communications, and transmission line protective relaying that will be installed in the control room of the Facility of the Interconnection Customer. Typically this equipment will be installed in two separate cabinets, each with dimensions of 36" X 36" X 90". A third cabinet, also 36" X 36" X 90", will contain all interface terminal blocks and will act as a demarcation point of ownership between the Interconnection Customer's equipment and wiring and Xcel Energy's relaying, load control, and telemetry equipment. This interface cabinet may also contain a box mounted to the front that houses Xcel Energy's revenue metering. Xcel Energy requires that space be allotted to install these three cabinets in the Interconnection Customer's control house or electrical room. All cabinets are free standing and will be mounted side by side. The cabinets have rear-swinging doors and will require both front and rear access.

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The Interconnection Customer will provide all cables that extend from the interface cabinet to the equipment of the Interconnection Customer located in the switchyard and to the turbine control system. These cables will be identified on a cable schedule provided to the Interconnection Customer by Xcel Energy's System Engineering. The cable material shall meet or exceed Xcel Energy's cable specification. In most cases, Xcel Energy will provide communication cable(s) (possibly fiber optic cable) from the interface cabinet to the transmission line dead-end tower, or a location designated by Xcel Energy, in the switchyard of the Interconnection Customer. The Interconnection Customer shall provide all ditching and conduit required for the installation of this cable. This cable shall remain the property of Xcel Energy.

AC and DC sources will be required to operate the protective relaying, load control, and communication equipment. Separately fused DC circuits are required for the primary and backup relaying. Load control telemetry equipment and communication equipment will require separately fused DC circuits.

APPENDIX C - PSCo Voltage Control, AGC, and Frequency Response Testing Procedures

Solar and Wind Facilities:

*NOTE** Performance test period begins upon 1) successful commissioning of all generation equipment and other major electrical equipment to be connected to the Point of Interconnection, 2) SCADA in place, with all points available and active, and 3) Notification to PSCo by owner of readiness to start. 4) Ring-down telephone from Lookout to Generator Operation Center in place to be used for test communications. Test Period ends upon successful completion of all tests.*

A single voltage controller is expected to coordinate the reactive output of all facilities to achieve the desired POI voltage, VAR, or Power Factor setpoint.

Requirement	Specific Req.	Test	Pass	Conditions
Power Factor/VAR control at Point of Interconnection (POI).	Prove Power Factor/VAR control and limits at various levels.	<p>Maximum leading and lagging reactive power capability at the POI and the high side of the GSU.</p> <p>Maximum leading and lagging reactive power capability at the POI and the high side of the GSU.</p>	<p>0.95 or lower leading/lagging Power Factor at the high side of the GSU shall be considered acceptable.</p> <p>Initial system conditions shall be considered when evaluating the performance of the facility.</p>	<p>Full lag and lead PF (0.95 both directions, measured at the high side of the GSU) at 10%–50%, and >90% of rated MW output.</p> <p>Voltages within acceptable limits.</p>

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		Unity power factor at the POI.	-1 ≤MVAR≤ +1 at the POI.	10%–50%, and >90% of rated MW output.
		Low MW output MVAR control.	-5 ≤MVAR ≤ 0 at the POI. Report reactive shunts in use, or other source(s) of reactive compensation. Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line charging.	<10% of rated MW output. The facility shall not be curtailed to achieve a low MW output.
	Full line and collector system capacitance compensation at zero wind or irradiance conditions (demonstrate full reactive power compensation for line/collector capacitance).	Offset VAR output of connecting line and collector system at the POI.	-5 ≤MVAR ≤ 0 at the POI. Report reactive shunts in use, or other source(s) of reactive compensation. Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line and collector system charging.	≤ 0 MW output at the POI. The facility shall not be curtailed to achieve zero MW output.

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Voltage control at the POI	Raise/lower setpoint.	Series selected at time of test, e.g., "raise 5.0 kV" Increment setpoint by predetermined value (minimum of two steps above and below base voltage).	Proper direction, e.g., raise not lower, as requested, subject to p.f. limits.	>50% of rated MW output.
	Hold voltage setpoint.	Setpoint selected at time of test, e.g., 1.01 p.u.	Voltage held within +/- 1% as plant is capable, within power factor limits. Variability recorded and noted.	>50% of rated MW output at start of test period (may drop below during test), up to 6+ hours duration.
Frequency Response	Per FERC Order 842, install, maintain, and operate equipment capable of providing primary frequency response.	Provide an increase/decrease in power due to sudden changes in frequency.	Provide an adequate response (based on rated output) given the binary response parameters or droop, dead band, and initial frequency excursion settings (e.g. binary response setpoint or 3% droop, ±.036Hz dead band, and 0.07Hz initial excursion setting).	Speed governor reference change with the applicable unit(s) online. Tests to be completed with the facilities at 30%-70% and at > 75% rated MW output. For the underfrequency tests curtailment will be required for each facility to provide the necessary headroom.
Communication	Responsiveness.	Series of reasonable requests, e.g., "switch to voltage control mode", "report inverters/turbines	Professional, prompt (within one minute) response, accurate and complete. 100%	0-100% of rated MW output test range.

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		online", "reduce output to XX MW".	compliance for one week.	
Physical link		Documented dedicated circuit between Lookout & Generator Operating center.	Documentation submitted prior to operational testing.	No operational requirement.
		Site visit to operations center (most likely a PSCo engineer or manager).	Written summary of how control center works, and first-hand validation. Visit may be waived or delayed at PSCo discretion.	No operational requirement.
		Provide EMS/SCADA points from plant to Lookout.	Verified receipt of points via EMS including MW/MVAR output at POI, inverter/turbine statuses, and other relevant data from the facility.	No operational requirement.
		Respond to EMS dispatch signals with change in output (adequate response at PSCo's discretion).	Demonstrate down and up response to AGC signal at the POI provided the system is already curtailed AND there is enough headroom to reach the AGC setpoint.	>50% of rated MW output available throughout the test.

Renewable Facilities with Battery Energy Storage Systems (BESS):

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*NOTE** Performance test period begins upon 1) successful commissioning of all generation equipment and other major electrical equipment to be connected to the Point of Interconnection, 2) SCADA in place, with all points available and active, and 3) Notification to PSCo by owner of readiness to start. 4) Ring-down telephone from Lookout to Generator Operation Center in place to be used for test communications. Test Period ends upon successful completion of all tests.*

A single voltage controller is expected to coordinate the reactive output of all facilities to achieve the desired POI voltage, VAR, or Power Factor setpoint.

Requirement	Specific Req.	Test	Pass	Conditions
Power Factor/VAR control at Point of Interconnection (POI).	Prove Power Factor/VAR control and limits at various levels.	Maximum leading and lagging reactive power capability at the POI and the high side of the GSU (combined renewable and battery facilities).	0.95 or lower leading/lagging Power Factor at the high side of the GSU shall be considered acceptable.	Full lag and lead PF (0.95 both directions, measured at the high side of the GSU) at 10%–50%, and >90% of rated MW output/charging. Voltages within acceptable limits.
		Maximum leading and lagging reactive power capability at the POI and the high side of the GSU while with both facilities are producing power, renewable power only, renewable power charging the battery, grid charging, and battery power only.	Initial system conditions shall be considered when evaluating the performance of the facility.	
		Unity power factor at the POI. This test will be performed with both facilities producing power, renewable power only, renewable power charging the battery, grid charging, and battery power only.	-1 ≤MVAR≤ +1 at the POI.	10%–50%, and >90% of rated MW output/charging.

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		Low MW output/charging MVAR control.	<p>$-5 \leq \text{MVAR} \leq 0$ at the POI.</p> <p>Report reactive shunts in use, or other source(s) of reactive compensation.</p> <p>Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line and collector system charging.</p>	<p><10% of rated MW output/charging</p> <p>The facility shall not be curtailed to achieve a low MW output.</p>
	Full line capacitance and collector system compensation at zero power production (Demonstrate full reactive power compensation for line/collector capacitance).	Offset VAR output of connecting line and collector system at the POI.	<p>$-5 \leq \text{MVAR} \leq 0$ at the POI.</p> <p>Report reactive shunts in use, or other source(s) of reactive compensation.</p> <p>Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line and collector system charging</p>	<p>≤ 0 MW output at the POI.</p> <p>The facility shall not be curtailed to achieve zero MW output.</p>

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Voltage control at the POI	Raise/lower setpoint.	<p>Series selected at time of test, e.g., "raise 5.0 kV" Increment setpoint by predetermined value (minimum of two steps above and below base voltage).</p> <p>This test will be performed with both facilities producing power, renewable power only, renewable power charging the battery, grid charging, and battery power only.</p>	<p>Proper direction, e.g., raise not lower, as requested, subject to p.f. limits.</p>	>50% of rated MW output/charging.
	Hold voltage setpoint	<p>Setpoint selected at time of test, e.g., 1.01 p.u.</p> <p>This test will be performed with both facilities producing power, renewable power only, renewable power charging the battery, grid charging, and battery power only.</p>	<p>Voltage held within +/- 1% as plant is capable, within power factor limits.</p> <p>Variability recorded and noted.</p>	>50% of rated MW output at start of test period (may drop below during test), up to 6+ hours duration.
Frequency Response	Per FERC Order 842, install, maintain, and operate equipment capable of providing primary frequency response.	<p>Provide an increase/decrease in power due to sudden changes in frequency.</p> <p>This test will be performed with both facilities producing power, renewable power only, renewable power charging the battery, grid charging, and battery power only.</p>	<p>Provide an adequate response (based on rated output) given the binary response parameters or droop, dead band, and initial frequency excursion settings (e.g. Binary response setpoint or 3%</p>	Tests to be completed with the facilities at 30%-70% and at > 75% rated MW output/charging.

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			droop, ± 0.036 Hz dead band, and 0.07Hz initial excursion setting)	
Communication	Responsiveness	Series of reasonable requests, e.g., "switch to voltage control mode", "report inverters/turbines online", "reduce output to XX MW".	Professional, prompt (within one minute) response, accurate and complete. 100% compliance for one week.	0-100% of rated MW output test range.
	Physical link	Documented dedicated circuit between Lookout & Generator Operating center	Documentation submitted prior to operational testing.	No operational requirement.
		Site visit to operations center (most likely a PSCo engineer or manager)	Written summary of how control center works, and first-hand validation. Visit may be waived or delayed at PSCo discretion.	No operational requirement.
		Provide EMS/SCADA points from plant to Lookout.	Verified receipt of points via EMS including MW/MVAR output at POI, inverter statuses, and other relevant data from the facility.	No operational requirement.
		Respond to EMS dispatch signals with change in output (adequate response at PSCo's discretion). PSCo may require separate AGC signals for each facility.	Demonstrate down and up response to AGC signal at the POI .	>50% of rated MW output available throughout the test >50% of rated charging MW.

Battery Energy Storage Systems (BESS) only:

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*NOTE** Performance test period begins upon 1) successful commissioning of all generation equipment and other major electrical equipment to be connected to the Point of Interconnection, 2) SCADA in place, with all points available and active, and 3) Notification to PSCo by owner of readiness to start. 4) Ring-down telephone from Lookout to Generator Operation Center in place to be used for test communications. Test Period ends upon successful completion of all tests.*

A single voltage controller is expected to coordinate the reactive output of all facilities to achieve the desired POI voltage, VAR, or Power Factor setpoint.

Requirement	Specific Req.	Test	Pass	Conditions
Power Factor/VAR control at Point of Interconnection (POI).	Prove Power Factor/VAR control and limits at various levels.	Maximum leading and lagging reactive power capability at the POI and the high side of the GSU.	0.95 or lower leading/lagging Power Factor at the high side of the GSU shall be considered acceptable.	Full lag and lead PF (0.95 both directions, measured at the high side of the GSU) at 10%–50%, and >90% of rated MW output/charging. Voltages within acceptable limits.
		Maximum leading and lagging reactive power capability at the POI and the high side of the GSU while generating and charging.	Initial system conditions shall be considered when evaluating the performance of the facility.	
		Unity power factor at the POI. This test will be performed while generating and charging.	-1 ≤MVAR≤ +1 at the POI.	10%–50%, and >90% of rated MW output/charging.

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		Low MW output/charging MVAR control.	<p>$-5 \leq \text{MVAR} \leq 0$ at the POI.</p> <p>Report reactive shunts in use, or other source(s) of reactive compensation</p> <p>Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line charging.</p>	<10% of rated MW output/charging.
	Full line capacitance and collector system compensation at zero power production (Demonstrate full reactive power compensation for line/collector capacitance).	Offset VAR output of connecting line and collector system at the POI.	<p>$-5 \leq \text{MVAR} \leq 0$ at the POI.</p> <p>Report reactive shunts in use, or other source(s) of reactive compensation.</p> <p>Demonstrate automatic and manual operation of shunt reactors or other source(s) of reactive compensation adequate to offset transmission line and collector system charging</p>	~0 MW output at the POI.

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Voltage control at the POI	Raise/lower setpoint.	<p>Series selected at time of test, e.g., "raise 5.0 kV" Increment setpoint by predetermined value (minimum of two steps above and below base voltage).</p> <p>This test will be performed while generating and charging.</p>	<p>Proper direction, e.g., raise not lower, as requested, subject to p.f. limits.</p>	>50% of rated MW output/charging.
	Hold voltage setpoint.	<p>Setpoint selected at time of test, e.g., 1.01 p.u</p> <p>This test will be performed while generating and charging.</p>	<p>Voltage held within +/- 1% as plant is capable, within power factor limits</p> <p>Variability recorded and noted.</p>	>50% of rated MW output/charging.
Frequency Response	Per FERC Order 842, install, maintain, and operate equipment capable of providing primary frequency response.	<p>Provide an increase/decrease in power due to sudden changes in frequency.</p> <p>This test will be performed while generating and charging.</p>	<p>Provide an adequate response (based on rated output) given the binary response parameters or droop, dead band, and initial frequency excursion settings (e.g. Binary response setpoint or 3% droop, ±.036Hz dead band, and 0.07Hz initial excursion setting)</p>	Tests to be completed with the facilities at 30%-70% and at > 75% rated MW output/charging.

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Communication	Responsiveness	Series of reasonable requests, e.g., "switch to voltage control mode", "report inverters online", "reduce output to XX MW". This test will be performed while generating and charging.	Professional, prompt (within one minute) response, accurate and complete. 100% compliance for one week.	0-100% of rated MW output/charging test range.
	Physical link	Documented dedicated circuit between Lookout & Generator Operating center.	Documentation submitted prior to operational testing.	No operational requirement.
		Site visit to operations center (most likely a PSCo engineer or manager).	Written summary of how control center works, and first-hand validation. Visit may be waived or delayed at PSCo discretion.	No operational requirement.
		Provide EMS/SCADA points from plant to Lookout.	Verified receipt of points via EMS including MW/MVAR output at POI, inverter statuses, and other relevant data from the facility	No operational requirement.
		Respond to EMS dispatch signals with change in output (adequate response at PSCo's discretion).	Demonstrate down and up response to AGC signal at the POI.	>50% of rated MW output/charging.

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Synchronous Generation:

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Requirement	Specific Req.	Test	Pass	Conditions
Power Factor/VAR control at Point of Interconnection (POI).	Prove Power Factor/VAR control and limits at various levels.	Maximum leading and lagging reactive power capability at the POI.	0.95 or lower leading/lagging Power Factor at the POI shall be considered acceptable. Initial system conditions shall be considered when evaluating the performance of the facility.	Full lag and lead PF (0.95 both directions, measured at the POI) at 0 MW, 50%, and 100% of rated MW output. Voltages within acceptable limits.
		Unity power factor at the POI.	-1 ≤MVARs≤ +1 at the POI.	0 MW, 50%, and 100% of rated MW output.
Voltage control at the POI.	Raise/lower setpoint	Series selected at time of test, e.g., "raise 5.0 kV" Increment setpoint by predetermined value (minimum of two steps above and below base voltage).	Proper direction, e.g., raise not lower, as requested, subject to p.f. limits.	0 MW, 50%, and 100% of rated MW output.

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	Hold voltage setpoint	Setpoint selected at time of test, e.g., 1.01 p.u.	Voltage held within +/- 1% as plant is capable, within power factor limits. Variability recorded and noted.	0 MW, 50%, and 100% of rated MW output, up to 6+ hours duration.
Frequency Response	Per FERC Order 842, install, maintain, and operate equipment capable of providing primary frequency response.	Provide an increase/decrease in power due to sudden changes in frequency.	Provide an adequate response (based on nameplate rating) given the droop and dead band (e.g. 3% droop, ±.036Hz dead band).	Speed governor reference change with the applicable unit(s) online. Tests to be completed with the facilities at 30%-70% and at > 75% rated MW output.
Communication	Responsiveness.	Series of reasonable requests, e.g., "switch to voltage control mode", "reduce output to XX MW".	Professional, prompt (within one minute) response, accurate and complete. 100% compliance for one week.	0-100% of rated MW output.
	Physical link.	Documented dedicated circuit between Lookout & Generator Operating center. Site visit to operations center (most likely a PSCo engineer or manager)	Documentation submitted prior to operational testing. Written summary of how control center works, and first-hand validation. Visit may be waived or delayed at PSCo discretion.	No operational requirement. No operational requirement.

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		Provide EMS/SCADA points from plant to Lookout.	Verified receipt of points via EMS including MW/MVAR output at POI, and other relevant data from the facility.	No operational requirement.
		Respond to EMS dispatch signals with change in output (adequate response at PSCo's discretion).	Demonstrate down and up response to AGC signal at the POI.	>50% of rated MW output available throughout the test.