



**MIDAMERICAN ENERGY TECHNICAL REQUIREMENTS  
FOR NEW INTERCONNECTIONS OF GENERATION TO THE  
MIDAMERICAN ENERGY TRANSMISSION SYSTEM**

The MidAmerican Energy Technical Requirements may be accessed via the web at <http://oasis.midwestiso.org/oasis/MEC> or upon request to the Electric System Planning department at 106 E 2<sup>nd</sup> Street, Davenport, IA. 52801. Telephone contact (563-333-8162)

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## **1.0 Scope**

These Technical Interconnection Requirements (“Requirements”) apply to all generator interconnections (“Interconnection” or “Interconnections”), regardless of size, for which the point of interconnection is the MidAmerican Energy transmission system. These Requirements shall be applied on a comparable basis to all generators within this scope. These Requirements specify the minimum technical requirements intended to ensure a safe, effective and reliable interconnection. The requirements outlined in this document may not cover all details in specific cases.

MidAmerican Energy reserves the right to revise these Requirements from time-to-time without advanced notice. MidAmerican Energy may revise these Requirements periodically to comply with new regulations from the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC), state, or other governmental authorities. MidAmerican Energy may require that all Interconnections comply with new regulations by implementing similar procedures and / or upgrades as would be expected on the MidAmerican Energy facilities in a non-discriminatory manner. If the Interconnection does not comply, MidAmerican Energy may disconnect the Interconnection after proper notification.

## **2.0 Purpose**

These Requirements are considered to be supplemental technical requirements to the procedures and requirements set forth in the Midwest ISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (“Midwest ISO Tariff”) and Midwest ISO business practice manuals, and the procedures and requirements set forth by FERC and NERC. To the extent that there is a conflict between these Requirements and the current requirements of the Midwest ISO Tariff, FERC, or NERC, then the Midwest ISO Tariff, FERC, or NERC requirements will govern.

In addition to the technical interconnection requirements provided in this document, the Interconnection shall comply with all applicable federal, state, and local requirements, environmental regulations, siting requirements, and Good Utility Practices.

These Requirements are intended to:

- i. Document MidAmerican Energy’s requirements and procedures for generators to interconnect to the MidAmerican Energy transmission system.
- ii. Provide a written summary of MidAmerican Energy’s plans to achieve required system performance according to the NERC, the Midwest Reliability Organization (MRO), Midwest ISO, and MidAmerican Energy criteria.
- iii. Document procedures for coordinated joint studies of new facilities to determine Interconnection impacts on the MidAmerican Energy and adjoining bulk power systems.

- iv. Document notification procedures to other entities responsible for bulk power reliability.

### 3.0 Procedures for Obtaining a Generator Interconnection

MidAmerican Energy has turned over functional control of its transmission facilities to the Midwest ISO; therefore, requests for generator interconnections to these facilities will be administered by the Midwest ISO according to the Midwest ISO Tariff and Midwest ISO business practice manual for generator interconnections. A brief summary of the interconnection process is provided below, and a process diagram obtained from the Midwest ISO website has been attached as Appendix A. Additional details, references, and frequently asked questions can be found on the interconnection planning portion of the Midwest ISO webpage at <http://www.midwestmarket.org/page/Generator%20Interconnection>. A listing of the milestones, both technical and non-technical, and the study deposits that the interconnection customer must meet through the interconnection process can be found in the Midwest ISO business practice manual for generator interconnections.

**Pre-queue phase:** This phase provides the customer an overview of the Midwest ISO interconnection process and associated timelines.

**Interconnection application:** In order for an Interconnection to be evaluated, an interconnection application available on the Midwest ISO webpage noted above must be submitted.

**Scoping Meeting:** Following the submittal of the interconnection application and Midwest ISO acceptance as a complete and valid application, the interconnection customer may request a scoping meeting to discuss alternative points of interconnection and general issues in the area of the proposed Interconnection such as thermal, voltage, stability, short circuit, etc.

**Interconnection Studies:** A series of interconnection studies are conducted by the Midwest ISO to evaluate the interconnection request. These studies identify the system upgrades, if any, that are required in order to reliably interconnect the generator. These upgrades will be included in the generator interconnection agreement that is signed between Midwest ISO, MidAmerican Energy and the interconnection customer.

The Midwest ISO interconnection study process includes forming an ad hoc study group including interconnection customers, Midwest ISO consultants, potentially impacted Transmission Owners and adjacent transmission service providers to comment on the study scope, models, contingencies, results, mitigation plans, draft reports, etc. The interconnection studies include:

- a. Feasibility Study - The feasibility study is intended to identify whether the proposed Interconnection is located in a constrained area, and therefore will require more extensive studies.

- b. System Impact Study – The system impact study includes the System Planning & Analysis Phase, if required, and the Definitive Planning Phase. Under the Midwest ISO process, these studies generally group multiple interconnection requests in a similar geographic area and analyses are performed to determine system impacts, both common impacts of multiple requests and local impacts specific to a particular request. A preliminary estimate of the cost and length of time necessary to implement the mitigation plans and the cost allocation amongst the interconnection requests are also provided as products of the system impact study.
- c. Facilities Study - The facilities study will involve more detailed engineering analyses to prepare cost estimates and schedule estimates to construct the system upgrades necessary to reliably interconnect the proposed generator to the MidAmerican Energy transmission system. The outcome of the facilities study will be used to populate the generator interconnection agreement appendices with the diagrams, cost estimates, and schedules for these system upgrades.

**Generator Interconnection Agreement (GIA) and Facilities Construction Agreements (FCAs)** – The GIA will consist of the standard Midwest ISO GIA with the appendices updated to reflect the specifics of the Interconnection as developed through the facilities study. Although the interconnection studies evaluate multiple interconnection requests and certain system upgrades may have shared cost responsibility, the GIA will be for a single interconnection request. For Interconnections to the MidAmerican Energy transmission system, the GIA will be between Midwest ISO, MidAmerican Energy and the interconnection customer. The GIA will describe all aspects of the Interconnection such as facility ownership, cost responsibility, financing responsibility, reimbursement eligibility, and construction schedule. The GIA will cover all upgrades to the facilities on the MidAmerican Energy system. If the Interconnection requires upgrades to other Midwest ISO transmission facilities not part of the MidAmerican Energy system, Facilities Construction Agreements will be executed. If the Interconnection requires upgrades to facilities owned by utilities outside the Midwest ISO, the GIA will reference the interconnection customer's obligation to work with those utilities to implement the necessary upgrades prior to interconnection of the generator.

**Optional Study Process** – The Midwest ISO generator interconnection procedures provide for optional studies to be performed outside of the queue process for Interconnections that desire to obtain a provisional interconnection agreement in the near term. The optional study process does not take the place of the normal queue process or the interconnection studies described above, and the results of the interconnection studies described above will dictate the ultimate requirements necessary for the Interconnection. Following the necessary evaluations in the optional study process, the interconnection customer may enter into a provisional interconnection agreement until the remaining interconnection studies are completed, presuming that the optional study identified capability on the system to accommodate the generation injection in the near term. The Midwest ISO will establish and review the output limits associated with the Interconnection quarterly and the Interconnection will be subject to the results of

those quarterly reviews. If an Interconnection pursues this process, the interconnection customer assumes all risks associated with changes to the Interconnection output limits and changes in the GIA.

At any point in the Midwest ISO study process or during the negotiation of the interconnection agreement, the interconnection customer may request an engineering & procurement agreement to allow MidAmerican Energy to begin engineering or material procurement if an expedited schedule is required. MidAmerican will not commence physical construction activities under the terms of such engineering & procurement agreement.

## **4.0 Construction and Ownership**

Following the execution of the Generator Interconnection Agreement (GIA), engineering, design and construction activities will commence according to the construction schedule documented in the GIA. Throughout the implementation phase of the interconnection process, MidAmerican Energy will conduct regular status update conference calls to discuss progress on the MidAmerican Energy system upgrades and the interconnection customer's construction and to discuss any coordination of construction activities.

Unless specified otherwise in the GIA, MidAmerican Energy shall construct, own, and operate all transmission facilities constructed for the Interconnection that are part of the MidAmerican Energy transmission system. MidAmerican Energy shall also construct, own, and operate all interconnection facilities on the MidAmerican Energy side of the point of change of ownership as defined in the GIA. MidAmerican Energy may, at its option, contract with a third party for construction of any of these facilities. The interconnection customer will normally construct and own, operate and maintain all facilities on the interconnection customer side of the point of change of ownership. Both MidAmerican Energy's and the interconnection customer's construction shall meet all applicable national, state and local construction and safety codes.

### **4.1 Permitting**

The interconnection customer shall be responsible for obtaining the required permits and regulatory approvals for its facilities, and MidAmerican Energy shall be responsible for obtaining the required permits and regulatory approvals for the MidAmerican Energy system upgrades including the MidAmerican Energy interconnection facilities. In addition, regulatory approvals may be required to be obtained by neighboring systems if the Interconnection requires system upgrades on third party facilities.

### **4.2 Interconnection Substation Configurations**

An Interconnection to the MidAmerican Energy transmission system may be made at an existing MidAmerican Energy transmission substation or via a connection with breakers into an existing MidAmerican Energy transmission line. The configuration requirements of the Interconnection depend in part on the voltage level where the Interconnection is to occur. At a minimum,

- i. If the Interconnection is to a 345 kV facility on the MidAmerican Energy system, the minimum configuration will be a ring-bus. A straight bus configuration may be used if the Interconnection is to a facility rated below 345 kV.
- ii. Generally, MidAmerican Energy will not allow a straight bus configuration with greater than five breakers. Expansion beyond this level will require conversion of the station into a ring-bus design. MidAmerican Energy, at its sole discretion, may consider different configurations due to physical limitations at the site.
- iii. Generally, MidAmerican Energy will not allow a ring bus configuration with greater than eight breakers. Expansion beyond this level will require conversion of the station into a breaker-and-a-half design. MidAmerican Energy, at its sole discretion, may consider different configurations due to physical limitations at the site.
- iv. No Interconnection configuration will be allowed that creates a three terminal transmission line configuration.
- v. If the Interconnection is to an existing MidAmerican Energy transmission substation, the interconnection must conform, at a minimum, to the original designed configuration of the substation.
- vi. Depending upon the configuration of the interconnection substation, the interconnection customer may be required to install a circuit breaker on the high voltage side of their generator step-up transformer (GSU). Depending upon the configuration of the interconnection substation, MidAmerican Energy may require capability to send a remote trip signal to the interconnection customer's circuit breaker on the GSU high-side.

In any case, the Facilities Study will determine final configuration of the Interconnecting Facilities.

## **5.0 Interconnection Requirements**

### **5.1 General Requirements**

Throughout the remainder of the document a number of national standards and guidelines (e.g. ANSI/IEEE) are referenced, the latest revision of these standards and guidelines, or the applicable superseding standard, shall govern the requirements of the Interconnection. The Interconnection must also comply with the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate the MidAmerican Energy Planning Reliability Criteria as documented in **Appendix B**, including those systems below 100 kV.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate equipment ratings as developed according to the MidAmerican Energy Company Transmission Facility Ratings Methodology as documented in **Appendix C**, including those systems below 100 kV.

An Interconnection shall meet the requirements in the MISO Tariff Process for Large Interconnections as documented in **Appendix D**.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate the applicable NERC reliability standards as documented in **Appendix E**.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate the applicable MRO Performance Standards as documented in **Appendix F**.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate MidAmerican Energy Flicker Standards as documented in **Appendix G**.

An Interconnection shall not violate nor cause the MidAmerican Energy electric system to violate MidAmerican Energy Harmonic Standards as documented in **Appendix G**.

In addition, the equipment associated with the Interconnection should be in accordance with the practices described in the latest revision of the following ANSI/IEEE Standards or Guides, or the applicable superseding standard. There may be additional special requirements imposed by MidAmerican Energy due to the specific project or application.

- General Requirements for Synchronous Machines, ANSI C50.10
- Requirements for Salient Pole Synchronous Generators and Condensers, ANSI 50.12
- Requirements for Cylindrical-Rotor Synchronous Generators, ANSI C50.13
- Requirements for Combustion Gas Turbine Driven Cylindrical-Rotor Synchronous Generators, ANSI C50.14
- Guide for Generator Ground Protection, ANSI/IEEE C37.101
- Guide for AC Generator Protection, ANSI/IEEE C37.102
- Guide for Abnormal Frequency Protection for Power Generating Plants, ANSI/IEEE C37.106
- Guide for Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems, ANSI/IEEE Std 1001
- Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547
- IEEE Std 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- IEEE / ANSI C84.1 American National Standard for Electric Power Systems and Equipment - Voltage Ratings (60 Hz)
- IEEE 1543, Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems
- ANSI C84.1-1995 Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)
- IEEE Std C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits
- IEEE Std C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits
- ANSI / IEEE Std C37.90.1, IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
- ANSI / IEEE Std. C37.90.2, Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
- IEEE 80, IEEE Guide for Safety in AC Substation Grounding Document Number
- IEEE 142, Recommended Practice for Grounding of Industrial and Commercial

## Power Systems

- IEEE Standard 421.2, IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems

## 5.2 System Protection Requirements

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for system protection.

The Interconnection shall incorporate equipment to detect system abnormalities or disturbances in either the interconnection customer's system or the MidAmerican Energy system. This equipment shall have the capability to isolate the sources of the disturbance. At a minimum, the interconnection customer shall install adequate protective devices to:

- i. Detect and clear short circuits on MidAmerican Energy facilities serving the interconnecting facilities
- ii. Detect the voltage and frequency changes which can occur if MidAmerican Energy facilities serving the interconnecting facilities are disconnected from the main system, and clear any generation / load from the isolated system if necessary.
- iii. Prevent reclosing generation to MidAmerican Energy, after an incident of trouble, until authorized by MidAmerican Energy's Des Moines Control Center.
- iv. Isolate the Interconnection from the MidAmerican Energy electric system upon:
  - a. Receipt of a direct trip signal from an upstream MidAmerican Energy substation
  - b. Failure of the communications channel used for direct tripping
  - c. Receipt of a trip command from the Des Moines Control Center via supervisory control and data acquisition (SCADA).

The interconnection customer is solely responsible for the design that affects its facility, including generation and connected load. The interconnection customer should be aware that certain conditions on MidAmerican Energy's system can cause negative sequence currents to flow in the generator. It is the sole responsibility of the interconnection customer to protect its equipment from excessive negative sequence currents.

The equipment associated with the Interconnection should be protected in accordance with the practices described in the latest revision of the following ANSI/IEEE Standards or Guides. There may be special requirements imposed by MidAmerican Energy due to the specific project or application.

- ANSI/IEEE C37.91, Guide for Protective Relay Applications to Power Transformers
- ANSI/IEEE C37.95, Guide for Protective Relaying of Utility-Customer Interconnections
- ANSI/IEEE C37.97, Guide for Protective Relay Applications to Power System Busses
- ANSI/IEEE C37.101, Guide for Generator Ground Protection
- ANSI/IEEE C37.102, Guide for AC Generator Protection

- ANSI/IEEE C37.106, Guide for Abnormal Frequency Protection for Power Generating Plants
- ANSI/IEEE Std 1001, Guide for Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems

The Interconnection shall be able to withstand Electromagnetic Interference (EMI) environments in accordance with latest revision of ANSI / IEEE Std. C37.90.2. The associated systems and protection systems shall not mis-operate due to EMI, including hand held communication devices.

The following interconnection relays would be required at a minimum:

- Over-voltage (59).
- Under-voltage (27).
- Over/Under Frequency (81O/81U).
- Two zone Distance, Phase and Ground, (21). On short transmission lines or installations where the MidAmerican Energy interconnection substation and the customer's interconnection substation are adjacent differential relay(s) may be substituted.
- Ground Overcurrent Relay (51TN).
- Transformer Differential Relay (87T).
- Breaker Failure Initiate from all appropriate protective relays.
- Reverse Power (32).
- Synchronizing Check (25X).
- Speed-Matching (15) for induction generators.

The following additional protection functions may be suggested or required to coordinate with the protective systems of MidAmerican Energy:

- Out-of-Step (68).
- Breaker Failure Relay (50BF).
- Voltage Balance (60).
- Phase Sequence (47).
- Transfer-Trip (TT).
- Directional Overcurrent (67).

All protective relays shall be "Utility Industry Grade" protective relays. These relays have more stringent tolerances and more flexible, widely published characteristics than "industrial quality" relays.

All protective devices supplied to satisfy the requirements of this section shall be equipped with operation indicators (targets) or shall be connected to an annunciator or event recorder so that it will be possible to determine, after the fact, which devices caused a particular trip.

MidAmerican Energy facilities serving the interconnection facilities may be equipped with high speed reclosing to expedite returning the facilities to service following a fault of temporary nature. The protective devices installed by the interconnection customer and acceptable to MidAmerican Energy are intended to disconnect the generation from faulted or isolated lines before reclosing occurs. Depending on the installation,

MidAmerican Energy may require “Hot Line Reclose Blocking” to be installed at the necessary points on MidAmerican Energy’s system. If desired by the interconnection customer, a breaker auxiliary contact may be provided, at the customer’s expense, to initiate transfer trip to protect the Interconnection from out-of-phase reclosing on the MidAmerican Energy system.

### **5.2.1 Redundant/Backup Relaying**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for redundant relaying.

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

MidAmerican Energy requires primary and secondary protective relaying, including independent primary and secondary communications paths for transmission lines operated at 345 kV.

### **5.2.2 Coordination & Testing of Protective Devices**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for coordination and testing of protective devices.

MidAmerican Energy shall review the generator, main transformer, main breakers, synchronizing and any other interface equipment protection schemes and the setting and certified test records for these protective devices. The proposed settings for these devices shall be submitted no less than 60 days prior to implementation. Acceptance will not be unreasonably withheld. Any changes required by MidAmerican Energy shall be made prior to final acceptance, and MidAmerican Energy shall be provided with final copies of the reviewed drawings and settings.

The interconnection customer shall not make any substantial modifications or alterations to its facility or any modifications to the protective devices or setting of the devices without written notice and acceptance from MidAmerican Energy at least 60 days before the proposed change is to be made. All relaying equipment shall be kept under seal, which shall be broken only when the relays are to be tested or adjusted, or subject to inspection by MidAmerican Energy.

All protective devices supplied to satisfy the requirements of this section shall be tested by qualified personnel at intervals at least as frequent as those used by MidAmerican Energy for the relays protecting the facilities serving the interconnection facilities. Special tests may also be requested by MidAmerican Energy to investigate apparent misoperations. Each routine or special test shall include both a calibration check and an actual trip of the circuit breaker from the device being tested. A report of each test shall be prepared and sent to MidAmerican Energy listing the tests made and the “as found” and “as left” calibration values.

### **5.2.3 Synch-Check Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for synchronization of generators to the transmission system.

The Interconnection design shall incorporate adequate facilities to enable the on-site generation to be synchronized with the MidAmerican Energy electric system. The interconnection customer shall be solely responsible for synchronizing the generator to the system. At the Midwest ISO's discretion or MidAmerican Energy's discretion, all occurrences of synchronizing the generator to the system shall be preceded with advance notification, of not less than one full clock hour, provided to the MidAmerican Energy Des Moines Control Center.

All points at which the generator can be paralleled with the MidAmerican Energy electric distribution system must be clearly defined as synchronization points in the submittal documentation. A given installation may be designed such that there are several synchronization points. Every circuit opening or closing device such as circuit breakers or disconnect switches in the circuit path between MidAmerican Energy and the on-site generation shall be either:

- i. Designated as a synchronization point and be equipped with its own dedicated synchronizing equipment or
- ii. Electrically or mechanically interlocked with the synchronizing device at the clearly defined synchronization point such that the synchronizing device will be automatically tripped and blocked from closing any time the interlocked circuit opening or closing device is opened.

A separate, independent, single-phase synchronism check relay shall be installed to supervise all manual and automatic synchronizing attempts. The synchronism check relay shall adhere to the following criteria:

- i. The output of the synchronism check relay must be wired directly in the breaker close path. Wiring the output of the synchronism check relay to supervise the breaker via a Programmable Logic Controller (PLC) is prohibited.
- ii. The generator synchronism check relay shall be set to the manufacturer recommended settings.

Induction generators may use a speed matching relay (Device 15) as a means of synchronization and to limit the magnetizing inrush current / voltage drop. The speed matching must keep voltage flicker at the point of interconnection within MidAmerican Energy voltage flicker requirement and within IEEE 519 requirements.

## **5.3 Frequency Control**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for frequency control.

The energy delivered to the MidAmerican Energy system must be 60 Hz sinusoidal alternating current. All new synchronous generators connected to the MidAmerican

Energy transmission system with a nameplate rating greater than 20 MVA shall be equipped with a speed/load governing control that has a speed droop characteristic in the 3 to 6% range. The preferred droop characteristic setting is 5%. Notification of changes in the status of the speed/load governing controls must be provided to the MidAmerican Energy System Operator.

The Interconnection Customer shall conform with MidAmerican Energy and any regional Under Frequency Load Shed (UFLS) plans as necessary. This may include the installation of relays with UFLS elements that would trip load during under frequency events according to MidAmerican Energy and regional guidelines. It may also require generation to ride through under voltage and under frequency events according to MidAmerican Energy and regional guidelines.

During any underfrequency situation, the interconnection customer shall agree to immediately make available to MidAmerican Energy any spinning or operating reserves that exist on their generation.

#### **5.4 Insulation Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for equipment insulation levels.

The interconnection customer shall design the Interconnection such that it is adequately protected from surges. Industry standard Basic Insulation Level (BIL) ratings shall be used for the Interconnection and electric system interface equipment. The interconnection customer shall install additional surge protection devices (e.g. surge arresters) to achieve proper insulation coordination. The electric equipment shall meet surge withstand requirements identified in the latest revision of IEEE C62.41 or C37.90.1.

#### **5.5 Grounding Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for substation and equipment grounding.

The Interconnection must be designed to provide adequate grounding. The ground grid must be designed according to the latest revision of IEEE 80. The interconnection customer shall provide MidAmerican Energy data on soil resistivity and a ground grid design prior to the construction of the ground grid. The Interconnection shall provide a ground current path that is acceptable to MidAmerican Energy. Where required, the ground path shall be effectively grounded according to the latest revision of IEEE 142 which specifies that the positive zero sequence reactance is greater than the zero sequence resistance ( $X1 > R0$ ) and zero sequence reactance is less than or equal to three (3) times the positive sequence reactance ( $X1 \leq 3 * X0$ ).

The Interconnection grounding scheme shall not cause overvoltages that exceed MidAmerican Energy equipment ratings or interconnection equipment ratings, and shall not disrupt ground fault protection coordination.

The Interconnection design shall be such that MidAmerican Energy will be able to ground and test any MidAmerican Energy owned or serviced equipment. This may require the interconnection customer to pay for and install approved grounding equipment at the facility.

In general, the generator step-up transformer (GSU) must be effectively grounded on the utility side providing an adequate ground reference and will isolate the generator's zero sequence current from the MidAmerican Energy system through the use of an ungrounded connection on the generator side.

## **5.6 Communications Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for communications.

Communication facilities shall be provided by the interconnection customer according to MISO Tariff requirements and procedures for communications between the Interconnection and MidAmerican Energy/Midwest ISO. The interconnection customer shall install, own, and maintain Remote Terminal Unit (RTU) equipment and associated communications that is compatible with MidAmerican Energy equipment. The interconnection customer shall be responsible for RTU installation and subject to MidAmerican Energy approval according to MISO Tariff requirements and procedures.

If required due to configuration of the interconnection substation, the Des Moines Control Center shall be provided with breaker control to allow the Interconnection to be disconnected from MidAmerican Energy transmission facilities. As necessary, during emergencies, MidAmerican Energy reserves the right to disconnect the Interconnection from the MidAmerican Energy electric system without prior notification.

## **5.7 Metering and Indication Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for metering and supervisory control and data acquisition (SCADA).

Suitable SCADA (metering and telemetering) equipment shall be provided to meter and to transmit electrical energy and demand information at the interface to the MidAmerican Energy Des Moines Control Center according to MISO Tariff requirements and procedures. Metering equipment shall be of the type currently prescribed by the MISO Tariff requirements and procedures. Such metering typically includes all watt-hour meters, VAR-hour meters, energy recorders, current and potential transformers and associated equipment at each point of interconnection for billing and system control. The interconnection meter shall be installed and maintained by MidAmerican Energy.

All metering equipment shall be maintained and tested periodically as specified by the more restrictive of NERC or MidAmerican Energy criteria. Accuracy of registration shall be maintained in accordance with prudent utility practices and accepted industry standards. Modern solid-state meters should be calibrated to at least +/- 0.3% and hold that accuracy. Installation of electro-mechanical meters is not allowed. On request of either party, a special test may be made at the expense of the party requesting such special test. Representatives of both parties shall be afforded the opportunity to be present at all routine and special tests. If, as a result of any test, any meter is found to be

registering more than one half of one percent (0.5%) above or below one hundred percent (100%) of accuracy, the registration of such meter shall be corrected for a period equal to one-half (1/2) of the elapsed time since the last prior test and adjustment, according to the percentage of inaccuracy so found, except that if the meter shall have become defective or inaccurate at a reasonably ascertainable time since the last prior test and adjustment of such meter, the correction shall extend back to such time. Should metering equipment fail to register, the electrical energy delivered shall be determined from the best available data. All metering equipment shall be kept under seal, which shall be broken only when the metering is to be tested, adjusted, or inspected by MidAmerican Energy.

## **5.8 Voltage Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for voltage performance.

### **5.8.1 Steady State Voltage**

The Interconnection shall not cause the MidAmerican Energy electric system to violate the MidAmerican Energy voltage criteria or voltage ranges defined in the latest revision of ANSI Std C84.1 Range A (plus or minus 5% of nominal). If real-time voltage measurements violate the MidAmerican Energy voltage criteria, and the Interconnection is causing or contributing to the violation, the Interconnection will be immediately disconnected. The Interconnection will remain disconnected until it can be verified through real-time studies by MidAmerican Energy and Midwest ISO that the restoration of the Interconnection would not cause violation of the MidAmerican Energy voltage criteria.

The interconnection customer shall design the Interconnection to maintain a power factor at the point of interconnection within the range of 0.95 leading to 0.95 lagging, unless MidAmerican Energy has established different requirements for its VAR-001/VAR-002 policy that apply to all generators in the control area on a comparable basis. This shall apply to all units unless specifically exempted by FERC or other governmental authority or the MidAmerican Energy VAR-001/VAR-002 policy. The Interconnection voltage-VAR schedule, consistent with the MidAmerican Energy VAR-001/VAR-002 policy, will be provided to the interconnection customer.

In cases where starting or load changing on induction generators will have an adverse impact on MidAmerican Energy system voltage, step-switched capacitors or other techniques may be required to attenuate the voltage changes to acceptable levels. To avoid self-excitation, care shall be exercised in applying power factor correction capacitors directly to or electrically near induction generator terminals.

The generator step-up transformer (GSU) shall be equipped with a no-load tap changer covering the range of plus or minus 5% in 2.5% steps from the nominal voltage of the interconnection. The interconnection customer will coordinate with MidAmerican Energy on setting its GSU taps in accordance with NERC standards VAR-001-1 and VAR-002-1 (R5). The interconnection customer will contact MidAmerican Energy at least 90 days in advance of changing GSU taps. The Generator Owner will also work with MidAmerican Energy to consider if GSU taps need to be changed due to changing system conditions.

The interconnection customer shall interconnect to the MidAmerican Energy electric system at the nominal voltage at the agreed upon point of interconnection. MidAmerican Energy, at its sole discretion, may elect to upgrade or change the voltage level of the MidAmerican Energy electric system serving the Interconnection. Any costs to upgrade or change the interconnection customer's facilities to maintain an interconnection with MidAmerican Energy shall be paid in accordance with the Midwest ISO Tariff requirements and procedures.

### **5.8.1.1 Automatic Voltage Regulation**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for automatic voltage regulation.

All synchronous generators connected to the MidAmerican Energy transmission system are to be equipped with automatic voltage regulators (AVR). Generators must operate with their excitation system in the automatic voltage control mode unless otherwise approved by the MidAmerican Energy system operator. Generating equipment owners shall maintain a log which records the date, time, duration and reason for not being in the automatic voltage control mode when operating in parallel with the MidAmerican Energy system. Generating equipment owners shall make this log available to MidAmerican Energy on request.

All synchronous generators connected to the MidAmerican Energy transmission system must maintain a network voltage or reactive power output as specified by the MidAmerican Energy system operator within the reactive power capability of the generating equipment. Generating equipment owners shall maintain a log which records the date, time, duration, and reason for not meeting the network voltage schedule or desired reactive power output when operating in parallel with the MidAmerican Energy system. Generating equipment owners shall make this log available to MidAmerican Energy on request.

The AVR's control and limiting functions must coordinate with the generator's short time capabilities and protective relay settings. The generating equipment owner shall provide MidAmerican Energy with the AVR's control and limiter settings as well as the protection settings which coordinate with AVR control and limiting functions.

Generating equipment owners shall test the AVR control and limit functions of their units at least every five years. An initial test result shall be provided to MidAmerican Energy prior to commercial operation and every five years thereafter. The initial test results shall include documentation of the settings AVR control and limit functions. Typical AVR limit functions are; maximum and minimum excitation limiters and volts per hertz limiters. Documentation of the generator protection that coordinates with these limit functions shall also be provided. Typical generator protection of this type includes overexcitation protection, loss of field protection.

## 5.8.2 Ride through Capabilities

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for ride through capability.

The Interconnection shall be designed such that the generation remains on-line for faults and for any resulting low voltages to maintain system reliability. Generation must remain on-line for the duration of a normally-cleared (single or three phase) fault on the electric system up to a maximum of nine (9) cycles, as well as for the recovery from such a normally cleared fault even where the voltage drops to zero during the clearing of the fault.

Generators must be designed to remain on line for normal clearing system faults within the close proximity to the plant switchyard. Voltage may approach zero at the switchyard bus for nine (9) cycles for some types of faults. Control systems, contactors, motors and auxiliary loads that are critical to the operation of the plant must not drop out under these conditions. Critical 480 volt supply contactors must be provided with ride-through capability where required. Additionally, generator protection systems such as the Load Drop Anticipator, Early Valve Actuator or Power Load Unbalance should not be designed to trip a generator for normal clearing external faults or stable swings.

Synchronous generators with a nameplate rating greater than 20.0 MVA shall have generator protection set such that it does not result in tripping of the generator for the following conditions;

- i. Generator terminal voltages that are within 5 % of the rated nominal design voltage.
- ii. Generator terminal voltage deviations that exceed 5% but are within 10% of the rated nominal design voltage and persist for less 10.0 seconds.
- iii. Generator volts per hertz conditions that are less than 116% (of generator nominal voltage) that last for less than 1.5 seconds.
- iv. Generator overexcited stator currents (or generator apparent impedance) less than 150% of nameplate rating persisting for less than 5.0 seconds.

Documentation of the generator protection and controls that could respond to these conditions by tripping the generator shall be provided to MidAmerican Energy. In the event the generating equipment owner can not correct or mitigate these potential generator trip conditions, a request for a waiver may be made to MidAmerican Energy. A waiver may be justified in certain special circumstances such as low adverse reliability consequences from generator tripping.

## 5.9 Power Quality/Harmonics Requirements

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for power quality and harmonics.

The harmonic content of the voltage and current wave forms of both the Interconnection and MidAmerican Energy's system, when not interconnected, shall comply with the latest revision of the IEEE Std 519, IEEE Recommended Practices and Requirements for

Harmonic Control in Electric Power Systems. MidAmerican Energy may install a power quality meter at the point of interconnection to monitor compliance with IEEE 519.

If high- or low-voltage complaints, transient voltage complaints, and/or harmonic (voltage distortion) complaints result from operation of the Interconnection, the Interconnection shall be disconnected from MidAmerican Energy's system until the interconnection customer resolves the problem. The interconnection customer is responsible for the expense of keeping the Interconnection in good working order so that the voltage, harmonics, power factor (PF), and VAR requirements are met.

## **5.10 Power System Stabilizer Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for power system stabilizers.

The Interconnection shall provide an appropriate high response excitation system and make provisions for a Power System Stabilizer (PSS) on all units rated at 70 MW and greater. The exciter shall meet the following requirements:

- i. The response ratio is less than 2.0 as demonstrated through calculations consistent with IEEE Standard 421.2-1990.
- ii. The response time is less than 0.1 seconds as demonstrated through the completion of a response ratio test.
- iii. The open circuit step-response test is satisfactory where satisfactory means that the response is not oscillatory in nature.

The interconnection customer shall demonstrate that they have the appropriate exciter model by providing P/SSE or other plots of generator response ratio tests and open-circuit step tests that demonstrate the unit meets the above criteria.

The interconnection customer shall meet all MRO requirements for the installation and tuning of Power System Stabilizers (PSS) where appropriate long-term dynamic stability and eigenvalue studies show a positive contribution to the damping torque in the frequency range from 0.25 Hz to 2.0 Hz. Where stabilizing equipment is installed on generating equipment for the purpose of maintaining generator or transmission system stability, the generating equipment owner is responsible for maintaining the stabilizing equipment in good working order and promptly reporting to the MidAmerican Energy System Operator any problems interfering with its proper operation.

## **5.11 Fault Current**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for fault currents.

The facilities study will identify the level of available fault current at the point of interconnection. The interconnection customer's facilities should be designed to accommodate reasonable increases in the available fault current, which may occur over time due to changes on the MidAmerican Energy transmission system.

Where the interconnection customer's generation or transmission facilities supplies fault currents to the MidAmerican Energy electric system that are in excess of breaker or other interrupting device maximum rated interrupting capability, the interconnection customer shall be required to install and pay for fault limiting equipment or pay for breaker or other interrupting device replacements according to the MISO Tariff requirements and procedures.

## **5.12 Operating Requirements**

The generator shall be operated in accordance with the latest requirements of NERC, MRO, Midwest ISO, and MidAmerican Energy.

In addition to the voltage and harmonics operating requirements described previously, the interconnection customer shall control the electrical real power (MW) output such that it will not exceed the approved level of interconnection service. The interconnection customer shall also operate its facilities in compliance with the latest revision of the National Electric Safety Code and applicable state codes. Failure to comply with said safety policies or failure to limit the output of the Interconnection to the approved level will result in the interconnection being opened. The interconnection will not be re-established until compliance has been determined.

The Interconnection shall also adhere to the MRO Operating Standards, any Midwest ISO or MidAmerican Energy Operating Guides, and any additional operating requirements either stated herein or mutually agreed to elsewhere.

MidAmerican Energy and the interconnection customer shall each identify one representative to serve as a coordination contact to be the initial point of contact and coordinate communications between the parties for both normal and emergency conditions. MidAmerican Energy and the interconnection customer shall notify each other in writing of the personnel that it has appointed as its coordination contact.

MidAmerican Energy and the interconnection customer shall abide by their respective switching and tagging rules for obtaining clearances for work or for switching operations on equipment. Such switching and tagging rules shall be developed in accordance with OSHA standards. MidAmerican Energy and the interconnection customer shall develop mutually acceptable switching and tagging rules for MidAmerican Energy's and the interconnection customer's facilities that involve common clearance requirements. The interconnection customer shall not be permitted to energize a de-energized MidAmerican Energy circuit and will follow lockout / tagout procedures.

The interconnection customer will follow all MidAmerican Energy and Midwest ISO defined outage processes and shall not commence parallel operation of generator(s) until final written acceptance has been given by MidAmerican Energy.

### **5.12.1 Abnormal/Emergency Conditions**

If required by Good Utility Practice to do so, MidAmerican Energy or Midwest ISO may require the interconnection customer to interrupt or reduce output if the Interconnection could adversely affect the ability of MidAmerican Energy and/or Midwest ISO to safely and reliably operate and maintain the electric system. The interconnection customer shall

be provided with advance notice if possible, or in the absence of advance notice the interconnection customer shall be informed as soon as soon as practicable of the reasons for the curtailment, interruption, or reduction, and, if known, its expected duration. The interconnection customer shall comply with all operating instructions provided by MidAmerican Energy or the Midwest ISO under emergency conditions to the extent that such actions are within the capabilities of the Interconnection.

### **5.13 Maintenance/Inspection Requirements**

The Interconnection shall adhere to the latest revision, if any, of NERC, MRO, Midwest ISO, and MidAmerican Energy standards and requirements for maintenance and inspection.

The interconnection customer must complete field-testing of all their electrical equipment prior to energization. Testing of equipment must be completed by qualified personnel according to manufacturer's recommendations and shall include testing of all protective relays and control systems according to manufacturer's recommendations. MidAmerican Energy reserves the right to inspect the interconnection customer's facilities and witness test any equipment or devices associated with the Interconnection. The interconnection customer shall submit a written, detailed procedure with specific requirements for initial commissioning of the interconnection customer's generation and interconnecting facilities for MidAmerican Energy approval.

The interconnection customer shall maintain its interconnection facilities and any generating equipment that could negatively impact the MidAmerican Energy system in good order. MidAmerican Energy reserves the right to inspect the interconnection customer's facilities on a periodic basis or whenever it appears that the Interconnection is operating in a manner hazardous to MidAmerican Energy's system integrity

MidAmerican Energy and the interconnection customer may, in accordance with good utility practices, remove from service facilities or network upgrades as necessary to perform maintenance, test, and install or replace equipment. MidAmerican Energy and the interconnection customer will use reasonable efforts to coordinate outages for maintenance on dates and times mutually acceptable to both parties.

The interconnection customer shall annually test the gross and net real and reactive capability of their units according to NERC / FERC/ MRO/ Midwest ISO requirements, if applicable, or at least every five years. These test results shall be provided to MidAmerican Energy.

## **6.0 Procedures for Coordinated Joint Studies and Notifications**

The Midwest ISO interconnection study process includes forming an ad hoc study group including interconnection customers, Midwest ISO consultants, potentially impacted Transmission Owners and adjacent transmission service providers to comment on the study scope, models, contingencies, results, mitigation plans, draft reports, etc. In order to participate in the Midwest ISO ad hoc study group and receive Midwest ISO models and study results, study group participants must first execute a general non-disclosure agreement and a CEII non-disclosure agreement with the Midwest ISO.

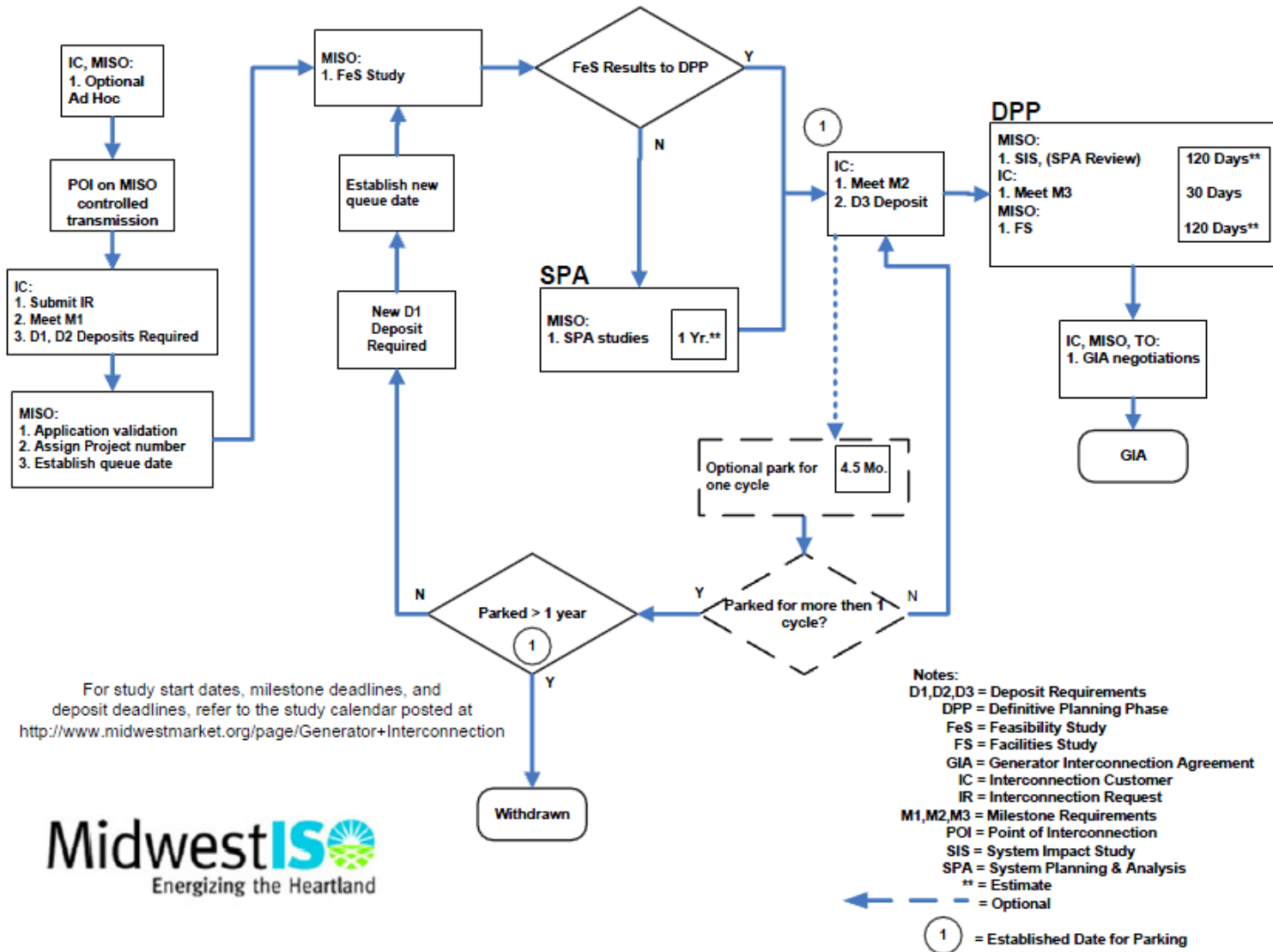
The Midwest ISO seeks input from affected transmission owners, whether or not they are a participant in the ad hoc study group, to validate results and potential criteria violations on their systems. Interconnections that require upgrades to affected systems will include these third-party upgrades as a condition of the interconnection agreement

Upon completion of new facilities or upgrades to the MidAmerican Energy system associated with new Interconnections, MidAmerican Energy will inform the Midwest ISO as soon as practical for inclusion in its state estimator model. To the extent that the MidAmerican Energy upgrade or new facility is part of a tie line to an adjacent transmission owner or transmission service provider, that third party shall be notified of the completion of the upgrade or new facility as soon as practical upon completion.

### **Program Document Change History**

<b>Version Date</b>	<b>Action</b>	<b>Change Date</b>
<b>5/1/08</b>	<b>Added wording interconnection customer shall follow MidAmerican and MISO defined outage processes to enhance R2.1.13</b>	<b>6/28/08</b>
<b>5/1/08</b>	<b>Added more wording to enhance for FAC-001 R2.1.14 about coordinating over / under voltage and frequency trip set points to insure coordination with MidAmerican and MRO programs</b>	<b>6/28/08</b>
<b>1/22/09</b>	<b>Complete document review</b>	<b>1/22/09</b>
<b>9/22/09</b>	<b>Revised document to reflect MidAmerican transfer of functional control for all FERC jurisdictional transmission facilities to the Midwest ISO.</b>	<b>9/22/09</b>
<b>10/15/10</b>	<b>Complete document review and update</b>	<b>10/15/10</b>
<b>03/23/11</b>	<b>Added reference to engineering &amp; procurement agreement in section 3.0. Other minor revisions</b>	<b>03/23/11</b>

**Appendix A**  
**Midwest ISO Generator Interconnection Process Diagram**  
 (obtained from <http://www.midwestiso.org/page/Generator+Interconnection+Request>)



## **Appendix B**

### **MidAmerican Planning Reliability Criteria**

The MidAmerican Planning Reliability Criteria may be accessed via the MidAmerican page node of the Midwest ISO OASIS at <http://oasis.midwestiso.org/oasis/MEC> or upon request to the Electric System Planning department at 106 E 2<sup>nd</sup> Street, Davenport, IA. 52801. Telephone contact (563-333-8162)

## Appendix C

### **MidAmerican Energy Company Transmission Facility Ratings Methodology**

The MidAmerican Energy Company Transmission Facility Ratings Methodology may be accessed via the MidAmerican page of the Midwest ISO OASIS at <http://oasis.midwestiso.org/oasis/MEC> or upon request to the Electric System Planning department at 106 E 2<sup>nd</sup> Street, Davenport, IA. 52801. Telephone contact (563-333-8162)

## **Appendix D**

### **Midwest ISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (“Midwest ISO Tariff”)**

The Midwest ISO Tariff may be accessed via the Midwest ISO website at  
<http://www.midwestiso.org/home>

## **Appendix E**

### **NERC Reliability Standards**

The NERC Reliability Standards may be accessed via the web at  
<http://www.nerc.com/>

## **Appendix F**

### **MRO Planning Standards**

The MRO Planning Standards may be accessed via the web at  
[http://www.midwestreliability.org/STA\\_approved\\_mro\\_standards.html](http://www.midwestreliability.org/STA_approved_mro_standards.html)

## **Appendix G**

### **MidAmerican Voltage Flicker Criteria**

The MidAmerican Voltage Flicker Criteria may be accessed upon request to the Electric System Planning department at 106 E 2<sup>nd</sup> Street, Davenport, IA. 52801.  
Telephone contact (563-333-8162)

## **Appendix G**

### **MidAmerican Harmonic Criteria**

The MidAmerican Voltage Harmonic Criteria may be accessed upon request to the Electric System Planning department at 106 E 2<sup>nd</sup> Street, Davenport, IA. 52801. Telephone contact (563-333-8162)