



Interconnection Requirements for Generation Systems

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I. Foreword

Electric distribution system connected generation units span a wide range of sizes and electrical characteristics. Electrical distribution system design varies widely from that required to serve the rural customer to that needed to serve the large commercial customer. With so many variations possible, it becomes complex and difficult to create one interconnection standard that fits all generation interconnection situations.

In establishing a generation interconnection standard there are three main issues that must be addressed: Safety, Economics and Reliability.

The first and most important issue is safety - the safety of the general public and of the employees working on the electrical systems. This standard establishes the technical requirements that must be met to ensure the safety of the general public and Nodak Electric Cooperative, Inc. (“Nodak Electric”) employees and its system. Typically, designing the interconnection system for the safety of the general public will also provide protection for the interconnected equipment.

The second issue is economics; the interconnection design must be affordable to build. The interconnection standard must be developed so that only those items that are necessary to meet safety and reliability are included in the requirements. This standard sets the benchmark for the minimum required equipment. If it is not needed, it will not be required.

The third issue is reliability; the generation system must be designed and interconnected such that the reliability and the service quality for all members of Nodak is not compromised.

Many generation interconnection standards exist or are in draft form. The Institute of Electrical and Electronics Engineers (IEEE), Federal Energy Regulatory Commission (FERC) and many states have been working on generation interconnection standards. There are other standards such as the National Electrical Code (NEC) that establish requirements for electrical installations. The above requirements are in addition to this standard. This standard is designed to document the requirements where the others have left the establishment of the standard to “the authority having jurisdiction” or to cover issues which are not covered in other national standards. This standard covers installations with an aggregated capacity up to 10MW.

II. Introduction

This standard has been developed to document the technical requirements for the interconnection between a Generation System and Nodak Electric’s system. This standard covers Generation Systems with an aggregate capacity of 10 MW or less at the Point of Common Coupling. This standard covers Generation Systems that are interconnected with Nodak Electric’s system

Nodak Electric has the right to limit the maximum size of any Generation System or number of Generation Systems that may want to interconnect if the Generation System would reduce the reliability to the other members connected to Nodak Electric’s system.

This standard only covers the technical requirements and does not cover the interconnection process from the planning of a project through approval and construction. Please read the companion document “Nodak Electric Cooperative, Inc.’s Interconnection Process for Generation Systems” for the description of the procedure to follow and a generic version of the forms to submit. It is important to also get copies of Nodak Electric’s rate schedules which will include available rates and applicable costs. The earlier the member or their consultant gets Nodak Electric involved in the planning and design of the Generation System interconnection, the smoother the process will go.

III. Definitions

The definitions defined in the “IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems” (1547) apply to this document as well. The following definitions are in addition to the ones defined in IEEE 1547, or are repeated from the IEEE 1547 standard.

- A. **Area EPS:** an electric power system (EPS) that serves Local EPSs. Note: Typically, an Area EPS has primary access to public rights-of-way, priority crossing of property boundaries, etc.
- B. **Area EPS Operator:** the entity that operates the Area EPS.
- C. **Closed Transition Transfer:** Method of transferring the local loads between Nodak Electric’s system and the generator such that the generator and Nodak Electric’s system are interconnected for a short time (100 msec. or less).

- D. **Dedicated Facilities:** the equipment that is installed due to the interconnection of the Generation System and not required to serve other Area EPS Members.
- E. **EPS:** (Electric Power System) facilities that deliver electric power to a load. Note: This may include generation units.
- F. **Extended Parallel:** The Generation System is designed to remain connected with Nodak Electric for an extended period of time.
- G. **Generation:** any device producing electrical energy, i.e., rotating generators driven by wind, steam turbines, internal combustion engines, hydraulic turbines, solar, fuel cells, etc.; or any other electric producing device, including energy storage technologies.
- H. **Generation Interconnection Coordinator:** the person or persons designated by Nodak Electric to provide a single point of coordination with the Applicant for the generation interconnection process.
- I. **Generation System:** the interconnected generator(s), controls, relays, switches, breakers, transformers, inverters and associated wiring and cables, up to the Point of Common Coupling.
- J. **Interconnection Member:** the party or parties who will own/operate the Generation System and are responsible for meeting the requirements of the agreements and Technical Requirements. This could be the Generation System applicant, installer, owner, designer, or operator, or any combination of these entities.
- K. **Local EPS:** an electric power system (EPS) contained entirely within a single premises or group of premises.
- L. **Nameplate Capacity:** the total nameplate capacity rating of all the Generation included in the Generation System. For this definition the “standby” and/or maximum rated KW capacity on the nameplate shall be used.
- M. **Open Transition Transfer:** Method of transferring the local loads between Nodak Electric’s system and the generator such that the generator and Nodak Electric’s system are never interconnected.
- N. **Point of Common Coupling:** the point where the Local EPS is connected to an Area EPS
- O. **Point of Delivery:** the point where the energy changes possession from one party to the other. Typically this will be where the metering is installed but it is not required that the Point of Delivery is the same as where the energy is metered
- P. **Soft Loading Transfer:** Method of transferring the local loads between Nodak Electric’s system and the generator such that the generator and Nodak Electric’s system are

interconnected for a limited amount of time (generally less than three minutes). If the interconnection extends beyond three minutes, the interconnection is then defined as extended parallel.

- Q. **Technical Requirements:** Nodak Electric Cooperative, Inc. “Interconnection Requirements for Generation Systems”

IV. Interconnection Requirements Goals

This standard defines the minimum technical requirements for the implementation of the electrical interconnection between the Generation System and Nodak Electric. It does not define the overall requirements for the Generation System. The requirements in this standard are intended to achieve the following:

- A. Ensure the safety of utility personnel and contractors working on the electrical power system.
- B. Ensure the safety of utility members and the general public.
- C. Protect and minimize the possible damage to the electrical power system and other members’ property.
- D. Ensure proper operation to minimize adverse operating conditions on Nodak Electric’s electrical power system.

V. Protection

The Generation System and Point of Common Coupling shall be designed with proper protective devices to promptly and automatically disconnect the Generation from Nodak Electric’s system in the event of a fault or other system abnormality. The type of protection required will be determined by:

- A. Size and type of the generating equipment.
- B. The method of connecting and disconnecting the Generation System from Nodak Electric’s electrical power system.
- C. The location of generating equipment on Nodak Electric’s system.

VI. Nodak System Modifications

Depending upon the match between the Generation System, Nodak Electric’s system, and how the Generation System is operated, certain modifications and/or additions may be required to Nodak Electric’s existing system with the addition of the Generation System. To the extent possible, this standard describes the modifications which could be necessary to Nodak Electric’s system for different types of Generation Systems. For some unique interconnections, additional and/or different protective devices, system modifications and/or additions will be required by Nodak Electric. In these cases, Nodak Electric will provide the final determination of the required modifications and/or additions. If any special requirements are necessary they will be identified by Nodak Electric during the application review process.

VII. Generation System Protection

The Interconnection Member is solely responsible for providing protection for the Generation System. Protection systems required in this standard are structured to protect Nodak Electric's system and the public. The Generation System protection is not provided for in this standard. Additional protection equipment may be required to ensure proper operation for the Generation System. This is especially true while operating disconnected from Nodak Electric's system. Nodak Electric does not assume any responsibility or liability for protection of the Generation System equipment or of any portion Local EPS.

VIII. Electrical Code Compliance

The Interconnection Member shall be responsible for complying with all applicable local, independent, state and federal codes such as, but not limited to: building codes, National Electric Code (NEC), National Electrical Safety Code (NESC) and noise and emissions standards. As required by North Dakota State law, Nodak Electric will require proof of complying with the National Electrical Code through installation approval by an electrical inspector recognized by the North Dakota State Electrical Board before the interconnection is made.

The Interconnection Member's Generation System and installation shall comply with latest revisions of the ANSI/IEEE standards applicable to the installation, especially IEEE 1547 "Standard for Interconnecting Distributed Resources with Electric Power Systems". See the reference section in this document for a list of the standards which apply to the generation installations covered by this standard.

IX. References

The following standards shall be used in conjunction with this standard. When the stated version of the following standards is superseded by an approved revision then that revision shall apply.

IEEE Std 100-2000, "IEEE Standard Dictionary of Electrical and Electronic Terms"

IEEE Std 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems"

IEEE Std 929-2000, "IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems".

IEEE Std 1547, "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems"

IEEE Std C37.90.1-1989 (1995), "IEEE Standard Surge Withstand Capability (SEC) Tests for Protective Relays and Relay Systems".

IEEE Std C37.90.2 (1995), "IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers".

IEEE Std C62.41.2-2002, “IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits”

IEEE Std C62.42-1992 (2002), “IEEE Recommended Practice on Surge Testing for Equipment Connected to Low Voltage (1000V and less) AC Power Circuits”

ANSI C84.1-1995, “Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)”

ANSI/IEEE 446-1995, “Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications”.

ANSI/IEEE Standard 80, “IEEE Guide for Safety in AC Substation Grounding”.

UL Std. 1741 “Inverters, Converters, and Controllers for use in Independent Power Systems”

NEC – “National Electrical Code”, National Fire Protection Association (NFPA), NFPA-70-2002.

NESC – “National Electrical Safety Code”. ANSI C2-2000, Published by the Institute of Electrical and Electronics Engineers, Inc.

X. Types of Interconnections

The manner in which the Generation System is connected to and disconnected from Nodak Electric’s system can vary. If a transfer system is installed which has a user accessible selection of several transfer modes, the transfer mode that has the greatest protection requirements will establish the protection requirements for that transfer system. Most transfer systems normally operate using one of the following four methods of transferring the load from Nodak Electric’s system to the Generation System. References to loads or capacity level refer to the total capacity of the generator or combined generators in the case of multiple power sources. Where multiple transfer switches are used with one or more generators, the combined total of the generation capacity or load served is the value to be used when determining which type of interconnection is applicable.

- A. Open Transition (Break-Before-Make) Transfer Switch – With this transfer switch, the load to be supplied from the Generation System is first disconnected from Nodak Electric’s system and then connected to the Generation. This transfer can be relatively quick, but voltage and frequency excursions are to be expected during transfer. Computer equipment and other sensitive equipment will shut down and reset. The transfer switch typically consists of a standard UL approved transfer switch with mechanical interlocks between the two source contactors that drop Nodak Electric’s system source before the Generation System is connected to supply the load.
 1. To qualify as an Open Transition switch and the limited protective requirements, mechanical interlocks are required between the two source contacts. This is required

to ensure that one of the contacts is always open and the Generation System is never operated in parallel with Nodak Electric's system. If the mechanical interlock is not present, the protection requirements are as if the switch is a closed transition switch.

2. As a practical point of application, this type of transfer switch is typically used for loads less than 500KW. This is due to possible voltage flicker problems created on Nodak Electric's system, when the load is removed from or returned to Nodak Electric's system as a source. Nodak Electric strongly recommends the Interconnecting Member discuss all relative aspects of an open transition transfer switch operation with Nodak Electric's Power Quality Department to properly understand the possible detrimental effects of this transition switch operation on the Member's equipment.
 3. Nodak Electric will allow a maximum project size of 300 KW using this type of transfer switch if the Interconnecting Member desires to participate in Nodak Electric's load management program using the generator as an alternate power source.
 4. Figure 1 at the end of this document provides a typical one-line diagram of this type of installation.
- B. Closed Transition (Make-Before-Break) Transfer Switch – The Generation System is synchronized with Nodak Electric's system prior to the load transfer occurring. The transfer switch then parallels with Nodak Electric's system for a short time (100 msec. or less) and then the Generation System and load is disconnect from Nodak Electric's system. This transfer is less disruptive than the Open Transition because it allows the Generation System a brief time to pick up the load before the support of Nodak Electric's system is lost. With this type of transfer, the load is always being supplied by Nodak Electric's system or the Generation System.
1. As a practical point of application this type of transfer switch is typically used for loads less than 500KW. This is due to possible voltage flicker problems created on Nodak Electric's system, when the load is removed from or returned to Nodak Electric's system source. Depending up Nodak Electric's system's stiffness this level may be larger or smaller then the 500KW level.
 2. Nodak Electric will allow generators up to 750 KW to utilize this type of transfer switch.
 3. Figure 2 at the end of this document provides a typical one-line diagram of this type of installation and shows the required protective elements. The closed transition switch must include a separate parallel time limit relay, reverse power flow relay, and overcurrent relay which is not part of the generation control Programmable Logic Control (PLC). These relays trip the generation from the system for a failure of the transfer switch and/or the transfer switch controls.

C. Soft Loading Transfer Switch

1. With Limited Parallel Operation – The Generation System is paralleled with Nodak Electric’s system for a limited amount of time (generally less than 3 minutes) to gradually transfer the load from Nodak Electric’s system to the Generation System. This minimizes the voltage and frequency problems by gradually loading and unloading the Generation System.
 - a. Nodak Electric requires this type of transfer switch for any generators larger than 750 KW. A minimum project size of 500 KW is required to utilize this type of transfer switch.
 - b. The maximum parallel operation shall be controlled via a parallel timing limit relay (62PL). This parallel time limit relay shall be a separate relay and not part of the generation control PLC.
 - c. Additional protective relaying is required as described in section XIII.
 - d. Figure 3 at the end of this document provides a typical one-line diagram of this type of installation and shows the required protective elements.
 2. With Extended Parallel Operation – The Generation System is paralleled with Nodak Electric’s system in continuous operation. Special design, coordination and agreements are required before any extended parallel operation will be permitted. Nodak Electric will complete an interconnection study that will identify the issues involved.
 - a. Any anticipated use of the Generation System in the extended parallel mode requires special agreements and special protection coordination.
 - b. Protective Relaying is required as described in section XIII.
 - c. Figure 4 at the end of this document provides a typical one-line diagram for this type of interconnection. It must be emphasized that this is a typical installation only and final installations may vary from the example shown due to transformer connections, breaker configuration, etc.
- D. Inverter Connection - This is a continuous parallel connection with the system. Small Generation Systems may utilize inverters to interface to Nodak Electric’s system. Solar, wind and fuel cells are some examples of Generation which typically use inverters to connect to Nodak Electric’s system. The design of such inverters shall either contain all necessary protection to prevent unintentional islanding, or the Interconnection Member shall install conventional protection to provide the same protection. All required protective elements for a soft-loading transfer switch apply to an inverter connection. Figure 5 at the end of this document shows a typical inverter interconnection.

1. Inverter Approval – The inverter shall be approved by Nodak Electric for interconnection to the electrical power system prior to installation. The approval will confirm its anti-islanding protection and power quality related levels at the Point of Common Coupling. Also, utility compatibility, electric shock hazard and fire safety are approved through UL listing of the model. Once this approval is completed for that specific model, additional design review of the inverter should not be necessary by Nodak Electric.
2. For three-phase operation, the inverter control must also be able to detect and separate for the loss of one phase. Larger inverters will still require custom protection settings, which must be calculated and designed to be compatible with Nodak Electric’s system.
3. A visible disconnect is required for safely isolating the Generation System when connecting with an inverter. The inverter shall not be used as a safety isolation device.
4. When banks of inverter systems are installed at one location, a design review by Nodak Electric must be preformed to determine any additional protection systems, metering or other needs. The issues will be identified by Nodak Electric during the interconnection study process

XI. Interconnection Issues and Technical Requirements

A. General Requirements - The following requirements apply to all interconnected generating equipment. Nodak Electric’s system shall be the source side and the member’s system shall be the load side in the following interconnection requirements.

1. Visible Disconnect - A disconnecting device shall be installed to electrically isolate Nodak Electric’s system from the Generation System. The only exception for the installation of a visible disconnect is if the generation is interconnected via a mechanically interlocked open transfer switch and installed per the NEC (702.6) “so as to prevent the inadvertent interconnection of normal and alternate sources of supply in any operation of the transfer equipment.”
 - a. The visible disconnect shall provide a visible air gap between Interconnection Member’s Generation and Nodak Electric’s system in order to establish the safety isolation required for work on Nodak Electric’s system. This disconnecting device shall be readily accessible 24 hours per day by Nodak Electric’s field personnel and shall be capable of padlocking by Nodak Electric’s field personnel. The disconnecting device shall be lockable in the open position.
 - b. The visible disconnect shall be a manual safety disconnect switch of adequate ampere capacity approved by either Underwriter’s Laboratories (UL) or the National Electrical Manufacturer’s Association (NEMA). The visible disconnect

shall not open the neutral when the switch is open. A draw-out type circuit breaker can be used as a visual open.

- c. The visible disconnect shall be clearly labeled “Generation Disconnect” to inform Nodak Electric’s field personnel.
 - d. Energization of Equipment by Generation System – The Generation System shall not energize Nodak Electric’s system if it is de-energized. The Interconnection Member shall install the necessary padlocking (lockable) devices on equipment to prevent the energization of a de-energized electrical power system. Lock out relays shall automatically block the closing of breakers or transfer switches on to a de-energized Nodak Electric system.
- B. Power Factor - The power factor of the Generation System and connected load shall be as follows:
1. Inverter Based interconnections – shall operate at a power factor of no less than +/- 90% at the inverter terminals.
 2. Limited Parallel Generation Systems, such as closed transfer or soft-loading transfer systems shall operate at a power factor of no less than +/-90%, during the period when the Generation System is parallel with Nodak Electric’s system, as measured at the Point of Common Coupling.
 3. Extended Parallel Generation Systems shall be designed to be capable of operating between 90% lagging and 95% leading. These Generation Systems shall normally operate near unity power factor (+/-98%) or as mutually agreed between Nodak Electric and the Interconnection Member.
- C. Grounding Issues
1. Grounding of sufficient size to handle the maximum available ground fault current shall be designed and installed to limit step and touch potentials to safe levels as set forth in “IEEE Guide for Safety in AC Substation Grounding”, ANSI/IEEE Standard 80.
 2. It is the responsibility of the Interconnection Member to provide the required grounding for the Generation System. A good standard for this is the IEEE Std. 142-1991 “Grounding of Industrial and Commercial Power Systems”.
 3. All electrical equipment shall be grounded in accordance with local, state and federal electrical and safety codes and applicable standards.
- D. Energy sales to others by the Interconnecting Member – Transportation of energy on the Transmission system is regulated by the area reliability council and FERC. Those contractual requirements are not included in this standard. Nodak Electric will provide

these additional contractual requirements during the interconnection approval process.

E. Additional Requirements - For Inverter based, closed transfer and soft loading interconnections, the following additional requirements apply:

1. Fault and Line Clearing - The Generation System shall be removed from Nodak Electric's system for any faults, or outages occurring on the electrical circuit serving the Generation System.
2. The Generation System shall meet the Voltage, Frequency, Harmonic and Flicker operating criteria as defined in the IEEE 1547 standard during periods when the Generation System is operated in parallel with Nodak Electric's system through operating limits in order to minimize objectionable and adverse operating conditions on the electric service provided to other members connected to Nodak Electric's system.

If the Generation System creates voltage changes greater than 4% on Nodak Electric's system, it is the responsibility of the Interconnection Member to correct these voltage sag/swell problems caused by the operation of the Generation System. If the operation of the interconnected Generation System causes flicker, which causes problems for other members interconnected to Nodak Electric's system, the Interconnection Member is responsible for correcting the problem.

3. Flicker - The operation of Generation System is not allowed to produce excessive flicker to adjacent members. See the IEEE 1547 standard for a more complete discussion on this requirement.

The stiffer Nodak Electric's system, the larger a block load change that it will be able to handle. For any of the transfer systems, Nodak Electric's system voltage shall not drop or rise greater than 4% when the load is added or removed from Nodak Electric's system. It is important to note that if another interconnected member complains about the voltage change caused by the Generation System, even if the voltage change is below the 4% level, it is the Interconnection Member's responsibility to correct or pay for correcting the problem. Utility experience has shown that customers have seldom objected to instantaneous voltage changes of less than 2%, so most utility operators use a 2% design criteria.

4. Interference - The Interconnection Member shall disconnect the Generation System from Nodak Electric's system if the Generation System causes radio, television or electrical service interference to other members via the EPS or interference with the operation of Nodak Electric's system, including possible degradation of Nodak Electric's load management 220 Hz ripple system signal. The Interconnection Member shall either effect repairs to the Generation System or reimburse Nodak Electric for the cost of any required system modifications due to the interference.
5. Synchronization of Member Generation Systems

- a. An automatic synchronizer with synch-check relaying is required for unattended automatic closed transition or soft loading transfer systems.
- b. To prevent unnecessary voltage fluctuations on Nodak Electric's system, it is required that the synchronizing equipment be capable of closing the Generation System into Nodak Electric's system within the limits defined in IEEE 1547. Actual settings shall be determined by Nodak Electric to establish the protective settings for the installation.
- c. Unintended Islanding – Under certain conditions with extended parallel operation, it would be possible for a part of Nodak Electric's system to be disconnected from the rest of Nodak Electric's system and have the Generation System continue to operate and provide power to a portion of the isolated circuit. This condition is called "islanding". It is not possible to successfully reconnect the energized isolated circuit to the rest of Nodak Electric's system since there are no synchronizing controls associated with all of the possible locations of disconnection. Therefore, it is a requirement that the Generation System be automatically disconnected from Nodak Electric's system immediately by protective relays for any condition that would cause Nodak Electric's system to be de-energized. The Generation System must either isolate with the member's load or trip off line. The Generation System must also be blocked from closing back into Nodak Electric's system until Nodak Electric's system is reenergized and Nodak Electric's system voltage is within Range B of ANSI C84.1 Table 1 for a minimum of one minute. Depending upon the size of the Generation System it may be necessary to install direct transfer trip equipment from Nodak Electric's system source(s) to remotely trip the generation interconnection to prevent islanding for certain conditions. The costs involved with this control modification would be the responsibility of the Interconnection Member.
- d. Disconnection – Nodak Electric may refuse to connect, or may disconnect, a Generation System from Nodak Electric's system under the following conditions:
 - i. Lack of approved interconnection application, interconnection agreement, or interconnection operating agreement.
 - ii. Termination of interconnection by mutual agreement.
 - iii. Non-Compliance with the technical or contractual requirements.
 - iv. System Emergency or for imminent danger to the public or Nodak Electric personnel (safety).
 - v. Routine maintenance, repairs and modifications to Nodak Electric's system. Nodak Electric shall coordinate planned outages with the Interconnection Member to the extent possible.

XII. Generation Metering, Monitoring and Control

- A. Nodak Electric's revenue meter(s) and any necessary instrument transformers for meter installations shall be supplied, owned and maintained by Nodak Electric.
- B. For Generation Systems that sell power, separate metering of the generation and of the load is required. A single meter recording the power flow at the Point of Common Coupling for both the Generation and the load is not allowed. Meters shall have detents installed to prevent reverse rotation of the meter.

XIII. Protective Devices and Systems

Protective devices required to permit safe and proper operation of Nodak Electric's system while interconnected with Member's Generation System are listed in Table 1 and shown in the figures at the end of this document. In general, an increased degree of protection is required for increased Generation System size. This is due to the greater magnitude of short circuit currents and the potential impact to system stability from these installations. Larger installations require more sensitive and faster protection to minimize damage and ensure safety.

If a transfer system is installed which has a user accessible selection of several transfer modes, the transfer mode which has the greatest protection requirements will establish the protection requirements for that transfer system.

The Interconnection Member shall provide protective devices and systems to detect the Voltage, Frequency, Harmonic and Flicker levels as defined in the IEEE 1547 standard during periods when the Generation System is operated in parallel with Nodak Electric's system. The Interconnection Member shall be responsible for the purchase, installation, and maintenance of these devices. Discussion on the requirements for these protective devices and systems follows:

- A. Relay settings and Testing (Trip Checks)
 - 1. For all closed transition, soft loading transition, and extended parallel transition installations, Nodak Electric requires that all relay settings be made per Nodak Electric's direction and tested by an approved entity after the installation is completed. If the Interconnection Member does not have access to an approved testing entity, Nodak Electric can arrange for the testing procedure. The Interconnection Member shall be responsible for all relay testing costs.
 - 2. All closed transition transfer installations shall be inspected by Nodak Electric every five years from the initial date of installation. All soft loading transfer installations shall be inspected by Nodak Electric every three years from the initial date of installation. The inspection process shall include an on-site review of the installation, review of any maintenance work performed on the installation, and testing of all relays. The Interconnection Member shall be responsible for all relay testing costs.

(See Commission Testing for more information)

B. Relays

1. All equipment providing relaying functions shall be utility grade and meet or exceed ANSI/IEEE Standards for protective relays, i.e., C37.90, C37.90.1 and C37.90.2.
2. Required relays that are not “draw-out” cased relays shall have test plugs or test switches installed to permit field testing and maintenance of the relay without unwiring or disassembling the equipment. Inverter based protection is excluded from this requirement for Generation Systems less than 40KW at the Point of Common Coupling.
3. Three phase interconnections shall utilize three phase power relays, which monitor all three phases of voltage and current, unless so noted in the appendix one-line diagrams.
4. All relays shall be equipped with setting limit ranges at least as wide as specified in IEEE 1547, and meet other requirements as specified in Nodak Electric’s system interconnect study of the Generation System installation. Setting limit ranges are not to be confused with the actual relay settings required for the proper operation of the installation. At a minimum, all protective systems shall meet the requirements established in IEEE 1547.
 - a. Over-current relays (IEEE Device 50/51 or 50/51V) shall operate to trip the protecting breaker at a level to ensure protection of the equipment and at a speed to allow proper coordination with other protective devices. For example, the over-current relay monitoring the interconnection breaker shall operate fast enough for a fault on the member’s equipment, so that no protective devices will operate on Nodak Electric’s system. 51V is a voltage restrained or controlled over-current relay and may be required to provide proper coordination with Nodak Electric’s system.
 - b. Over-voltage relays (IEEE Device 59) shall operate to trip the Generation System per the requirements of IEEE 1547.
 - c. Under-voltage relays (IEEE Device 27) shall operate to trip the Generation System per the requirements of IEEE 1547
 - d. Over-frequency relays (IEEE Device 81O) shall operate to trip the Generation System off-line per the requirements of IEEE 1547.
 - e. Under-frequency relay (IEEE Device 81U) shall operate to trip the Generation System off-line per the requirements of IEEE 1547. For Generation Systems with an aggregate capacity greater than 30KW, the Distribution Generation shall trip off-line when the frequency drops below 57.0-59.8 Hz. Typically this is set at 59.5 Hz, with a trip time of 0.16 seconds, but coordination with Nodak electric’s

system is required for this setting. Nodak Electric's system will provide the reference frequency of 60 Hz. The Generation System control system must be used to match this reference. The protective relaying in the interconnection system will be expected to maintain the frequency of the output of the Generation.

- f. Reverse power relays (IEEE Device 32) (power flowing from the Generation System to Nodak Electric's system) shall operate to trip the Generation System off-line for a power flow to the system with a maximum time delay of 1.0 seconds.
- g. Lockout Relay (IEEE Device 86) is a mechanically locking device which is wired into the close circuit of a breaker or switch and when tripped will prevent any close signal from closing that device. This relay requires that a person manually resets the lockout relay before that device can be reclosed. These relays are used to ensure that a de-energized system is not reenergized by automatic control action, and prevents a failed control from auto-reclosing an open breaker or switch.
- h. Transfer Trip – All Generation Systems are required to disconnect from Nodak Electric's system when Nodak Electric's system is disconnected from its source to avoid unintentional islanding. With larger Generation Systems which remain in parallel with Nodak Electric's system, a transfer trip system may be required to sense the loss of Nodak Electric's system source. When Nodak Electric's system source is lost, a signal is sent to the Generation System to separate the Generation from Nodak Electric's system. The size of the Generation System vs. the capacity and minimum loading on the feeder will dictate the need for transfer trip installation. Nodak Electric's system interconnection study of the Generation System installation will identify the specific requirements.

If multiple power sources or multiple points of sectionalizing are available on Nodak Electric's system, then more than one transfer trip system may be required. The area EPS interconnection study will identify the specific requirements. For some installations, the alternate Nodak Electric source(s) may not be utilized except in rare occasions. If this is the situation, the Interconnection Customer may elect to have the Generation System locked out when the alternate source(s) are utilized, if agreeable to Nodak Electric.

- i. Parallel limit timing relay (IEEE Device 62PL) set at a maximum of 120 seconds for soft transfer installations and set no longer than 100ms for closed transition transfer installations, shall trip the Generation System circuit breaker on limited parallel interconnection systems. Power for the 62 PL relay must be independent of the transfer switch control power. The 62PL timing must be an independent device from the transfer control and shall not be part of the generation PLC or other control system.

I. Agreements

A. Interconnection Agreement – This agreement is required for all Generation Systems that parallel at any time with Nodak Electric’s system. This agreement contains the terms and conditions upon which the Generation System is to be connected, constructed and maintained, when operated in parallel with Nodak Electric’s system. Some of the issues covered in the interconnection agreement are as follows:

1. Construction Process
2. Testing Requirements

TABLE 1 SUMMARY OF RELAYING REQUIREMENTS								
Type of Interconnection	Over-current (50/51)	Voltage (27/59)	Frequency (81 0/U)	Reverse Power (32)	Lockout (86)	Parallel Limit Timer 62PL	Sync-Check (25)	Transfer Trip
Open Transition Mechanically Interlocked (Fig. 1)	—	—	—	—	—	—	—	—
Closed Transition (Fig. 2)	—	—	—	Yes	Yes	Yes	Yes	—
Soft Loading Limited Parallel Operation (Fig. 3)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—
Soft Loading Extended Parallel (Fig. 4)	Yes	Yes	Yes	—	Yes	—	Yes	Maybe
Inverter (Fig 5)								
< 40 KW	Yes	Yes	Yes	—	Yes	—	Yes	—
> 40 KW	Yes	Yes	Yes	—	Yes	—	Yes	Maybe

3. Maintenance Requirements
4. Firm Operating Requirements such as Power Factor
5. Access requirements for Nodak Electric’s system personnel
6. Disconnection of the Generation System (Emergency and Non-emergency)
7. Term of Agreement

8. Insurance Requirements

9. Dispute Resolution Procedures

B. Operating Agreement – For Generation Systems that normally operate in extended parallel with Nodak Electric’s system, an agreement separate from the Interconnection Agreement, called the “Interconnection Operating Agreement”, is usually created. This agreement is created for the benefit of both the Interconnection Member and Nodak Electric and will be agreed to between the Parties. This agreement will be dynamic and is intended to be updated and reviewed annually. For some smaller systems, the operating agreement can simply be a letter agreement; for larger and more integrated Generation Systems the operating agreement will tend to be more involved and more formal. The operating agreement covers items that are necessary for the reliable operation of both the Interconnecting Member’s and Nodak Electric’s systems. The items typically included in the operating agreement are as follows:

1. Emergency and normal contact information for both Nodak Electric’s Control center and for the Interconnection Member.
2. Procedures for periodic Generation System test runs.
3. Procedures for maintenance on Nodak Electric’s system that affect the Generation System.
4. Emergency Generation Operation Procedures.

C. Maintenance Agreement - Each Generation System interconnection will be unique and will require a unique Maintenance Agreement. It is envisioned that this Exhibit will be tailored for each Generation System interconnection. It is also intended that this Maintenance Agreement Exhibit will be reviewed and updated periodically to allow the maintenance of the Generation System to be changed to meet the needs of both Nodak Electric and the Interconnection Member, provided that such change does not negatively affect the other Party. There may also be changes required by outside issues such as changes in MAPP, FERC, and MISO requirements and/or policies which will require this agreement to be modified.

Issues defined in this agreement will include:

1. Routine Maintenance Requirements
 - a. Who is providing maintenance and their contact information
 - b. Periods of maintenance
2. Modifications to the Generation System - The Interconnection Member shall notify Nodak Electric in writing of plans for any modifications to the Generation System interconnection equipment at least twenty (20) business days prior to undertaking such modification. Modifications to any of the interconnection equipment, including all required protective systems, the generation control systems, the transfer

switches/breakers, VTs & CTs, generating capacity and associated wiring shall be included in the notification to Nodak Electric. The Interconnection Member agrees not to commence installation of any modifications to the Generating System until Nodak Electric has approved the modification in writing. Nodak Electric shall have a minimum of five (5) business days and a maximum of ten (10) business days, to review and respond to the modification after the receipt of the information required to review the modifications.

- D. Electric Service Agreement – This agreement will pertain to those systems which are interconnected to Nodak Electric’s for extended periods of time for the purpose of reselling electrical energy to Nodak Electric. Each agreement will be unique to the installation for which it is written and contain the terms and conditions on the sale of the energy between the Interconnection member and Nodak Electric.

XIV. Testing Requirements

A. Protective Relaying and Equipment Related to Islanding

1. Generation System shall be equipped with protective hardware and/or software designed to prevent the Generation from being connected to a de-energized Nodak Electric system.

The Generation may not close into a de-energized Nodak Electric system and protection must be provided to prevent this from occurring. It is the Interconnection Member’s responsibility to provide a final design and to install the protective measures required by Nodak Electric. Nodak Electric will review and approve the design, the types of relays specified, and the installation. Mutually agreed upon exceptions may at times be necessary and desirable. It is strongly recommended that the Interconnection Member obtain Nodak Electric’s written approval prior to ordering protective equipment for parallel operation. The Interconnection Member will own these protective measures installed at their facility.

2. The Interconnection Member shall obtain prior approval from Nodak Electric for any revisions to the specified relay calibrations.

B. Commission Pre-testing

The following tests shall be completed by the Interconnection Member for all transfer designs except open transition. All of the required tests in each section shall be completed prior to moving on to the next section of tests. Nodak Electric has the right to witness all field testing and to review all records prior to allowing the system to be made ready for normal operation. Nodak Electric shall be notified with sufficient lead time to allow the opportunity for its personnel to witness any or all of the testing.

The following tests are required to be completed on the Generation System prior to

energization by the Generator or Nodak Electric's system. Some of these tests may be completed in the factory if no additional wiring or connections were made to that component. These tests are marked with an “*”:

1. Grounding shall be verified to ensure that it complies with this standard, the NESC and the NEC.
2. *CTs (Current Transformers) and VTs (Voltage Transformers) used for monitoring and protection, shall be tested to ensure correct polarity, ratio and wiring.
3. CTs shall be visually inspected to ensure that all grounding and shorting connections have been removed where required.
4. Breaker / Switch tests – Verify that the breaker or switch cannot be operated with interlocks in place or that the breaker or switch cannot be automatically operated when in manual mode. Various Generation Systems have different interlocks, local or manual modes etc. The intent of this section is to ensure that the breaker or switch controls are operating properly.
5. *Relay Tests – All Protective relays shall be calibrated and tested to ensure the correct operation of the protective element. Documentation of all relay calibration tests and settings shall be furnished to Nodak Electric.
6. Trip Checks - Protective relaying shall be functionally tested to ensure the correct operation of the complete system. Functional testing requires that the complete system is operated by the injection of current and/or voltage to trigger the relay element and proving that the relay element trips the required breaker, lockout relay or provides the correct signal to the next control element. Trip circuits shall be proven through the entire scheme (including breaker trip).

For factory assembled systems such as inverters, the setting of the protective elements may occur at the factory. This section requires that the complete system including the wiring and the device being tripped or activated is proven to be in working condition through the injection of current and/or voltage.

7. Phase Tests – the Interconnection Member shall work with Nodak Electric to complete the phase test to ensure proper phase rotation of the Generation and wiring.
8. Synchronizing test – The following tests shall be done across an open switch or racked out breaker. The switch or breaker shall be in a position that it is incapable of closing between the Generation System and Nodak Electric's system for this test. This test shall demonstrate that at the moment of the paralleling-device closure, the frequency, voltage and phase angle are within the required ranges, stated in IEEE 1547. This test shall also demonstrate that if any of the

parameters are outside of the ranges stated, the paralleling-device shall not close. For inverter-based interconnected systems this test may not be required unless the inverter creates fundamental voltages before the paralleling device is closed.

C. On-Line Commissioning Test – the following tests will proceed once the Generation System has completed Pre-testing and the results have been reviewed and approved by Nodak Electric. The Generation System shall be functionally verified for specific interconnections as follows:

1. Anti-Islanding Test – For Generation Systems that parallel with the utility for longer than 100msec.
2. The Generation System shall be started and connected in parallel with Nodak Electric's system source.
3. Nodak Electric's system source shall be removed by opening a switch, breaker etc.
4. The Generation System shall either separate with the local load or stop generating.
5. The device that was opened to remove Nodak Electric's system source shall be closed and the Generation System shall not re-parallel with Nodak Electric's system for at least five minutes.
6. Periodic Testing and Record Keeping
 - a. Any time the interface hardware or software, including protective relaying and generation control systems are replaced and/or modified, Nodak Electric shall be notified. This notification shall, if possible, be with sufficient warning so that Nodak Electric can be involved in the planning for the modification and/or witness the verification testing. Verification testing shall be completed on the replaced and/or modified equipment and systems. The involvement of Nodak Electric will depend upon the complexity of the Generation System and the component being replaced and/or modified. Since the Interconnection Member and Nodak Electric are now operating an interconnected system, it is important for each to communicate changes in operation, procedures and/or equipment to ensure the safety and reliability of the Member's and Nodak Electric's system.
 - b. All closed transition transfer installations shall be inspected by Nodak Electric every five years from the initial date of installation. All soft loading transfer installations shall be inspected by Nodak Electric every three years from the initial date of installation. The inspection process shall include an on-site review of the installation, review of any maintenance work performed on the installation, and testing of all relays. The Interconnection Member shall be

responsible for all relay testing costs (see Commission Testing for more information). Periodic test reports and a log of inspections shall be maintained by the Interconnection Member and made available to Nodak Electric upon request. Nodak Electric shall be notified prior to the period testing of the protective systems so that it may witness the testing if so desired.

- c. Verification of inverter connected system rated 15kVA and below may be completed as follows. The Interconnection Member shall operate the load break disconnect switch and verify the Generator automatically shuts down and does not restart for at least five minutes after the switch is closed.
- d. Any system that depends on a battery for trip/protection power shall be checked and logged once per month for proper voltage. Once every four years, the battery(s) must be either replaced or a discharge test performed. Longer intervals are possible through the use of “station class batteries” with Nodak Electric approval.









