



# Graham County Electric Cooperative, Inc.

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## Graham County Electric Cooperative, Inc.

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### 1. INTRODUCTION TO DISTRIBUTED GENERATION INTERCONNECTION

This document specifies Graham County Electric Cooperative, Inc.'s (Utility) requirements for safe and effective Interconnection of Distributed Generation with the Distribution System. Interconnection requirements as outlined here are for those installations that will be connected to the Distribution System at 69kV or less and do not backfeed onto the Transmission System. Installations that backfeed onto the Transmission System or are 1 MW or larger have additional requirements and need to comply with all applicable requirements set forth by Arizona Electric Power Cooperative (AEPCCO), WECC (Western Electricity Coordinating Council), and NERC (National Electric Reliability Council). Facilities that will be connected directly to the Distribution System up to and including 69 kV will be reviewed by Utility on an individual basis. Customers and Utility personnel shall use this document when planning the installation of Distributed Generation and the Customer should discuss project plans with Utility before designing the facility or purchasing and installing equipment. These requirements apply to installations not subject to the AEPCCO Open Access Transmission Tariff (OATT).

This document does not provide for nor include transmission service. The availability of transmission service may not be inferred or implied from this document. Transmission service on the Transmission System is available pursuant to the AEPCCO OATT.

The required protective relaying and/or safety devices and requirements specified in this document are for protecting the Distribution System and other Utility customers' equipment from damage or disruptions caused by a fault, malfunction or improper operation of the Generating Facility. They are also necessary to ensure the safety of Utility workers and the public. The requirements specified herein do not include additional relaying, protective or safety devices as may be required by industry and/or government codes and standards, equipment manufacturer requirements and prudent engineering design and practice to fully protect Generating Facility or facilities; those are the sole responsibility of the Customer. In addition to all applicable regulatory, technical, safety, and electrical requirements and codes, Customers will also be subject to contractual and other legal requirements, which will govern over the general provisions in this document.

Customers and Utility personnel shall use this document when planning the installation of Distributed Generation to be connected to or expecting back-up electrical service from the Utility. Note that these requirements may not cover all details in specific cases. In addition to all applicable regulatory, technical, safety, and electric requirements and codes, which are not contained in their entirety in this manual, Customers will also be subject to contractual and other legal requirements, a summary of which are in this manual. The complete regulations, requirements, contracts and other materials contain additional information concerning Interconnection and govern over the general provisions in this manual.

The technical Interconnection requirements outlined in this manual shall also apply to any interconnected Utility owned or operated Distributed Generation facility.



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Utility is committed to making sure that Interconnection applications are handled promptly, and to do everything possible to complete the Interconnection process in a safe and timely manner. We look forward to working with our Customers to ensure successful generation projects.

### 2. DEFINITIONS

"A.A.C. " means the Arizona Administrative Code

"AC" means alternating current.

"Backfeed" means to energize a section of the Utility Distribution System with a Generating Facility.

"Certified Equipment" means a specific generating and protective equipment system or systems certified as meeting the requirements in A.A.C. R14-2-2611 relating to testing operation, safety, and reliability by an NRTL.

"Clearance" means documentation from the Utility stating that a line or equipment is disconnected from all known sources of power and tagged: that for safety purposes all proper precautionary measures have been taken: and that workers may proceed to inspect, test, and install ground on the circuit.

"CFR" means Code of Federal Regulations.

"Customer" means an electric consumer applying to connect a Generating Facility on the consumer's side of the Utility meter, whether an Exporting System, a Non-Exporting System, or an Inadvertent Export System; also refers to a non-Utility consumer or entity who invests in, owns or operates a Generating Facility.

"DC" means direct current.

"Disconnect Switch" means a device that:

- a. Is installed and maintained for a Generating Facility by the Customer;
- b. Is a visibly-open, manual, gang-operated, or load break disconnect device;
- c. Is capable of being locked in a visibly-open position by a standard Utility padlock that will completely isolate the Generating Facility from the Distribution System; and
- d. If the voltage of the Generating Facility is over 500 volts, is capable of being grounded on the Utility side.

"Distributed Generation" (DG) means any type of Customer electrical generator, solid-state or static inverter, or Generating Facility interconnected with the Distribution System that either can be operated in electrical parallel with the Distribution System or can feed a Customer load that can also be fed by the Distribution System.



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"Distribution System" means the infrastructure constructed, maintained and operated by the Utility to deliver electric service at the distribution level (25kV or less) to retail consumers.

"Electric Supply/Purchase Agreement" means an agreement or special contract, signed between Utility, wholesale power supplier to Utility, and the Customer, covering the terms and conditions governing the sale and purchase of power and capacity including any appendices to the agreement.

"Exporting System" means any type of Generating Facility that is designed to regularly Backfeed the Distribution System.

"Facilities Study" means a comprehensive analysis of the actual construction cost needed to take place based on the outcome of a System Impact Study.

"Fault Current" means the level of current that can flow if a short circuit is applied to a voltage source.

"Feasibility Study" means a preliminary review of the potential impacts on the Distribution System that will result from a proposed Interconnection.

"Generating Facility" means all or part of a Customer's electrical generator(s), energy storage system(s), or any combination of electrical generator(s) and storage system(s), together with all inverter(s) and protective, safety, and associated equipment necessary to produce electric power at the Customer's facility; this includes solid-state or static inverters, induction machines, and synchronous machines.

"IEEE" means the Institute of Electrical and Electronics Engineers. Inc.

"Inadvertent Export" means the unplanned, uncompensated transfer of electrical energy from a Generating Facility to the Distribution System across the Point of Interconnection.

"Interconnection" means the physical connection of a Generating Facility to the Distribution System.

"Interconnection Agreement" means an agreement, signed between the Utility and the Customer, covering the terms and conditions governing the Interconnection and operation of the Generating Facility including any appendices to the agreement.

"Interconnection Facilities" means the electrical wires, switches, and related equipment that are required, in addition to the facilities required to provide electric distribution service to a Customer, to allow Interconnection. Interconnection Facilities may be located on either side of the Point of Interconnection as appropriate to their purpose and design.

"Interconnection Study" means a study that may be undertaken by Utility (or a Utility-designated third party) in response to Utility receipt of a completed Interconnection application. An



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Interconnection Study may include (i) a Feasibility Study (ii) a System Impact Study; (iii) a Facilities Study; and (iv) any additional analysis required by the Utility.

"kW" means kilowatt.

"Maximum Capacity" means the nameplate AC capacity of a Generating Facility, or, if the Operating Characteristics of the Generating Facility limit the power transferred across the Point of Interconnection to the Distribution System, only the power transferred across the Point of Interconnection to the Distribution System, not including Inadvertent Export, shall be declared as the Maximum Capacity of the Generating Facility.

"MW" means megawatt.

"Network System" means an electrical system that can be fed simultaneously from multiple resources.

"Non-Exporting System" means a system in which there is no designed, regular export of power from the Generating Facility to the Distribution System.

"NRTL" means a Nationally Recognized Testing Laboratory recognized by the U.S. Occupational Safety and Health Administration.

"Operating Characteristics" means the mode of operation of a Generating Facility (Exporting System, Non-Exporting System, or Inadvertent Exporting System) that controls the amount of power delivered across the Point of Interconnection to the Distribution System.

"Parallel Operation" means the operation of a Generating Facility that is electrically interconnected to a bus common with the Distribution System, either on a momentary or continuous basis.

"Point(s) of Interconnection" means the physical location where Utility's service conductors are connected to the Customer's service conductors to allow Parallel Operation of the Generating Facility with the Distribution System.

"Protective Functions" means the equipment, hardware, or software in a Generating Facility that protects against Unsafe Operating Conditions.

"Relay" means an electric device that is designed to interpret input conditions in a prescribed manner and, after specified conditions are met, to respond and cause contact operation or similar abrupt change in associated electric control circuits.

"Representative" means an agent of the Customer who is designated by the Customer and is acting on the Customer's behalf.

"System Impact Study" means a full engineering review of the impact on the Distribution System from a Generating Facility, including power flow, Utility system protective device coordination, generator protection schemes (if not Certified Equipment), stability, voltage fluctuations,



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frequency impacts, and short circuit study. A System Impact Study may consider total nameplate capacity of the Generating Facility.

"Transmission System" means the electric infrastructure network including transmission wiring and substations, which move power from a generating source to the Distribution System.

"Unsafe Operating Conditions" means conditions that, if left uncorrected, could result in any of the following:

- a. Harm to personnel;
- b. Damage to equipment;
- c. An adverse effect to the safe operation of the Distribution System; or
- d. Operation of the Generating Facility outside pre-established parameters required by the Interconnection Agreement.

### **3. UTILITY POLICY ON CUSTOMER-OWNED GENERATION**

Any Customer may operate its generating equipment in parallel with Utility provided that the Customer provides equipment that in the judgement of Utility will:

- a. Not present any hazards to Utility personnel, other Utility customers or public;
- b. Minimize the possibility of damage to Utility and other Utility customer equipment;
- c. Not adversely affect the quality of service to other Utility customers; and
- d. Minimally hamper efforts to restore a feeder to service (specifically when a Clearance is required).

In addition, the Customer must also comply with the following requirements to the satisfaction of Utility:

- a. Install its Generating Facility to meet all the Interconnection, safety, and protection requirements outlined in this document and as required by the Interconnection Study.
- b. Enter into an Interconnection Agreement with Utility and, if applicable, an Electric Supply/Purchase Agreement.
- c. Comply with all applicable service schedules and requirements, pricing plans, tariffs, rules and regulations, and any other applicable requirements approved by the Arizona Corporation Commission.

Due to Relay coordination and potential Backfeed problems, Utility may require additional studies and may reject Interconnection of Distributed Generation (regardless of size or class) to a Network System.

The minimum protective and safety devices (Relays, circuit breakers, Disconnect Switches, communication channels, etc.) specified in this document must be installed and placed into service before allowing Parallel Operation of Generating Facility with Utility's Distribution System. The purpose of these devices is to isolate the Customer's Generating Facility from the



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Distribution System whenever faults or disturbances occur and for maintenance purposes. Modifications to Utility's electrical system configuration or protective equipment may also be required, at the expense of the Customer, in order to accommodate Parallel Operation. Additional agreements may be required between the Customer and Utility before modifications to the Distribution System are made. Utility reserves the right to re-assess the need for modifications to its electrical system configuration or protective equipment in the event of any significant changes to Customer's Generating Facility, including changes to Operating Characteristics.

Utility will not assume any responsibility for the protection of the Customer's generator(s), or of any other portion of the Customer's electrical equipment. The Customer is fully and solely responsible for protecting its equipment in a manner to prevent any faults or other disturbances on the Distribution System from damaging the Customer's equipment.

The Customer must obtain, to the satisfaction of Utility, all required permits and inspections indicating that the Generating Facility complies with local and other applicable safety codes. Utility can disallow the Interconnection of a Generating Facility if, upon review of the Customer's design, Utility determines that the proposed design is not in compliance with applicable safety codes, or is such that it could constitute a potentially unsafe or hazardous condition or threaten the reliability of the Distribution System.

This document is not a complete description or listing of all laws, ordinances, rules and regulations, nor is this document intended to be an installation or safety manual. The Customer requesting Interconnection shall follow where applicable, the current IEEE 1547 Standard Guide for Distributed Generation Interconnection, other IEEE standards, ANSI standards, current National Electric Code, National Electrical Safety Code, governmental and regulatory laws, rules, ordinances and requirements.

Any Generating Facilities larger than 1 MW are not covered by this manual and will be considered by Utility on a case-by-case basis.

#### **4. DISTRIBUTED GENERATION TYPES**

Distributed Generation is any type of generator or Generating Facility which has the potential to (a) feed a Customer load, where this load can also be fed by, or connected to, the Distribution System, or (b) for electrically paralleling with, or for feeding power back into the Distribution System.

Distributed generators include induction and synchronous electrical generators as well as any type of electrical inverter capable of producing AC power. A separate system, or emergency or standby generation system, is designed so as to never electrically interconnect or operate in electrical parallel with Distribution System. A parallel system, or interconnected generation system, is any generator or generation system that can perform Parallel Operations, or has the potential to



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perform Parallel Operations via design or normal operator control, either temporarily or on a continuous basis, with the Distribution System.

The Customer may elect to operate their generator as a separate system with non-parallel load transfer between the two independent power systems, or they may run it in parallel with the Distribution System. A description and the basic requirements for these two methods of operation are outlined below.

### 4.1 Separate System

A separate system is one in which there is no possibility of electrically connecting or operating the Customer's generation in parallel with Distribution System. The Customer's equipment must transfer load between the two power systems in an open transition or non-parallel mode. If the Customer claims a separate system, Utility may require verification that the transfer scheme meets the non-parallel requirements.

Emergency or standby generators, used to supply part or all of the Customer's load during a Utility power outage must be connected to the Customer's wiring through a permanent and approved transfer switch. The transfer switch must be of a visible and fail-safe mechanical throw-over design, which will under no circumstances allow the generator to electrically interconnect or parallel with Distribution System. The transfer switch must always disconnect the Customer's load from Distribution System prior to connecting it to the generator. Conversely, the transfer switch must also disconnect the load from the generator prior to reconnecting to the Distribution System. These requirements apply to both actual emergency operations as well as to testing the emergency or standby generator. All transfer switches and transfer schemes must be inspected and approved by the jurisdictional electrical inspection agency.

Portable generators are not designed for connection to a building's permanent wiring system, and are not to be connected to any such wiring unless a permanent and approved transfer switch is used. Failure to use a transfer switch can result in Backfeed into Distribution System, where the generator voltage can Backfeed through the Utility transformer and be stepped up to a very high voltage, which poses a potentially fatal shock hazard to anyone working on the power lines or on Utility equipment.

In addition to the technical requirements outlined in this section, Customers interconnecting a separate system must comply with the other applicable requirements set forth in this document, including without limitation Utility's Application Requirements and Documentation Requirements.

### 4.2 Parallel System

A parallel, or interconnected, generator is connected to a bus common with Distribution System, and a transfer of power between the two systems is a direct result. A consequence of such interconnected operation is that the Customer's generator becomes an integral part of the Utility system that must be considered in the electrical protection and operation of the Utility system.



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Parallel generators encompass any type of distributed generator or Generating Facility that can electrically parallel with, or potentially Backfeed into Distribution System. Additionally, any generator system using a “closed transition” type transfer switch or a multi-breaker transfer scheme, or an electrical inverter that can be configured or programmed to operate in a “utility interactive mode” constitutes a potential Backfeed source to Distribution System, and is classified as an interconnected generator.

For a Customer to interconnect its generator to Distribution System, specific Interconnection and contractual requirements, as outlined in this manual, must be met and complied with and information must be submitted for all interconnected generators as is specified in the various sections of this document. These include a visibly-open Disconnect Switch meeting certain requirements to isolate the Customer’s system from Distribution System, as well as protective relaying, metering, communication links, special rates schedules, and other safety and information requirements.

The Customer will be responsible for having the generation system protective schemes tested by a qualified testing/calibration company, subject to Utility approval. Utility reserves the right to witness testing of these protective schemes. Utility personnel will inspect the system and the Customer will be required to sign an Interconnection Agreement and, if applicable, an Electric Supply/Purchase Agreement. Utility approval is not extended to any specific type of generator or generator scheme since each project is site specific and needs to be reviewed on a case-by-case basis.

With respect to the above protection objectives, it is necessary for Utility to be enabled with equipment to disconnect the parallel generator when trouble occurs. This is to:

- a. Ensure if a fault on the Distribution System persists, the Fault Current supplied by the Customer’s generator is interrupted;
- b. Prevent the possibility of reclosing into an out-of-synchronization isolated system composed of the Distribution System, or a section thereof, and the Customer’s generator; and
- c. Prevent reclosing into the Customer’s generation system that may be out of synchronization or stalled.

The protection requirements are minimal for smaller installations, but increase as the Maximum Capacity of the Customer’s Generating Facility increases. Small installations usually ensure that the generator is small compared with the magnitude of any load with which it might be isolated. Thus, for any fault on the Utility system, Utility protective devices will operate and normally isolate the generation with a large amount of load, causing voltage collapse and automatic shutdown of the generator. For larger installations, the probability of isolated operation is higher since the available generation may be sufficient to carry the entire load, or part, of the local Utility circuit. In instances where the Distribution System arrangement is such that it is possible that the



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generators will not always be isolated with comparatively large amounts of load, additional protection and generator shutdown schemes are required.

The Customer is solely responsible for the protection of their equipment from automatic reclosing by Utility. Utility normally applies automatic reclosing to overhead distribution circuits. When the Utility source breaker trips, the Customer must ensure that their generator is disconnected from the Utility circuit prior to automatic reclosure by Utility. The automatic reclosing time on the Utility Distribution System varies from feeder to feeder. Automatic reclosing out-of-synchronization with the Customer's generator may cause severe damage to Customer equipment and could also pose a serious hazard to Customer or Utility personnel. The design of the facilities is the Customer's responsibility and at the Customer's expense.

The Customer shall adequately design and protect the Generating Facility against the impact of switching operations and contingencies on Distribution System. Some examples are as follows (not to be considered an all-encompassing list):

- a. Load rejection of the Generating Facility will cause overspeed and overvoltage in the Generating Facility.
- b. Self-excitation can occur where an islanded Distribution System, left connected to the Generating Facility, represents a capacitive load in excess of the generator's capability to absorb it. The Generating Facility and Utility's equipment could be damaged by the resulting overvoltage if the Generating Facility is not quickly disconnected from the Distribution System.
- c. Acceleration of the Generating Facility during faults on nearby Utility distribution feeders could cause the Generating Facility to slip out of synchronism with Distribution System.
- d. Broken conductors on Utility's feeders could cause high levels of negative sequence current in the Customer's generator.
- e. Voltage unbalance at the Point of Interconnection can cause negative sequence heating in the generator and/or the interconnecting transformer.

### **5. CUSTOMER RIGHTS AND RESPONSIBILITIES**

A Customer has the following rights:

- a. To designate a Representative to act on the Customer's behalf;
- b. To submit an Application to interconnect a Generating Facility with a Distribution System;
- c. To expect prompt and professional responses from Utility during the Interconnection process;
- d. To receive detailed and itemized good faith estimates of costs from Utility;
- e. To expect documentation of proposed work before Utility undertakes any studies or system upgrades to accommodate the Generating Facility;
- f. To electronically transmit signed documents to Utility; and



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- g. To request a one-time 90-day extension from Utility and not to have an extension unreasonably withheld for circumstances beyond the Customer's control.

A Customer shall be responsible to ensure that:

- a. The Generating Facility meets or exceeds all minimum Interconnection, safety and protection requirements outlined in this Interconnection Manual and as determined by the design review process with Utility and the Customer;
- b. The Generating Facility meets all applicable construction codes, safety codes, electric codes, laws and requirements of government agencies having jurisdiction;
- c. The Generating Facility's Certified Equipment is installed and operated in a manner that protects the Generating Facility, Utility personnel, the public, and the Distribution System from harm;
- d. The Generating Facility design, installation, maintenance and operation minimize the likelihood of causing a malfunction in, damaging or otherwise impairing the Distribution System;
- e. The Generating Facility does not adversely affect the quality of service to other Utility customers;
- f. The Generating Facility does not hamper efforts to restore a feeder to service when a Clearance is required;
- g. The Generating Facility is maintained in accordance with applicable manufacturer's maintenance schedules; and
- h. Utility is notified of any emergency or hazardous condition or occurrence involving the Generating Facility that could affect safe operation of the Distribution System.

The Customer shall pay for, lease or own, and be responsible for designing, installing and operating all Interconnection Facilities on the Customer's side of the Point of Interconnection. The Customer shall ensure that the Interconnection Facilities are located on the Customer's premises, and are enabled to deliver power from the Generating Facility to the Distribution System at the Point of Interconnection. This includes connection, transformation, switching, protective relaying, metering, communication and safety equipment, including a visibly-open Disconnect Switch and any other requirements as outlined in this manual or other items specified by Utility.

In the event that, in the judgement of Utility, additional facilities are required to be installed on the Distribution System to accommodate the Customer's generation, Utility will install such facilities at the Customer's expense. Utility may also charge the Customer for any administrative costs and/or the cost of studies required to interconnect the Customer's generation, and the Customer shall pay said costs.

The Customer will own and be responsible for designing, installing, operating and maintaining:

- a. The Generating Facility in accordance with the requirements of all applicable electric codes, laws and governmental agencies having jurisdiction which shall include but not be



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- limited to the current IEEE 1547 Standard Guide for Distributed Generation Interconnection, other IEEE standards, ANSI standards, current National Electrical Code requirements and the current National Electrical Safety Code as applicable.
- b. Control and protective devices, in addition to minimum protective Relays and devices, specified in this manual, to protect its facilities from abnormal operating conditions such as, but not limited to, electric overloading, abnormal voltages, and Fault Currents. Such protective devices must promptly disconnect the Generating Facility from Distribution System in the event of a power outage on Distribution System.
  - c. Interconnection Facilities on the Customer's premises as may be required to deliver power from the Generating Facility to the Distribution System at the Point of Interconnection.

A Customer interconnecting a Generating Facility with the Distribution System will be required to sign an Interconnection Agreement with Utility, in addition to any other applicable purchase, supply or other standby or special agreements.

Customers may be required to sign an Electric Supply/Purchase Agreement.

### **6. MUTUAL UNDERSTANDING**

Utility shall interconnect a Generating Facility to the Distribution System, subject to the requirements of the A.A.C. Title 14. Public Service Corporations, Chapter 2. Fixed Utilities, Article 26. Interconnection of Distributed Generation Facilities, and this Interconnection Manual.

Utility has the right to expect prompt, reasonable, and professional responses from a Customer during the Interconnection process.

Utility requires that an interconnected Generating Facility:

- a. Does not present any hazards to Utility personnel, other Utility customers, or the public;
- b. Minimize the possibility of damage to Utility's and other Utility customers' equipment;
- c. Not adversely affect the quality of service to the other Utility customers; and
- d. Not hamper efforts to restore a feeder to service when a Clearance is required.

The Customer shall ensure that Interconnection Facilities are located on the Customer's premise. To enable delivery of power from the Generating Facility to the Distribution System at the Point of Interconnection, the Customer will include necessary equipment for connection, transformation, switching, protective relaying, metering, communication, and safety requirements. Utility shall notify a Customer if there is a reason to believe that operation of the Generating Facility has caused disruption or deterioration of service to other Utility customers or to the Distribution System.

#### **6.1 Interconnections**

Utility will not install or maintain any lines or equipment on a Customer's side of the Point of Interconnection, except for a meter and potentially, research equipment. Only authorized



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Utility employees (with proper credentials to identify their Utility affiliation) may make and energize the service connection between the Distribution System and the Customer's Interconnection Facilities.

Normally, the Interconnection will be arranged to accept only one type of standard service at one Point of Interconnection. If a Generating Facility requires a special type of service, or if sales to Utility's wholesale power supplier(s) will be at a different voltage level, the services will only be provided according to additional specific terms that are outlined in the Electric Supply/Purchase Agreement, applicable rate schedules, or other terms and conditions governing the service.

### **6.2 Easements and Rights-of-Way**

Where an easement or right-of-way is required to accommodate the Interconnection, the Customer must provide Utility with a suitable easement or right-of-way, in Utility's name, on the premises owned, leased or otherwise controlled by the Customer. If the required easement or right-of-way is on property not owned by the Customer, the Customer must obtain and provide to Utility a suitable easement or right-of-way, in Utility's name, at Customer's expense and in sufficient time to comply with the Interconnection Agreement requirements. All easements or rights-of-way must be on terms and conditions acceptable to Utility. Utility will use reasonable efforts to utilize existing easements to accommodate Interconnection, and will use reasonable efforts to assist a Customer in securing necessary easements at the Customer's expense.

### **6.3 Purchase Rates**

Any energy purchases from the Customer's facility will be in accordance with the applicable tariffs and/or Electric Supply/Purchase Agreement. A Generating Facility with requirements of unusual size or characteristics may require additional or special rate and contract arrangements.

### **6.4 Regulatory Commissions**

The rates, terms and other provisions governing the electric power sold to a Customer by Utility are set forth in Utility's tariffs approved by the Arizona Corporation Commission. Utility retains, at all times and without restriction, the right to file a unilateral application for a change in requirements, charges, classification, or service, or any rule, regulation or agreement as allowed by law.

## **7. DESIGN CONSIDERATIONS AND DEFINITION OF CLASSES**

Protection requirements are influenced by the size and characteristics of the parallel generator along with the nature and operational characteristics of the Distribution System. Therefore,



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similar units connected to different lines could have different protection requirements based on varying load conditions, as well as on Utility feeder and transformer characteristics.

### 7.1 Synchronous Units

Synchronous generators are generally capable of supplying sustained current for faults on the Distribution System. These units can also supply isolated Utility load providing the load is within the units' output capability.

Reclosing of the Utility onto synchronous units must be blocked to prevent out-of-synchronization paralleling and must also be prevented from energizing a de-energized Utility line. Automatic reclosing by Utility is time-delayed to allow for automatic Customer generator separation prior to Utility circuit re-energization.

### 7.2 Induction Units

Induction generators are basically induction motors that are mechanically driven above synchronous speed to produce electric power. These units do not have a separate excitation system and, as such, require that their output terminals be energized with AC voltage and supplied with reactive power to develop the magnetic flux. Induction generators are therefore normally not capable of supplying sustained Fault Current into faults on the Utility system and are generally not capable of supplying isolated load when separated from the Utility system; however, it is possible for an induction generator to become self-excited if a sufficient amount of capacitance exists at its output terminals.

Under conditions of self-excitation, an induction generator will be capable of supplying isolated load, providing the load is within the induction generator's output capability. In most cases when self-excitation occurs it will be accompanied by a sudden increase in terminal voltage. Utility and its other customers must be protected from out-of-phase closing and over-voltages that can occur whenever an induction generator becomes self-excited. Induction units must therefore be designed to automatically separate from the Utility system upon loss of Utility voltage and prior to reclosing of the Utility feeder.

### 7.3 Static Inverters

Static inverters convert DC power to AC by means of electronic switching. Switching can be controlled by the AC voltage of the Utility's supply system (line-commutated) or by internal electronic circuitry (forced-commutated). Line-commutated inverters are generally not capable of operating independently of the Utility's AC supply system and, as such, cannot normally supply Fault Current or isolated loads. Forced-commutated, or self-commutated, inverters are capable of supplying Fault Current and load independently of the AC supply system. Any forced-commutated inverter that is to be interconnected with the Utility must be specifically designed for that purpose, i.e. it must be designed to accommodate parallel interfacing and operation.



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Reclosing of the Utility onto inverter units must be blocked to prevent out-of-synchronization closing and to prevent the energizing of a de-energized Utility line.

### 7.4 Definition of Generator Size Classes

The following generator size classifications are used in determining specific minimum protective requirements for Distributed Generation facilities. Specified ratings are for each connection to the Distribution System. Customers must satisfy, in addition to the general requirements specified in this manual, the minimum relaying requirements given in this document for each generator class.

- a. Class I: 20 kW or less, single or three phase
- b. Class II: 21 kW to 100 kW, single or three phase
- c. Class III: Greater than 100 kW, three phase
- d. Class IV: Non-Exporting inverter-based energy storage with Maximum Capacity of 20 kW or less

## 8. INTERCONNECTION TECHNICAL REQUIREMENTS

The requirements and specifications outlined in this section are applicable to all classes of Generating Facilities, unless otherwise specified. The minimum protection and safety devices and other requirements specified in the following sections are intended to provide protection for Distribution System, Utility workers, other Utility customers and the general public. They are not imposed to provide protection for the Customer's generation equipment or personnel; this is the sole responsibility of the Customer. The Customer is responsible for an Interconnection that is designed in accordance with prudent utility standards and as agreed to in the Interconnection design review.

### 8.1 General Technical Requirements

Customer is responsible for obtaining and maintaining all required permits and inspections indicating that Generating Facility complies with local and other applicable construction and safety codes, and making copies thereof available to Utility. Customer requesting Interconnection shall follow, where applicable, the current IEEE 1547 Standard Guide for Distributed Generation Interconnection, other IEEE standards, and the current National Electric Code, including without limitation Sections 200-6, 210-6, 230-70, 240-3, 250-26, 250-50, 250-122, and all of Article 690 pertaining to Solar Photovoltaic Systems.

- a. Multiple generator connections on the same Point of Interconnection are permitted subject to Utility approval; however, a single Disconnect Switch for the facility will be required (normally located at the service entrance section).
- b. A communication channel and telemetry may be required, at the Customer's expense, to facilitate proper Parallel Operation.



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- c. For synchronous generators, the Customer shall ensure that any potential open points such as breakers, fused Disconnect Switches, and other equipment located between the generator breaker and Point of Interconnection are appropriately equipped with either (a) Kirk key interlocks to prevent them from being inadvertently opened when the generator breaker is closed, or (b) contacts that will instantaneously trip the generator breaker if any such switch were opened while the generator breaker was closed. This is to prevent the opening and subsequent (inadvertent) reclosing of such a breaker or switch onto an unsynchronized generator.
- d. For photovoltaic facilities, Customer shall insure its components are certified as meeting the requirements of IEEE-929 (Recommended Practice for Utility Interface of Photovoltaic Systems) and UL-1741 (Power Conditioning Units for use in Residential Photovoltaic Power).
- e. In the event that Utility is required to install (at Customer's expense) electric meter(s) to record the output of the generator(s), Customer shall ensure that the design is such that the meter(s) are located on the Utility-side of the generator breaker on a normally energized bus. Electronic meters are not designed to be de-energized for any length of time.
- f. Customer is responsible for the design, installation, operation and maintenance of all equipment for connection to the Distribution System, and all associated costs thereof. The Customer is also required to submit specifications and detailed plans for the installation as specified in Appendix A of this Interconnection Manual, for review and written approval from Utility, prior to the purchase and installation of the system. Written approval by Utility does not indicate acceptance by other authorities.

### 8.2 Disconnect Switch

The Customer shall install and maintain a visibly-open, manually and gang-operated load-break Disconnect Switch capable of being locked in a visibly-open position by a standard Utility padlock that will completely isolate the Generating Facility from the Distribution System.

Utility shall have the right to lock open the Disconnect Switch without notice to the Customer when interconnected operation of the Generating Facility with the Distribution System could adversely affect the Distribution System or endanger life or property, or upon termination of the Interconnection Agreement.

### 8.3 Dedicated Transformer

Customer generators with a combined total rating of over 10 kW, as measured at the service entrance, must be isolated from other customers fed off the same Utility transformer by a dedicated power transformer connecting to the Utility distribution feeder. The primary purpose of the dedicated transformer is to ensure that (a) the generator cannot become isolated



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at the secondary voltage level with a small amount of other-customer load, and (b) the generator does not contribute any significant Fault Current to other customers' electrical systems.

Dedicated transformers also help to confine any voltage fluctuation or harmonics produced by the generator to the Customer's own system. Utility will specify the transformer winding connections, impedance and grounding requirements.

### 8.4 Power Quality

In order to minimize interference on Distribution System, the Customer shall ensure that the electrical characteristics of its load and generating equipment will maintain Utility's normal power quality requirements and meet, as a minimum, the specifications promulgated in the IEEE Standard 519-1992. Those power quality items will generally include the following:

- a. Current Imbalance - The current imbalance for a three-phase system as measured at the Customer's service entrance section shall not be greater than ten percent (10%) at any time.
- b. Harmonics - The electric output of the Generating Facility shall not contain harmonic content which may cause disturbances on or damage to Distribution System, nor other Customer's systems, such as but not limited to computer, telephone, communication and other sensitive electronic or control systems.
- c. Power Factor - The current imbalance of the Generating Facility shall not be less than ninety-five percent (95%) lagging, but shall not be leading, unless agreed to by Utility.
- d. Power Fluctuations – The Customer must exercise reasonable care to assure that the electrical characteristics of its load and generating equipment, such as deviation from sine wave form or unusual short interval fluctuations in power demand or production, shall not be such as to result in impairment of service to other customers or other communication systems or facilities.
- e. Voltage Flicker – The Generating Facility shall not cause voltage flicker at the Point of Interconnection. In accordance with IEEE 519, the flicker shall not exceed 3.0% voltage change, measured at the point of common coupling. If high or low voltage complaints or flicker complaints result from the operation of the Customer's electrical generation, the Customer's generating system shall be disconnected until the problem is resolved.
- f. Monitoring Requirements – Utility shall have the option to install, at the Customer's expense, power quality monitoring equipment at the Generating Facility to investigate any power quality problems that may be caused by the operation of the Customer's generator.

### 8.5 Voltage Requirements

Customer generating equipment must deliver at the Point of Interconnection, 60 Hertz, either single or three-phase power at one standard voltage (normally three-phase 24k, 12.47k 480/277; 208/120 volts or single-phase 120/240 volts as may be selected by the Customer



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subject to availability at the premises). Interconnections at other voltage levels will be handled on a case-by-case basis.

### 8.6 Labeling Requirements

- a. Disconnect Switch – The Customer shall label the Disconnect Switch “Interconnected Utility Disconnect Switch” (or “Photovoltaic Inverter, Wind Turbine, etc., Utility Disconnect Switch,” as the case may be) by means on a permanently attached placard with clearly visible and permanent letters.
- b. Breaker Panels – The Customer is responsible for ensuring that all electrical devices such as panel boxes, etc., which are or can be back-fed by the Customer’s generator(s) are clearly identified/labeled as such in accordance with the requirements of the National Electric Code. Utility will assume responsibility for labeling any Utility equipment.
- c. Service Entrance – A sign shall be placed at the service entrance indicating type and location of onsite emergency power sources, legally required standby power sources, and onsite optional standby power sources, as defined by the Utility.

Utility also requires a permanent directory, denoting all electrical power sources on or in the premises, shall be installed at each service equipment location and at locations of all electric power production sources capable of being interconnected. Installations with large numbers of power production sources shall be permitted to be designated by groups.

### 8.7 Protective Relaying Equipment

#### General Requirements

- a. The Customer shall be solely responsible for properly protecting and synchronizing their generator(s) with the Distribution System. The Customer is solely responsible for the protection of their equipment from automatic reclosing by the Utility.
- b. The Generating Facility shall include a UL approved automatic interrupting device that is rated to interrupt available fault (short circuit) current. The interrupting device shall be tripped, as a minimum, by all protective devices required herein.
- c. Inherent characteristics of induction disk type voltage and frequency Relays render their use unsuitable for some generator interface protection applications. Therefore, Relays with definite level and timing characteristics (e.g. solid-state type Relays) will be necessary to meet the minimum requirements established herein.
- d. The generator protective scheme shall be of a fail-safe design such that loss of the protection scheme control power will immediately cause the generator breaker to open. The Relays provided shall be equipped with Utility approved test switches to provide isolation for CT’s, VT’s and Outputs and to facilitate testing.
- e. For Class III (Greater than 100 kW), Relays for overvoltage, undervoltage, over frequency, and under frequency are required. Generators in this class may require



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additional Relays and Direct Transfer Trip equipment. These requirements and others will be determined during the Interconnection Study.

### Relay Settings

Voltage and frequency Relays needed for minimum interface protection for all classes will have setting limits as specified below:

- a. Undervoltage Relays will operate at no less than 90% of the nominal voltage level (108 volts on a 120V base) and will have a maximum time delay of 1.0 seconds.
- b. Overvoltage Relays will operate at no greater than 110% of nominal voltage (132 volts on a 120V base) and will have a maximum time delay of 1.0 seconds.
- c. Over frequency Relays will operate at no greater than 60.5 Hz and will have a maximum time delay of 0.1 seconds.
- d. Under frequency Relays will operate at no less than 59.5 Hz and have a maximum time delay of 0.1 seconds.

## **9. METER REQUIREMENTS**

The Customer must provide and install at Customer's expense, and in accordance with Utility service standards, meter sockets and metering cabinets in a suitable location.

Utility will furnish, own, install and maintain all meters that register the flow of all energy from the Customer. The Customer will be invoiced, or billed as specified in the applicable tariffs and/or Electric Supply/Purchase Agreement, for the cost of the required meter(s) and maintenance costs.

## **10. APPLICATION PROCESS AND DOCUMENTATION REQUIREMENTS**

Utility will employ best reasonable efforts to comply with the timelines set forth in the applicable provisions of the Arizona Interconnection Rules (A.A.C. R14-2-2614 and R14-2-2616 through 2623). Specifically, Utility will employ best efforts to process Class I Interconnections as set forth in A.A.C. R14-2-2617, Class II Interconnections as set forth in A.A.C. R14-2-2618, and Class III Interconnections as set forth in A.A.C. R14-2-2619.

For Class IV Interconnections, Utility will employ best efforts to process applications as set forth in A.A.C. R14-2-2623, with the following exceptions: (a) Utility shall have ten (10) working days to review and provide notice regarding whether the application is complete or incomplete; (b) Utility shall have ten (10) working days from the date of notice of receipt of a complete application to determine whether the application is approved as submitted or requires further processing; (c) once the application is approved, Utility shall have five (5) working days to provide the customer with an Interconnection Agreement for review and signature; and (d) prior to approving the Generating Facility for Parallel Operation, the Utility may require a site inspection pursuant to A.A.C. R14-2-2621.



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If Utility is unable to meet the above-referenced deadlines, Utility will process all Interconnection applications and conduct all inspections and tests in the shortest time practical (A.A.C. R14-2-2627).

Utility approvals given pursuant to the review and approval process and the Interconnection Agreement shall not be construed as any warranty or representation to Customer or any third party regarding the safety, durability, reliability, performance or fitness of Customer's generation and service facilities, its control or protective device or the design, construction and installation or operation thereof, to Customer or any third party.

- a. The Customer must submit written equipment specifications and plans for the installation and operation of its Generating Facility, Interconnection Facilities, control and protective devices and facilities for Utility review and advance written approval prior to actual equipment installation. An "Application for Operation of Consumer-Owned Generation" (the current version of which is attached to this document as Appendix A) must be completed and all supplementary information requested therein must be provided.
- b. Utility strongly encourages each Customer to contact and work closely with Utility at the conceptual stages of the design to ensure that the project proceeds smoothly. Utility will generally require a single point of contact with Utility to coordinate the Interconnection process.
- c. A Customer must reimburse Utility for the costs incurred, to the extent they exceed those normally incurred for Customers who do not have self-generation facilities, upon invoice, or as specified in the applicable tariffs and/or Electric Supply/Purchase Agreement, for Interconnection Facilities on its system (including but not limited to control or protective devices, or any other facilities), in order to accommodate or protect the Customer's Generating Facility or Utility equipment.
- d. Following Utility approval of the Customer's proposed Generating Facility and associated facilities, any change, alteration or modification may not be made by the Customer without resubmitting plans to Utility and obtaining written approval from Utility. This includes the equipment specifications, the plans, control and protective devices or settings, and in general the Generating Facility system configuration or any facilities appurtenant thereto.
- e. In the event it is necessary for Utility to install facilities on its system (including but not limited to control or protective devices, or any other facilities) in order to accommodate the Customer's Generating Facility, Utility will install such facilities at the Customer's expense. Utility shall also charge the Customer for any administrative costs and/or the costs of studies required to interconnect the Customer's Generating Facilities. The payment for Utility's services to prepare estimates, design, procure material, and construct will be arranged in a payment schedule agreed to by both Utility and Customer prior to the start of the project.



## **11. TESTING AND START-UP REQUIREMENTS**

Following Utility's approval of the Customer's Interconnection, the Customer shall, at a minimum, have all specified interface equipment, and associated protective devices field tested and calibrated at the time of installation and shall also perform functional trip testing of these Relays and associated generator or inverter breaker.

- a. Calibration shall include on-site bench testing of pickup and trip setpoints and timing characteristics of the Protective Functions as required herein.
- b. Functional testing, witnessed by Utility personnel, must demonstrate that each (minimum) protective Relay trip function or device function as required herein, upon a (simulated) out-of-tolerance input signal, will trip the generator breaker. Functional testing shall also include a simulated loss of control power to demonstrate that the generator breaker or contactor will open. A trip timing test (simulated loss of voltage) will suffice for static inverters rated 50kW or less.
- c. The Customer shall provide Utility with a copy of calibration and functional test results. Customer must also notify Utility at least five (5) working days in advance that such tests are to be performed and allow Utility personnel to witness such tests and/or conduct additional startup tests if necessary.
- d. The Customer shall be required to have a signed Interconnect Agreement with Utility, the preconditions for the effectiveness of which have been satisfied and completed, and must provide Utility with a copy of the insurance certificate, as applicable, prior to electrically paralleling the Generating Facility with the Utility system.
- e. The Customer shall not commence interconnected operation of its Generating Facility until the installation has been inspected by a Utility authorized representative and final written approval is received from Utility to commence interconnected operation. The Customer shall give Utility at least five (5) working days' notice as to when initial startup is to begin. Utility shall have the right to have a representative present during initial energizing and testing of the Customer's system.
- f. The Customer shall have all protective devices tested at the time of installation, prior to initial Interconnection, and at intervals not to exceed four years. The Customer shall (a) notify Utility as to when such tests are to be performed at least five (5) working days prior to such tests and allow Utility personnel to witness the testing, and (b) provide Utility with a certified copy of the test results.

## **12. OPERATIONAL AND MAINTENANCE REQUIREMENTS**

Customer shall be responsible for operating and maintaining the Generating Facility in accordance with the requirements of all applicable safety and electrical codes, laws and governmental agencies having jurisdiction.



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- a. The Customer shall protect, operate and maintain the Generating Facility in accordance with those practices and methods, as they are changed from time-to-time that are commonly used in prudent engineering practice and electric Utility operations and shall operate and maintain the Generating Facility lawfully in a safe manner and non-hazardous condition.
- b. The Customer will allow Utility and its authorized agents to access the protective relaying and control facilities to conduct whatever startup or periodic tests Utility deems necessary. Utility will provide the Customer with advance notice of such tests, so that the Customer's Representatives may be in attendance when such tests are performed.
- c. In the event Utility authorized personnel lock open to Disconnect Switch, the Customer shall not remove or tamper with such lock.
- d. Utility will be allowed to install on Customer's premises any instrumentation equipment for research purposes. Such equipment shall be owned, furnished, installed and maintained by Utility.
- e. Utility (including its employees, agents and representatives) shall have the right to enter Customer's premises at any time without notification to Customer to: (a) inspect Generating Facility, protective devices, and to read or test Utility installed equipment and (b) isolate the Generating Facility from Distribution System without notice if, in Utility's opinion, a hazardous or emergency condition exists and such immediate action is necessary to protect persons, Utility facilities or other customers' or third parties' property and facilities from damage or interference caused by Generating Facility, or improperly operating protective devices.
- f. Upon termination of the Interconnect Agreement, the Customer shall be responsible for ensuring that the Disconnect Switch is immediately opened, and that the electric conductors connecting the Customer's generator(s) to the Disconnect Switch are lifted and permanently removed, so as to preclude any possibility of interconnected operation in the future. Utility reserves the right to inspect the Generating Facility to verify that the generator(s) is permanently disconnected.



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### **APPENDIX A<sup>1</sup>**

#### Supplementary Information

Application for Operation of Consumer-Owned Generation

System Facilities Upgrade Agreement

Consumer Guidelines for Electric Power Generation Installation and Interconnection

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<sup>1</sup> Utility may revise or update the materials provided in this Appendix as needed. Customer should contact Utility for a current version of the Application and other relevant documents prior to submittal.