Wisconsin Public Service
Interconnection Technical Requirements

1. Introduction

This document describes the technical requirements for the interconnection of Customer-Owned generation to the Wisconsin Public Service (WPS) electric distribution facilities. These requirements apply only to the interconnection of generation facilities greater than 20 kW subject to the rules detailed in the Public Service Commission of Wisconsin (PSCW) Chapter PSCW 119. This document is meant to supplement and clarify items not directly defined in PSCW 119. Distributed generation (DG) is defined as any device designed to generate electrical energy, such as rotating generators, sources utilizing DC to AC inverters, or any other electric generating device.

This document defines the minimum requirements for safe and effective operation of the customer-owned generation connected to the WPS electric distribution system. These requirements apply only to those systems that are designed and operated in parallel with WPS electric distribution facilities. These requirements do not apply to those systems designed intentionally to operate disconnected from the WPS electric distribution system. Exceptions may be made, subject to review and written agreement by WPS, for infrequent momentary parallel operation of emergency standby generation.

It is in the best interest of both the customer and WPS to submit a complete application early and include WPS in the process of planning a new facility to avoid any unnecessary expenses and delays.

WPS does not assume liability or responsibility for the protection of or damage to the customer's generating equipment or any other customer equipment. The customer is solely responsible for protecting its equipment to prevent damage due to faults, line re-closing, imbalances or disturbances on the WPS distribution system, as well as assuring that generation equipment is paralleled in synchronism with the WPS distribution system. The customer is responsible for damage to property and/or injury to personnel of WPS or others when caused by customer's generation facility because of malfunction, improper design, improper operation, human error, or other negligence of the customer or derived from the generation facility or controls.

2. Point of Service Requirements

All services must meet all applicable requirements of WPS service rules, which are summarized in the Gas and Electric Service Manual available online at http://www.wisconsinpublicservice.com/service/manual.aspx.

2.1 Electric Service Sizing

The electric service will be sized to meet the maximum load demand. The expense of any additional capacity or metering requirements to accommodate the generation shall be the responsibility of the customer. The size of the generation at the site may require service at a higher voltage or may require three-phase service. The total single-phase generation shall not exceed 100 kW.

2.2 Transformer

The transformer will be sized to meet the maximum load demand. The expense of any additional capacity shall be borne by the customer. Furthermore, if the distributed generation facility needs to be isolated from other customers' load because of utility requirements or customer request, the cost of the transformer will be borne by the customer.

2.3 Interconnection Disconnect Switch

The customer shall supply an interconnection disconnect switch that opens, with a visual break, all ungrounded poles of the circuit. This switch shall be rated for the voltage and fault current requirements of the DG facility and shall meet all applicable UL, ANSI, and IEEE standards. The switch shall be accessible at all times, located for ease of access for utility personnel and shall be capable of being locked in the open position. The customer shall label this switch "Interconnection Disconnect Switch" by means of a permanent sign. The customer shall post the procedure for disconnecting the DG facility next to the switch, protected from the environment.

2.4 Customer OCP Interconnection Device

The customer shall install interconnection protection devices capable of interrupting fault current from the DG supplying a distribution system fault. This device shall automatically disconnect the DG under such an event and shall electrically prevent closing of the DG to the distribution system during a system outage or closing the DG out of synchronization with the electric system.

2.5 Grounding

The customer shall follow all applicable grounding requirements dictated by the Wisconsin State Electrical Safety Code Volumes 1 & 2 as found in chapters Comm. 16 and PSCW 114. Also, the customer shall follow any additional requirements stated in PSCW 119.

2.6 WPS OCP device

WPS will install an electronic circuit re-closer, at the customer's expense, to serve Categories 3 and 4 DG facilities as defined by PSCW 119. This re-closer will have over-current protection designed to protect other WPS customers from current from the DG in the event of a system event. The re-closer will be equipped with relaying to open under fault conditions, under/over frequency conditions, under/over voltage conditions and possibly transfer-trip functionality (given certain circuit conditions). This re-closer shall be equipped with an RTU capable of transmitting information about re-closer status, voltage, and current. The RTU will also be capable of open and close control of the re-closer to assist in connecting or disconnecting the DG from the electric distribution system. The control will NOT prevent closing out of synchronization with the electric distribution system, and operating procedures developed by WPS and the customer shall dictate the operation of this re-closer.

3. Interconnection Protection Requirements

Protection of the interconnection is necessary to avoid unintentional islanding of portions of the WPS distribution system during abnormal system operating conditions. Equipment installed by WPS will protect other WPS customers from the effects of the DG, and equipment installed by the customer will protect the DG from the effects of the WPS system, as well as protect the DG from adversely impacting other WPS customers. The customer may design the system to generate power to run their own internal loads non-parallel to the WPS system during abnormal conditions.

3.1 Interconnection Protective Relay Requirements

The purpose of the protective relays installed are to detect fault conditions on or loss of the WPS distribution system and automatically disconnect the DG from the WPS system. The customer shall be responsible for the purchasing, setting, testing, operation and maintenance of their relays. WPS shall review the relay package for suitability. The minimum requirement for a Category 2, 3, or 4 DG facility is over/under frequency, over/under voltage, over-current, ground fault and synchronism check relays.

3.2 Transfer-Trip

A transfer-trip scheme is utilized to trip a device to disconnect the DG in the event that another upstream device has operated. This is intended to avoid islanding of a portion of the WPS distribution system with the DG. Such a scheme is necessary when the minimum load served from a disconnecting device is less than twice the rated output of the DG. At such loads the DG may support an island long enough to prevent successful re-closing of the circuit, resulting in damage to the DG and possibly other equipment (WPS and customer-owned) connected to the WPS distribution system.

A transfer-trip scheme entails the installation of communication equipment at the upstream device and the WPS interconnection disconnecting device. When the upstream device operates, the WPS re-closer at the DG site will receive a trip signal from the upstream device and operate. When the circuit is clear and ready to re-energize the DG, the operating guide will detail the procedure to reconnect the DG to the WPS system.

4. WPS Electrical System Design and Operating Conditions

The WPS electrical distribution system is dynamic and can change over time. Load growth in an area may require more capacity for distribution line loading, voltage regulation, or over-current protection coordination. These changes could effect modifications to the electric distribution system to properly protect the DG facility and/or other WPS customers, which may require further charges to the customer.

4.1 Steady State Voltage Design

The steady state voltage as defined by code in PSCW 113 requires the utility to provide voltage between 5% above and below the standard service voltage for retail service. For retail power service with load of less than 500 kW, the code requires the voltage to be between 5% above and 10% below the standard service. For retail power service with load of greater than 500 kW, the code requires the voltage to be between 10% above and 10% below the standard service. Due to the requirements of the retail service (most circuits have a mix of retail service and retail power service customers), it is generally the practice of WPS to attempt to regulate the voltage between 5% above and below the standard voltage on its distribution system in order to meet the lower limit. Exceptions to this practice are circuits where a retail power customer is the only customer served by the circuit and consequently no other customer's voltage limits would be exceeded by operation beyond the 5% threshold. Customer generation should have the ability to operate within these ranges as these voltages are likely to be encountered. Operation of the customer's generation shall not interfere with WPS's ability to regulate the voltage on circuits within this described bandwidth.

4.2 System Voltage Unbalance

For three-phase systems, the maximum voltage unbalance allowed by code in PSCW 113 is 3% unbalance with no electrical load running at the customer location. PSCW 113 references ANSI standard C84.1 - 1989 Appendix D Electrical Power Systems and Equipment - Voltage Ratings (60 Hz). The customer's equipment must be capable of operating in such an environment.

4.3 Conductor Loading

Overhead conductors are rated for maximum amperage based on the summer and winter 194 degree F conductor design ampacity. If addition of a customer generator causes the electrical load to surpass this level, the customer will be responsible for the costs associated with alleviating this overload.

4.4 Over-current Protection

WPS has certain practices and guidelines to design the protection system to de-energize the distribution circuit or section of a circuit for the failure of a component of that circuit. Because the nature of many faults is temporary (lightning, incidental tree contact), the scheme includes automatic re-closing of a breaker or re-closer to re-energize the circuit in an attempt to restore electric service to the area without an extended outage. This automatic re-closing may be problematic for a generator connected to the feeder.

The first challenge is that as the circuit is de-energized for the fault, the generator will continue to supply electricity to the distribution system to which it is connected. However, if the distribution breaker or re-closer closes in with the generator still on-line, the generator will probably not be synchronized with the electric distribution system. Closing the system out of synchronization will likely damage the generator and cause voltage fluctuations on the distribution system that could potentially damage other customers' equipment or WPS distribution equipment. It is for this reason that when a device equipped with automatic re-closing feeding a circuit that contains a parallel generator operates, the generator must be tripped off-line in some fashion before the circuit is re-energized.

WPS will design its distribution over-current protection plan for each circuit using its established practices and guidelines, ignoring the presence of the generator. Any modifications to the plan that occur as a result of the addition of the generator will be the responsibility of the customer adding the generation.

4.5 Distribution Voltage Regulators

In order to maintain acceptable voltage on its circuits, WPS utilizes voltage regulators to adjust the primary system voltage accordingly. WPS practice is to limit the loading on distribution line voltage regulators (those installed outside the substation fence) to the nameplate rating plus a load cycle rating adder of 20% when applicable. Voltage regulators installed in the substation are limited to the nameplate rating plus a load cycle rating adder of 20% (when applicable) and an additional load bonus of up to 60% corresponding to restricting the travel of the regulator steps. If addition of a customer-owned generator results in overloading a voltage regulator, the customer will be responsible for the cost of mitigating that overload.

The second consideration with voltage regulators is the possibility of backfeeding the voltage regulator. Distribution systems are typically radial in nature, meaning that electricity flows from the source to the loads in one direction. If a generator is supplying electricity, there are now two sources and electricity will flow in different directions on the circuit as electricity consumption and generation change. The customer's system may result in current flowing in the opposite direction through a voltage regulator, and this may cause the control to malfunction. In order for it to function properly, some modifications are required to the regulator. If the addition of a customer-owned generator causes such a condition, the customer will be responsible for the addition of such equipment.

4.6 Substation Transformer Loading

If the addition of a customer-owned generator causes an overload of a distribution or substation transformer, the customer will be responsible for the cost of mitigating that overload.

4.7 Voltage Flicker

The starting of motors and generators may cause inrush currents in excess of normal steady-state operating current. These inrush currents will cause a voltage sag (flicker), which can adversely impact the operation of some electrical equipment. The customer shall not cause flicker in excess of WPS standards. The standard is a function of the number of flickers per hour and the percent change in voltage. Consult WPS for determination of flicker.

4.8 Power Factor

Categories 1 and 2 DG facilities shall be operated at a power factor greater than 0.9 as specified by PSCW 119. Categories 3 and 4 DG facilities shall be operated at a power factor of unity or as mutually agreed between WPS and the customer as specified in PSCW 119.

4.9 Harmonics

The customer's equipment shall not introduce harmonics to the distribution system above the levels specified by IEEE 519 "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems." If complaints from other customers arise and the source is the DG facility, the customer must mitigate the problem.

4.10 Frequency

The customer's equipment shall maintain an output frequency of 60 hertz. The operating frequency of the customer's generating equipment shall not deviate more than 0.5 hertz from the 60 hertz base.

4.11 Maintenance

All interconnection protective devices owned by the customer shall be periodically maintained, tested and calibrated by qualified personnel at intervals specified by the device manufacturer, or in accordance with accepted industry practice.

5. Definitions

Alternating Current (AC): That form of electric current that alternates or changes in magnitude and polarity (direction) in what is normally a regular pattern for a given time period. The number of direction changes in a given time period is called the frequency. Alternating current is supplied by WPS to your home or business.

ANSI: American National Standards Institute.

Automatic: Self-acting, operated by its own mechanism when actuated by some impersonal influence as, for example, a change in current strength; not manual; without personal intervention.

Automatic Re-closing: A circuit breaker has automatic re-closing when means are provided for closing without manual intervention after it has tripped under abnormal conditions.

Automatic Tripping (Automatic Opening; Automatic Disconnecting): The opening of a circuit breaker under predetermined conditions without the intervention of an operator.

Biomass/Agricultural Digesters: Anaerobic digester processes farm manure through a process that converts waste products over time into methane, which then can be combusted in a device listed below.

Current: A flow of electric charge measured in amperes.

Current Transformer (CT): A transformer intended for metering, protective or control purposes, which is designed to have its primary winding connected in series with a circuit carrying the current to be measured or controlled. A current transformer normally steps down current values to safer levels. A CT secondary circuit must never be open circuited while energized.

Delivered Energy: Energy sold to the customer.

Delta Connected Circuit: A three-phase circuit with three source windings connected in a closed delta (triangle). A closed delta is a connection in which each winding terminal is connected to the end (terminal) of another winding.

Direct Current (DC): An electric current flowing in one direction only and substantially constant in value. A flashlight uses direct current produced by the batteries.

Disconnect: A device used to isolate a piece of equipment. A disconnect may be gang operated (all poles switched simultaneously) or individually operated.

Energy Storage Devices: Batteries, flywheels, compressed air, super magnetic energy or other devices that store energy for later use. They also can be components in an uninterruptible power supply.

External Combustion Engines: Engines where the combustion process heats a fluid which in turn drives pistons or turbines. Common examples are steam engines, steam turbines, and Stirling engines.

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

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

Fuel cells: Produce electric and thermal energy through electrochemical process using hydrogen, which can be produced from natural gas or by renewable energy resources.

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

Ground: A term used in electrical work in referring to the earth as a conductor or as the zero of potential. For safety purposes, circuits are grounded while any work is being done on or near a circuit or piece of equipment in the circuit; this is usually called protective or safety grounding.

Hertz: The term denoting frequency, equivalent to cycles per second.

IEEE: The Institute of Electrical and Electronics Engineers.

Industrial Gas Turbines: Combustion turbines in the 1 to 15 MW range.

Interconnection: The physical system of electrical transmission between the customer's generation and the utility.

Interconnection Agreement: The standard form of agreement that has been approved by the Commission. The interconnection agreement sets forth the contractual conditions under which a utility and a customer agree that one or more facilities may be interconnected with the utility's distribution system.

Internal Combustion Engines: Devices much like an automotive engine, fueled with either diesel or natural gas, connected to and driving an electrical generator.

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

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

Island: A part of an interconnected system that may be isolated during a system disturbance and start operating as a subsystem with its own generation, transmission and distribution capability. The subsystem then becomes an island of the main interconnected system without a tie. In such a case, the islanded system and the main interconnected system will operate at different frequencies and voltages.

Kilowatt (kW): An electric unit of power which equals 1,000 watts. One watt is the basic measure of electrical power and is equal to one volt of electrical potential times one ampere of current.

Kilowatt-hour (kWh): One thousand watts of power supplied for one hour. A basic unit of electric energy equal to the use of one kilowatt for a period of one hour.

Lagging Power Factor: Occurs when reactive power is predominately inductive, such as with high motor loads or large numbers of transformers.

Leading Power Factor: Occurs when reactive power flows are predominately capacitive, such as a circuit with large numbers of power factor capacitors or over-excited synchronous generators.

Line Losses: Electrical energy converted to heat in the resistance of all transmission and/or distribution lines and other electrical equipment.

Microturbines: Small combustion turbines that burn natural gas to produce less than 500 kW. Simpler than internal combustion engines, they have only one moving part on a central rotating shaft that generates electricity. They are characterized by simple design, modularity and fuel flexibility.

One-Line Diagram: A diagram in which several conductors are represented by a single line and in which various devices or pieces of equipment are denoted by simplified symbols. The purpose of such a diagram is to present an electrical circuit or circuits in a simple way so that their function can be readily grasped.

Parallel Operation: The operation of a customer-owned generator while connected to the utility's grid.

Point of Interconnection: The point where the customer's conductors meet WPS's (point of ownership change).

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

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

PSCW: Public Service Commission of Wisconsin.

Potential: The voltage of an electrical circuit.

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

Re-close: To return a circuit breaker to its closed position after it has opened by relay action.

Relay: A device that is operative by a variation in the condition of one electric circuit to affect the operation of another device in the same or in another electric circuit.

Self-Excited: An electric machine in which the field current is secured from its own armature current.

Separately Excited: Use of an exciter for sending current through the field windings of an electric machine in place of taking the field current from its own armature current.

Solar/Photovoltaic: Photovoltaic materials contained in solar cell array convert energy from sunlight directly into electricity, typically connecting to utility distribution system via inverter.

Stirling Engines: A sealed external combustion heat engine that, in theory, can provide quiet and efficient power.

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

Synchronism: Expresses the condition across an open circuit wherein the voltage sine wave on one side matches the voltage sine wave on the other side in frequency and amplitude without phase angle difference.

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

Utility Grade Relays: Relays which meet IEEE standards C37.90, C37.90.1, and C37.90.2.

Voltage: The electromotive force or electrical potential causing current to flow in a circuit. One volt will cause 1 ampere to flow through a resistor of 1 ohm dissipating one watt of energy in the form of heat.

Wind: Wind turbine generators, harnessing energy contained in wind to turn wind turbine blades connected to generator for electricity production.

Wye or "Y" Connected Circuit (Star Connected): A three-phase circuit in which windings of all three phases have one common connection. The WPS distribution system is a grounded wye system where the common point is connected to ground.