## FOREWORD

The purpose of this document is to provide guidelines for the interconnection of (customer-owned) distributed generating equipment with Unitil's electric power system.

Any questions or inquiries regarding information provided in this document should be referred to the Manager of Distribution Engineering or the Director of Engineering.

5/31/2017

Kevin E. Sprague — Date
Director, Engineering

MAY 12, 2017

John J. Bonazoli, Manager — Date
Manager, Distribution Engineering

## REVISION HISTORY

| Revision # | Date | Description of Changes |
|---|---|---|
| 0 | 03/20/2000 | Initial Issue |
| 1 | 05/01/2000 | General update |
| 2 | 04/01/2017 | General update |
| | | |
| | | |
| | | |

## Table of Contents

**List of Appendices**

## 1.0 Introduction

### 1.1 Purpose

The purpose of this document is to provide guidelines for the interconnection of distributed generating equipment with Unitil's Electric Power System (EPS).

### 1.2 Policy

It is the policy of Unitil and its distribution company affiliates ("the Company") to permit customer-generators to operate generating equipment in parallel with its electric system whenever this can be done without adverse effects to the general public or to the Company's equipment or personnel. Protective devices specified by the Company must be installed at any location where a Customer desires to operate generation in parallel with the electric system. Protection, metering and other interconnection requirements will be specified, reviewed and approved by the Company on a case-by-case basis in accordance with the provisions of this guideline.

Nothing contained in this guideline is intended to replace or supersedes any requirement of the Independent System Operator (ISO New England). Customer-generators will be required to comply with all applicable ISO New England information requests, rules and requirements that are necessary to interconnect the generating facility to the electric system.

### 1.3 Applicability

This document describes the process and minimum requirements for the safe and effective design, installation and operation of interconnection equipment for distributed generators interconnecting under state jurisdiction. These requirements are applicable to Qualifying Facilities, On-Site Generating Facilities, Limited Electrical Energy Producers, Eligible Customer-Generators, Small Power Producers, Co-generators, and other interconnections of customer generation to the Company's electrical system. Customer-owned generation will hereafter be referred to as a "customer-generator", or "the Customer".

This document refers to, but does not detail the requirements of an interconnection application falling under FERC jurisdiction. Generators that connect to the transmission system or intend to sell power to a third party or in the wholesale market, may fall under the FERC jurisdiction. In that case the application may be administered by the Independent System Operator – New England, Inc. (ISO-NE).Customers interested in applying for interconnection on the Unitil system should contact the Distributed Generation team at Unitil to determine the appropriate process that should be followed. Until works closely with ISO-NE and neighboring utilities to determine whether the application should fall under the individual state or FERC jurisdiction.

Final design approval will be subject to Company review on a case-by-case basis. These requirements will be periodically revised to reflect ongoing electric system changes and operating practices.

## 2.0 Definitions

Company: Unitil and its distribution company affiliates

Company EPS: The electric power system owned, controlled, or operated by the Company used to provide transmission or distribution services to its customers.

Distributed Generation (DG): Customer-owned generators connected to the electric distribution system also known as Qualifying Facilities, On-Site Generating Facilities, Limited Electrical Energy Producers, Eligible Customer-Generators, Small Power Producers, Co-generators Generator-Owner: Any Non-Utility Generator even though they may also actually take electric service from the Company.

Point of Interconnection: The point where the generation facility connects to the Company EPS.

Interconnection System: The collection of all interconnection equipment and functions, taken as a group, used to interconnect a DG unit(s) to the Company EPS.

Islanding: Generation serving utility load (or lines) without a synchronizing utility source connected.

ISO-NE: Independent System Operator - New England.

Large Generator: Generating facility with an AC rating of In MA: 500kW or larger

In NH: greater than 100kW

Light Load: minimum modeled load level used for analysis of the impact of generator interconnection on the Company EPS.

NERC: North American Electric Reliability Council.

NPCC: Northeast Power Coordinating Council.

Peak load: Maximum modeled load level used for analysis of the impact of generator interconnection on the Company EPS..

SCADA: Supervisory Control and Data Acquisition- A computer system for gathering and analyzing real time data used to monitor and control Electric Power System transmission and distribution.

## 3.0 Generator Interconnection Process

The generator interconnection process is intended only for generators that are proposed to electrically interconnect (or run in parallel) with the Company EPS. Emergency back-up generators with a break-before-make transfer switch and other generators that operate with no electrical connection to the Company EPS do not pertain to the interconnection process.

As part of the generator interconnection process, Unitil will coordinate with ISO-NE, and neighboring utilities when applicable, to notify and comply with the appropriate ISO-NE procedures. ISO-NE Schedule 22 or Schedule 23 interconnection procedures may be used depending on the size, location, and/or the power sale of the proposed generating facility. Unitil will work with ISO-NE to determine whether the Unitil process or the ISO-NE process will be used and who will take the lead in processing the application.

### 3.1 Unitil Application Process Overview

This section describes the Unitil DG interconnection application process in general. The process details differ for Massachusetts and New Hampshire. Specific detailed process requirements and study timelines can be found in the associated state requirements listed below

Massachusetts:

- FITCHBURG GAS AND ELECTRIC LIGHT COMPANY, STANDARDS FOR INTERCONNECTION OF DISTRIBUTED GENERATION, SCHEDULE IC
- FITCHBURG GAS AND ELECTRIC LIGHT COMPANY, NET METERING SCHEDULE NM

New Hampshire:

- Unitil Energy Systems, Inc., Interconnection Standards For Inverters Sized Up To 100 kVA
- NEW HAMPSHIRE CODE OF ADMINISTRATIONS RULES, CHAPTER PUC 900 NET METERING FOR CUSTOMER-OWNED RENEWABLE ENERGY GENERATION RESOURCES OF 1,000 KILOWATTS OR LESS

### 3.2 Interconnection Application

- A written application must be submitted by the customer-generator to the Company to initiate the request for interconnection.

### 3.3 Required Documentation

- The following information must be submitted to the Company with the application for review and approval prior to finalizing the protection scheme of the Customer interconnection.
    - A One-Line drawing of the system showing all switching and protective devices and the tie point to Utility system.
        - The One-line shall include all Current transformers (CT's) and Voltage Transformers (VT's) with all ratios
    - AC Elementary diagram (three-line) showing all current and voltage circuits and relays and meters (if applicable).
    - Control Diagrams (DC Schematics)
    - A list of all protective relay equipment proposed to be furnished including: relay types, styles, and manufacturer's catalog numbers, ranges and descriptive bulletins.
    - Proposed settings of all interconnection relays specified in this document.
    - Schematic drawings showing the control circuits and synchronizing breakers.
    - Interconnection breaker operating time.
    - The machine and step-up transformer impedance and capability data.
    - Site plan including location of:
        - Interconnecting transformer
        - Interconnecting device
        - Point of Common Coupling
        - Point of Interconnection
        - Line Extension
    - Inverter based facilities:

- Inverter Manufacturer's Data Sheet indicating:
  - Model Number
  - IEEE-1547 and UL-1741 certification
  - Max Capacity of Inverter
  - DC-STC output
  - Max Short Circuit Current (Standard/Expedited Applications)

### 3.4 Changes to the Interconnection

- If the generator-owner plans any changes to the interconnection that could affect the safety, reliability or performance of the interconnection, including protective relaying and metering, the Customer shall give the Company written notice of such plans. Some changes may require a new application.
- The Customer must not remove from service any equipment or protection schemes specified by the Company without written approval of the Company.
- All changes including those required by the Company shall be at the expense of the customer-generator.

## 4.0 Interconnection Studies and Cost Estimates

### 4.1 Study Procedure

Each installation of DG is unique. The level of analysis and the need for detailed engineering study is estimated on, among other things, the size and type of the proposed generating facility, the character of service at the location of the generate, and the inherent limitations of the transmission and distribution system. Upon receipt of all required information from the Customer, engineering study estimates will be developed. Any or all of the interconnection studies may be performed in response to a request for interconnection, as required on a case-by-case basis.

### 4.2 Engineering Analyses

4.2.1 Facility Configuration

- Facility rated output voltage must match System nominal operating voltage at the Point of Common Coupling.
- Facility capacity must not exceed System capacity or jeopardize the integrity of System protection or controls.
- Transformer winding configurations and grounding methods will be analyzed for compatibility with Company EPS.

4.2.2 Steady State Analysis

- Steady State analyses will demonstrate compliance with applicable voltage and thermal loading criteria.
- No generation resource(s) will be assumed as "must run" as a condition for acceptable operation of the new generator.
- Load levels and resource capability to be evaluated:

  Peak load: Load will be modeled at 100% of the projected peak system load for the year the generator is projected to be in service with the output at full capability or the actual peak load experienced from the year prior.

  Light Load: Load will be modeled at 25% Peak Load.

Daytime Light Load: Specific to analysis of PV systems, the Daytime Light load will be used and calculated as 30% of the Peak Load.

4.2.3 Protection & Short Circuit Analysis

- Protection studies will demonstrate that the sensitivity of fault detection of the existing line protection is not substantially degraded, the existing speed of fault clearing is not substantially degraded, and the existing coordination margin between relays is not decreased.

- Short Circuit analyses will demonstrate that short circuit duties will not exceed equipment capability. All generating units will be assumed in-service.

- Existing non-directional line relays must not operate for faults external to the line due to the generating facility's current contribution to the fault.

4.2.4 Stability

- Stability studies, when required, will demonstrate that stability is maintained for all reasonable conditions and that un-damped oscillatory responses are not created between generation resources.

- Power Flows across applicable transmission lines or interfaces should be at or below the most limiting of the existing stability or thermal transfer limits.

- Reasonable combinations of resources and devices that would be expected to have significant interactions will be considered.

- Load levels to be evaluated at full capability of the new resource:

  Peak load: Load will be modeled at 100% of the projected peak system load for the year the generator is projected to be in service.

  Light Load: Load will be modeled at 25% of the projected peak system load for the year the generator is projected to be in service.

4.2.5 Anti-Islanding

- System equipment ratings and settings shall not allow mis-coordination between System Operation and Facility protective devices and controls.

- System equipment ratings shall not be exceeded during reverse power flow resulting from partial circuit load reduction caused by the opening one or more reclosers, sectionalizers or fuses on the same circuit.

- Large generator facilities may be required to provide advanced protection devices preventing Islanding conditions

### 4.3 Identification of System Upgrades

- Upon completion of all necessary steady state, protection, short circuit and stability analyses, a facilities study will be conducted if additions or changes to the existing transmission and distribution system, or to protection and relaying systems, are necessary to permit the interconnecting of the Customer's generation to the Company electric system.

- This study will identify the minimum upgrades to the Company's electric system necessary to eliminate constraints, address protection or short circuit concerns, and/or to restore dynamic or steady state operating conditions to acceptable limits.

### 4.4 Interconnection Cost Estimates

- Upon completion of all studies, including the facilities study, the Customer will be notified in writing of any required system modifications and the estimated cost to implement the changes.

- Because of the wide variations in circumstances and conditions, it is not possible to develop standard interconnection cost estimates.

    - All such estimates will be developed on a case-by-case basis. The customer-generator will be provided with a detailed estimate including the invoice cost of all equipment and materials, labor estimates, and an itemization of charges for each addition or change identified in the facilities study.

## 5.0 Interconnection Requirements for Customer-Owned Generation

### 5.1 Codes and Standards

The Customer's Generating Facility shall comply to the latest revision of all applicable local, state, and federal codes and standards; specifically, but limited to:

- ANSI/IEEE C37.90 - Standard for Relays and Relay Systems Associated with Electric Power Apparatus
- IEEE Std C62.45TM-2002, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits.
- IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems
- NESC - National Electrical Safety Code
- NFPA 70 - National Electrical Code (NEC)
- UL 519 - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- UL 1741 - Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

### 5.2 Design Requirements

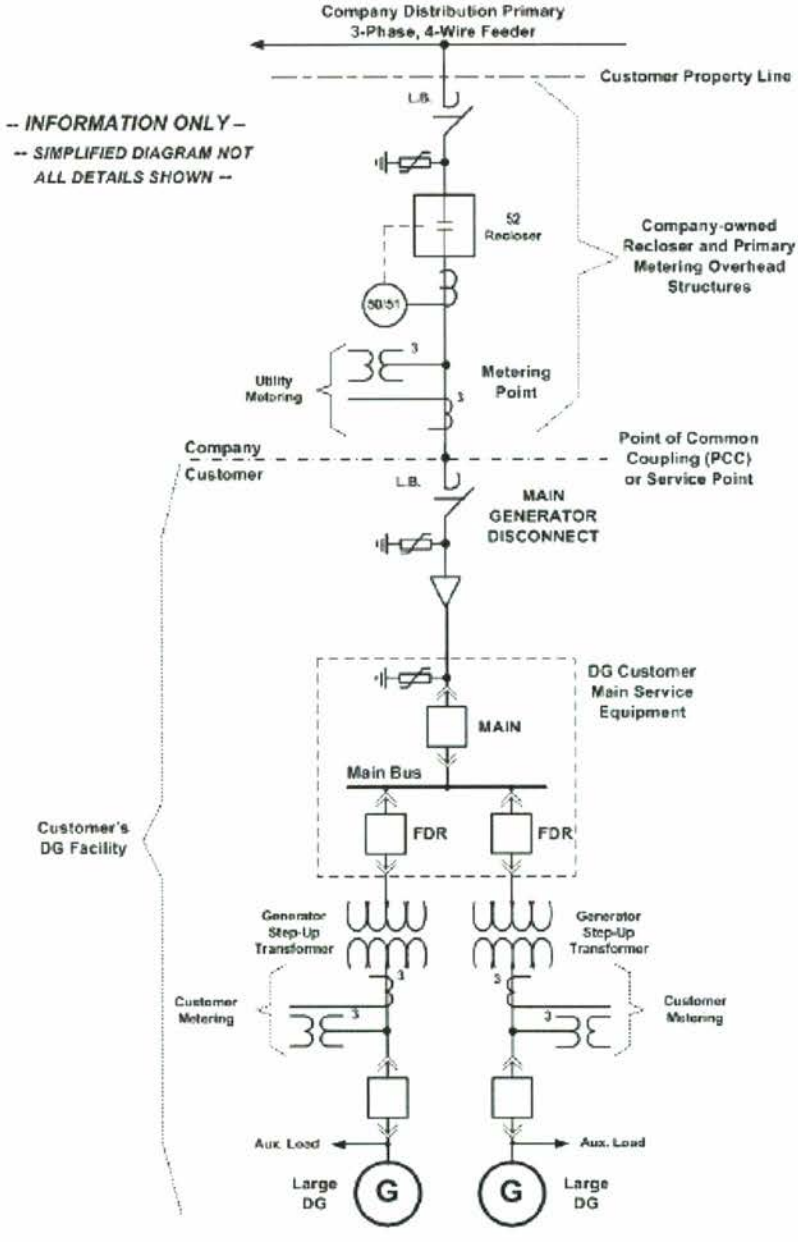
The interconnection of generators with the Company EPS, requires safeguards for synchronization and back-feed situations. And, from the electric system perspective, the challenges posed by any given parallel connection do not diminish significantly with reduction in generator size. For this reason, each specific connection must be studied on a case by case basis with respect to its size, type and the nature of the system at the point of interconnection.

All parallel generation shall be designed to ensure:

- Capability to synchronize with the Company EPS

- Capability to separate from the Company EPS upon loss of Company source
- All energy supplied to the Company's electrical system shall meet the Company's power quality and operation requirements.

The Generator-owner shall be responsible for on-going compliance to regulatory, code, and system design and operating changes pertaining to their installation. This work will be performed at the cost of the Generator-owner.


Company Distribution Primary
3-Phase, 4-Wire Feeder
Customer Property Line
-- INFORMATION ONLY --
-- SIMPLIFIED DIAGRAM NOT ALL DETAILS SHOWN --
L.B.
52
Recloser
50/51
Company-owned Recloser and Primary Metering Overhead Structures
Utility Metering
Metering Point
Company
Customer
Point of Common Coupling (PCC) or Service Point
L.B.
MAIN GENERATOR DISCONNECT
DG Customer Main Service Equipment
MAIN
Main Bus
FDR
FDR
Customer's DG Facility
Generator Step-Up Transformer
Generator Step-Up Transformer
Customer Metering
Customer Metering
Aux. Load
Aux. Load
Large DG
G
G
Large DG

## 5.3 General Requirements

### 5.3.1 Character of Service

- The Customer's equipment must be compatible with the character of service supplied by the Company at the Customer's location.

- Single-phase installations will be evaluated by the Company on a case-by-case basis subject to the system characteristics and capabilities at the point of interconnection, and will be bound by the same general requirements as three-phase installations unless otherwise specified.

### 5.3.2 Wiring, Connections, Codes

- Interconnection equipment shall meet all required local, state and federal codes and regulations including, but not limited to, the National Electric Safety Code and the National Electric Code.

- Interconnection equipment, methods and practices shall comply with established standards of good utility practice for the New England region, as represented by the requirements and practices of the Company, ISO New England and other regional distribution companies. All wiring, connections, and devices and shall be fit for purpose, properly applied, and installed in accordance with manufacturer instructions.

### 5.3.3 Emergency Generators

- Emergency generators are not intended to operate in parallel with the Company's system.

- Each such installation shall be inspected and documented by qualified Company personnel to confirm that such generation is properly installed with an approved double throw switch and cannot be operated in parallel with or be connected to the electric system when the electric system is de-energized.

### 5.3.4 Synchronous Inverters

- Direct Current (DC) generators may be operated in parallel with the Company system through a synchronous inverter.

- Synchronous inverters shall be designed, manufactured and installed in compliance with UL-1741 and IEEE-1547 as well as NESC, NEC, MEC and any applicable local and nationally recognized codes and standards.

- The inverter installation will be designed such that a utility system interruption will result in the removal of the inverter in-feed to the utility. Harmonics generated by a DC generator-inverter combination must not cause any reduction in the quality of service provided to other electric or telephone utility customers.

- The Company may disconnect any DC generator causing harmonic interference from the Company system until the condition has been corrected.

- If the Company determines that the customer-owned generator is the cause of the problem, all costs associated with research and corrective action will be at the generator owner's expense.

## 5.4 Capacitors

- Excitation or power factor correction capacitors may not be installed on induction generators without written consent of the Company.

- The Company will determine if the proposed capacitors could have an adverse impact on the Company system and make any special requirements known to the Customer.

## 5.5 Single Phase Protection

- Single-phase fuses and single-phase line switching devices may be installed between the Company substation and the generator interconnection.

- Such devices may result in the loss of potential on one or more phases when operated, thus causing current and voltage unbalances at the point of interconnection.

- It is the sole responsibility of the Customer to protect customer-owned equipment from harm by such an occurrence.

### 5.6 Live Line Blocking

- The Company's circuits, feeders and transmission lines are normally equipped with relaying to provide automatic reclosing in the event of interruption.
- Live Line Blocking scheme is intended to prevent the closing of a breaker or recloser onto a line that is being energized by Distributed Generation
- At the Customer's request and expense, or as a Company requirement and at the Customer's expense, live-line blocking may be added to the source recloser(s), to inhibit manual or automatic closing of the Company equipment to an energized line.

### 5.7 Synchronizing

- The Customer will be solely responsible for properly synchronizing their generator(s) with the Company system.
- No more than a 3% instantaneous variation in voltage (flicker) is to be caused when connecting or disconnecting the generator or station loads from the line.

### 5.8 De-energized Circuits

- The Customer will not be permitted to energize a de-energized circuit.
- As specified in IEEE 1547, Customer-Owned Generation must detect and disconnect if EPS becomes intentionally or inadvertently de-energized.

### 5.9 Communication Equipment

- The Company may require the installation of additional equipment to insure the rapid separation of the customer-generator from the Company system in order to facilitate restoration of service to other customers, to maintain system stability, to mitigate possible fault damage, or for other reasons.
- This equipment will be designed and installed at the Customer's expense.
    - Additional relaying equipment may be required to provide automatic separation of the Customer's generator from the Company system in the event of system disturbances detected by the Company equipment remote from the generating site.

- A remote terminal unit located in the Customer's plant and compatible with the Company's SCADA system may be required. This unit would permit direct control of the Customer's interconnecting circuit breaker or motor operated switch by Company Operations personnel.

- SCADA communications equipment shall be required to be installed at generating facilities with capacity of 500kW or greater.

- Such equipment shall be specified or approved by Company.

- The Company may require that a communication channel(s) be installed, at the Customer's expense, as part of the relay protection scheme, SCADA control, or for other reasons.

- This channel may be a leased telephone circuit, power line carrier, company-owned pilot wire circuit, or other means as determined by the Company.

### 5.10 Quality of Service

- The interconnection of the Customer's generating equipment with the Company system shall not cause any reduction in the quality of service being provided to other customers of the Company.

- The voltage from generators must be controlled so that the Company can maintain the distribution voltage within a bandwidth of 114 volts to 125 volts of a nominal voltage of 120 volts.

- Voltage limits for customer-owned generators connected to the Company's transmission facilities will be determined by Company.

### 5.11 Islanding

- The customer-generator is not permitted to separate from the Company system and deliver electricity to local load normally supplied by Company (islanding). Per IEEE1547, anti-islanding protection is required for generators interconnected to the Company EPS.

- Due to operating times of some system protective devices, Customer-Owned Distributed Generation including photovoltaic generation may be required to demonstrate that the Generator Facility protective devices and switches are configured to detect loss of utility voltage and disconnect in less than the IEEE-1547 requirement. This will be determined on a case-by case basis.

- The customer-generator shall be solely responsible for any damage to Company or customer equipment resulting from Islanding.

### 5.12 Harmonic Interference

- The harmonic content of the voltage and current waveforms in the Company system must be restricted to levels within the limits specified in the latest edition of Electrical and Electronic Engineers (IEEE) Standard 519, Figure 10.3.
- All harmonic problems will be addressed on a complaint basis.
- The Company may disconnect any generator causing harmonic interference from the Company system until the condition has been corrected.
- If the Company determines that the customer-owned generator is the cause of the problem, all costs associated with research and corrective action will be at the generator owner's expense.

### 5.13 Power Factor Operating Limits

- All customer-owned synchronous generators should be rated to operate continuously at any power factor between 90 percent lagging and 95 percent leading at any voltage level within +/- 5% of rated voltage.
- The actual power factor requirements of each customer-generator will be specific to their location in the Company system and will be determined by Company.
- The Customer must provide the Company with a power factor capability curve for each generator.

### 5.14 Synchronizing to the Company system

#### 5.14.1 Synchronizing Breaker

- The Customer shall designate one or more breakers to be used to synchronize the Customer's generator to the Company's system.
- This "synchronizing breaker" may be a breaker other than the interconnection breaker.

5.14.2 Out of Synchronism Close Inhibit

- The Customer shall provide protective relaying to prevent the closing of the synchronizing breaker while the generating facility is out of synchronism with the Company system.

- The Company will establish power factor and voltage hold limits on a case-by-case basis incorporating the actual unit capability and system characteristics at the point of interconnection.

**5.15 Transformer Interface**

- In general, the Customer's generation shall interface with the Company system through a transformer or bank of transformers of an adequate KVA rating and proper voltage rating for conversion from the Customer's generator voltage to the Company's distribution or transmission voltage.

- For most three-phase transformer installations, the transformer connection and grounding arrangement shall be of a configuration that will not establish an additional ground current source to the Company system. However, the Company may require or allow other methods of transformer neutral grounding, such as reactance grounding, under certain system configurations.

**5.16 Service Equipment and Revenue Metering**

- Each interconnection service entrance must be provided with appropriate switching devices and interrupting devices shall be rated for at least

    - the maximum fault current available from the Company EPS and the contribution from the Customer's generator(s)

    - Interrupting the Customer's step-up transformer magnetizing current as supplied from the Company system.

- Suitable metering will be required at any location where customer-owned generation is connected in parallel with the Company system.

- Metering will normally be provided to measure energy flow in two directions.

- Incremental metering costs required solely to measure the output and delivery of customer-owned generation to the Company's electric system shall be borne by the Customer.

- All metering requirements will be specified and approved by the Company.

### 5.17 Relaying and Protective Equipment

- Protective relaying will be required to protect the electric system from damage, to minimize the likelihood of injury to operating personnel and third parties, and to allow the Company to maintain service to its non-generating customers in the event the Customer's facility or interconnection equipment experiences problems.

- Protective relaying and devices shall be provided by the Customer and properly installed in accordance with this document. All protective relays, settings, and schemes described in this document will be specified and approved by the Company.

- The Company is not responsible for any additional relays installed by the Customer to protect customer-owned equipment.

-

## 6.0 Relaying and Protection Requirements

### 6.1 Protective Relay System

- Protective relays, potential transformers, current transformers, power circuit breakers and other associated auxiliary equipment are combined to create a protective relay system.
- Each location where customer-owned generation is connected in parallel with the Company electric system must have such a protective system installed.
- The total protective relay system shall consists of a) the Company relaying; b) Customer relaying provided for the interconnection, and c) Customer relaying provided to protect customer-owned equipment.
- Interconnection relaying equipment, including instrument transformers, shall meet ANSI/IEEE standard C37.90 and be of a manufacturer and type generally accepted for use by the Company.
- Protective relaying systems provided by the Customer, as required by this policy, shall be sufficiently redundant to provide adequate protection, as determined by the Company, upon the failure of any one component.
- The use of a single all-inclusive relay package is generally not acceptable.

### 6.2 Standards for Interconnection

- All customer-generator interconnections shall provide protection against the following:
    - Inadvertent and unwanted energizing of a dead line or bus.
    - Interconnection while out of synchronization.
    - Ground faults and phase faults.
    - Frequency outside permissible limits.
    - Voltage generated outside permissible limits.

## 6.3 Requirements for Synchronous Inverters

### 6.3.1 Standard Protection

- The inverter shall include under voltage, overvoltage, under frequency, and over frequency protection integrated into the electronic controller and shall comply with Underwriters Laboratories 1741 "Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources" and IEEE 1547 "Standard for Interconnecting Distributed Resources with Electric Power Systems".

### 6.3.2 Anti-islanding

- To prevent the inverter-based system from islanding with a portion of the Company system, the generation protection shall trip the interconnection breaker upon loss of utility voltage to the supply line.

### 6.3.3 Surge Protection

- The inverter system shall include a surge protector on the utility side of the inverter.
- The surge protection system shall comply with testing criteria detailed in ANSI/IEEE standard C62.41 and shall be tested per UL 1449.
- It is recommended that this surge protector be integrated within the inverter. However, a separate surge protector may be used if the inverter does not comply with the surge protection standards.

## 6.4 Requirements for Synchronous Generators:

- A synchronous generator is a source of current for a fault occurring on the Company's system.
- The Customer must provide relaying to detect any faults on the Company's system or within the generating facility, whether the fault is phase-to-phase or phase-to-ground.

6.4.1 Minimal Relaying Protection required for synchronous generators:

- As a minimum the customer shall install the following types of relaying:

| Function | Description |
|---|---|
| 27 | Under voltage (phase-to-phase or phase-to-ground) |
| 50 | Instantaneous Overcurrent (each Phase) |
| 51 | Phase Time Delayed Overcurrent (each Phase) |
| 51G | Ground Overcurrent |
| 59 | Overvoltage (phase-to-phase or phase-to-ground) |
| 81O/U | Over/Under Frequency |

6.4.2 Protection Coordination Criteria:

- The relay systems must work with and coordinate with the Company protection system to isolate the generating facility from the Company system per the following criteria:
  - The sensitivity of fault detection of the existing line protection is not substantially degraded
  - The existing speed of fault clearing is not substantially degraded.
    - The existing coordination margin between relays is not decreased.
    - Existing non-directional line relays will not operate for faults external to the line due to the generating facility's current contribution to the fault.
  - The sustained voltage on an un-faulted phase during a line-to-ground fault is not increased beyond 1.25 times the normal phase-to-ground voltage.
- If due to the interconnection of the Customer's generating facility, the above criteria are violated, the Company will require the Customer to pay for the purchase and installation of any modification or replacement of protection

systems to correct the violation and restore the protection to the level of protection prior to the interconnection.

6.4.3 High Speed Relaying:

- The Customer may be required to use high-speed relaying if time-delayed protection would result in degradation of the speed or sensitivity of the existing protection on the Company system.

6.4.4 Breaker Failure Relaying:

- The Customer may be required to provide breaker failure protection, which may include a Direct Transfer Trip (DTT) scheme to the Company's station(s).

6.4.5 Communications Channels:

- The Customer is responsible for procuring any communications necessary between the Customer's facility and the Company's stations.

**6.5 Requirements for Induction Generators:**

- Induction generators normally are not a source of current to a fault on the Company's system, as the generator receives its excitation from the Company System.

- The Customer may be required to install capacitors to limit the adverse effects of drawing reactive power from the system for excitation of the generator.

- Capacitors for supply of reactive power at or near the induction generator with a kVAR rating greater that 30% of the generator's kW rating may cause the generator to become self-excited.

- If self-excitation can occur the Customer shall be required to provide protection as specified for synchronous generator.

6.5.1 Minimum Relaying Protection required:

- As a minimum the customer shall install the following types of relaying:

**Function Description**

27 Undervoltage (phase-to-phase or phase-to-ground)

59 Overvoltage (phase-to-phase or phase-to-ground)

81O/U Over/Under Frequency

### 6.6 Coordination of Company, Customer and Interconnection Relaying

- The Company will review all the relay settings as submitted by the Customer to assure adequate protection for the Company's facilities.
- In addition, the Company will determine if changes are required to the Company protection systems due to the connection of the Customer's generation.
- If changes are required, they will be performed by the Company at the Customer's expense prior to connection of the Customer's generation.
- Interconnection relay requirements do not intrinsically provide any protection for the Customer's generator(s) or any other portion of the Customer's electrical system or equipment.
- The Customer must provide for all additional protective relaying to protect the generator(s) and electrical system(s) and equipment.

### 6.7 All generating facilities equal to or larger than 500kW

- For any generation facility sized approximately 500 kW or larger, a utility grade relay is required to be installed as redundant protection with the minimum protection function of 27, 59, 81 O/U, 51, 51N activated. Note: if the Company requires a recloser to be installed at the PCC, this recloser is considered redundant protection for any relaying functions activated in the recloser.

### 6.8 Test Blocks

- For any relays requiring testing or connection to company EPS, ABB type FT test blocks shall be provided to permit injection of test voltage or current as required, to verify the calibration and operation of the interconnection protection relays.
- These test blocks shall also interrupt the relay trip outputs.

- The Company must review and approve the location of the test points in the sensing and trip circuits as part of the initial design review.

### 6.9 Wiring and Connections

- All secondary wiring and connections of the interconnection relay system and its associated equipment shall meet all requirements of applicable federal, state and local electrical codes and good utility practice.

- Screws, studs, nuts, and terminals used for electrical connections shall be of brass or plated brass.

- The wire used will be no smaller than #14 AWG stranded copper, with insulation suitable for the particular application.

- In no case will the insulation be rated for less than 600 volts.

- Wire terminations shall be by use of non-soldered "crimp-style" ring lug terminals.

- Primary or high voltage wiring of CT's, PT's, breakers, and related equipment shall be installed in accordance with all applicable sections of the National Electrical Code, National Electric Safety Code as well as applicable federal, state and local codes, Company standards, and all standards of good utility practice.

## 7.0 General System Upgrade Requirements

### 7.1.1 Interval Revenue Metering

- Facilities greater than 60 kW in MA, and 100kW in NH, shall be equipped with bi-directional interval meters with remote access.
- Interconnecting Customer shall be responsible for providing and maintaining all necessary telecommunications lines and equipment per the Company's requirements.

### 7.1.2 Facilities 500 kVA or larger

- Facilities 500 kVA or larger shall require a motorized gang operated disconnect switch owned and operated by the Company.
- Facilities 500 kVA or larger shall be required to provide real-time remote monitoring and control via a RTU or similar equipment. This monitoring is required at the designated interconnection device of the overall DG facility. If a Company owned recloser at the PCC is installed, monitoring of the recloser can serve as this purpose.
- In addition, relay-time monitoring at the interrupting device for each individual unit of 500 kVA or larger. For units from 60 kVA to 500 kVA, recording interval metering (accessible by the Company) may be allowed instead of real-time monitoring.
- Data Monitored (minimum)
  - Connection or Unit status
  - Active and reactive power flow (Three phase)
  - Voltage – facility side (per phase)
  - Voltage – Utility side (per phase)
  - Current (per phase)
  - Frequency

- Protective relay status (if applicable)
- DC control system status (if applicable)

7.1.3 Facilities 1,000 kW or larger

- Facilities 1,000 kW or larger will require installation of a dedicated three phase recloser and gang operated switch.
- Existing pole configurations, space or easement limitations or other factors may necessitate pole replacement or additional poles and or equipment.

7.1.4 Direct Transfer Trip

- Large generating facilities (1,000 kW and larger) may require direct transfer trip (DTT) to mitigate potential anti islanding concerns.
- DTT requirements shall be determined on a case-by case basis detailed in the impact study.
- DTT operation will require communications with equipment located on the Company EPS. The Interconnecting Customer shall be responsible for the cost of equipment and communications necessary for DTT operation.

## 8.0 Disconnect Switches and Devices

### 8.1 General Requirements

- All generators greater than 10 kW will require a disconnect device at the Point of Common Coupling. Inverter-based facilities in New Hampshire that are less than 100 kW that do not employ primary metering, a disconnect is not required y the Company, but requested and recommended for first responder usage. Disconnect switches shall be gang operated and capable of:
    - Interrupting the Customer's full generation capability.
    - Providing a suitable visual separation of the Customer's generating facility from the Company system.

- Interrupting the Customer's step-up transformer magnetizing current as supplied from the Company system.

- The Customer shall provide direct unencumbered access to the disconnect switch to allow Company personnel to operate the disconnect switch at any time of the day and year without contacting the Customer.

### 8.2 Three Phase Generators

- A three-phase, gang-operated, load-break, lockable, visible disconnect device is required for three-phase generator installations.

- This requirement may be waived if the total generation at the site is less than 200 kW provided that suitable single-phase disconnecting devices are installed.

- The Company will not be responsible for problems or damage to the customer's equipment created by the operation of single-phase switching or protective devices.

### 8.3 Single Phase Generators

### 8.4 Company Access and Operation

- Disconnect devices must be available for operation by Company personnel at all times.

- Facilities for numbering, locking or tagging such devices may be required.

- The Company reserves the right to open these switching devices without prior notice to the Customer for any of the following reasons:

  - System emergencies.

  - Inspection of the Customer's generating and/or protective equipment reveals a hazardous condition

  - The Customer's generating equipment interferes with other customers or with the operation of the Company system.

  - As necessary to maintain Company facilities.

### 8.5 Customer Operation

- The Customer shall not attempt to operate any equipment, including customer owned equipment, which has been switched, tagged, opened or locked out by Company personnel.

## 9.0 Acceptance

### 9.1 Inspection

- Interconnection equipment between the Customer's generator and the point of delivery to the Company must be inspected and accepted by a qualified Company representative before the Customer will be allowed to connect their generating equipment to the Company network.

### 9.2 Calibration and Testing

- All interconnection relay settings will be reviewed and approved by the Company.
- The Customer is required to have evidence that the relays have been calibrated and must provide accurate documentation of the calibrations.
- All components of the protective relaying scheme must be activated and must function correctly before the Customer will be allowed to connect their generating equipment to the Company network.
- Relaying which serves only to protect the Customer's equipment and is not specifically required by the Company may not require detailed review by the Company.

### 9.3 Functional Testing

- In addition to relay calibration and testing, a complete functional test of the entire interconnection protection package will be required. The customer shall provide the proposed testing procedure to the Company for review and approval.
- This shall include an operational test of individual relays, a functional test of the subsystems and the total system and as many trips of the generator breaker as necessary to verify the correct operation of the interconnection protective relays and the breaker trip circuits.

- Operational and functional testing may be performed by the Company or by a qualified contractor approved by the Company.

- Test blocks, as specified in Section 6.0, Part 6.7 of this document, shall be provided for this purpose.

### 9.4 As-Built Drawings

- Prior to the initial functional test, the Customer shall supply the Company with as-built drawings with sufficient information to safely perform, review and/or interpret the functional test results.

### 9.5 Commission Testing

- After the construction of the Customer facility and the Company system modifications is complete, and after the Company has received a Certificate of Completion signed by the local authority responsible for electrical inspection, a commissioning test will be performed and witnessed by the Company.

- The Customer will submit a test procedure to the Company for review.

- The Company may elect to forgo witnessing of the test and require written test results certifying the facility tested successfully to all steps of the commissioning test required by the Company.

- On successful inspection of the commission test, the Company will install the required meter (if necessary) and will notify the customer of approval to interconnect the facility.

-

## 10.0 Customer Responsibilities

### 10.1 Company Approval

- No generation, no matter its intent, shall be installed or operated in parallel with the Company EPS without prior notification to and approval by the Company.
- This responsibility applies to an initial facility, as well as to subsequent additions and/or modifications of Generator-owner equipment or change of ownership through sale. The Generator-owner is responsible for modifying their system to comply with any future mandate of the Regional ISO; NPCC; and NERC or successor organizations including cost incurred.
- If the Generator-owner makes significant changes in the design or scheduling of the project, then any previous information furnished by the Company to the Generator-owner shall be subject to review and possible change. Failure to communicate such changes to the Company may result in delay of service or termination of service by the Company.
- The Generator-owner is responsible for maintaining Company specified telecommunication equipment and services as required for the installation.

### 10.2 Protection of Customer Owned Equipment

- The Customer is responsible for protecting customer-owned equipment in such a manner that faults or other disturbances on the Company's system do not cause damage to the Customer's equipment.
- The Company will not assume responsibility for protection of customer-owned generator(s) or of any other portion of the Customer's electrical equipment.

### 10.3 Maintenance and Testing

- The Customer is responsible for the maintenance and testing of all interconnection equipment, including power apparatus and the interconnection relay system.
- Periodic tests should be performed according to the manufacturer's recommended test guidelines and, as a minimum, shall be performed in accordance with the Company's relay maintenance procedures.

- Specific relay test data shall be made available to the Company upon request to provide evidence that each relay will operate as desired.

- Failure of the Customer to provide proper testing and maintenance will result in the Customer being notified and requested to take prompt corrective action within ten (10) days.

- Should the Customer then fail to provide proper testing and maintenance within the ten days, parallel operation may be required to cease until appropriate corrective action is taken and Company approval is obtained.

- The Customer shall bear the cost of any necessary testing that may be requested by the Company. Such testing may be required as a result of a malfunction of a component of the protective system, accidental damage to parts of the protective system, or the like.

### 10.4 Compliance and Notification

- The customer-generator must not operate interconnected to the Company's system if any equipment, relays or protection schemes specified by the Company are not in-service or are not functioning correctly.

- The Company is to be made aware, immediately, of any protective relay that is found to be defective if not replaced immediately by a duplicate, operable device.

## 11.0 Right to Inspect

- The Company reserves the right to inspect, test, and certify in writing the accuracy of any metering equipment owned by the Customer.

- The Company reserves the right to inspect, test, and certify in writing the Customer's compliance with the protection standards established herein and approved by the Company.

- The Company reserves the right to inspect and test the electrical interface at any time to certify its proper operation.

## 12.0 Disclaimer and Contact Information

### 12.1 Disclaimer

- The Company's review of the Customer's facility, equipment, interconnection equipment, protective devices and metering, shall not be construed as confirming or endorsing the design, or as any warranty of safety, durability or reliability of the facility or any of the equipment.

- The Company shall not, by reason of such review or failure to review, be responsible for the strength, safety, adequacy or capacity of the Customer's facility, equipment, interconnection equipment, or protective devices, nor shall the Company's acceptance be deemed an endorsement of such facility or of any equipment or details of design.

- The Customer must agree to change its facility, equipment interconnection equipment, or protective devices as may be reasonably required by the Company to meet changing requirements of the Company's system.

### 12.2 Exceptions

- While this document is intended to address the requirements of most customer-generator installations, it is recognized that this, or any similar document, cannot cover every possible contingency or variation in equipment to be encountered at the various customer-owned generation installations.

- The Company will address, on a case-by-case basis, customer installations with unique or special requirements not covered elsewhere in this document.

### 12.3 Company Contact

- All correspondence, including the written application requesting an interconnection and all required technical information, shall be directed as follows:

Unitil Service Corp.
Attn: Engineering-Generator Interconnections
6 Liberty Lane West
Hampton, NH 03842-1720
(603) 773-6480

## Appendix A - Request for Procedure/Change Form

Requestor: _____
Title: _____
Department: _____
Location/DOC: _____
Date: _____
Procedure No.: _____

Item(s)/Section to be changed (if applicable):
Section: _____
Page: _____
Figure: _____
Appendix _____
Other: _____

**For New Procedures**

Description of new procedure to be developed: _____

Reason for new procedure: _____

**For Changes to Existing Procedures**

Description of requested change(s): _____

Reason for requested change(s): _____

**Instructions:** The individual requesting a new procedure or change(s) to existing procedures shall complete this form and submit it to the Director of the applicable department. For changes to procedures please attach a copy of the existing procedure with revisions marked on the copy.

Requestors Signature: _____ Date: _____

| For Reviewers Use Only | | | | |
|---|---|---|---|---|
| Change(s) Approved? | YES | NO | If No, briefly explain | _____ |
| Changes Implemented? | YES | NO | Date Implemented: | _____ |

Reviewers Signature: Date: