

**Central Hudson Gas & Electric Corporation (CHG&E)
Interconnection Protection Requirements for Distributed Generators of
Greater than 300 kVA Connected in Parallel with the CHG&E
Electrical Delivery System**

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I. GENERAL REQUIREMENTS

The primary concern with the interconnection of customer owned generation is safety. A protection system is required for the interconnection to insure general public safety as well as the safety of Central Hudson employees. The protection of Central Hudson and customer owned equipment from damage and the quality of service for other customers are also major concerns which must be adequately addressed for each installation.

1. System Design

The customer must have protective equipment, including automatic disconnecting devices, which will disconnect and lockout the generator in the event that the portion of the Central Hudson System to which the customer owned generation is interconnected is de-energized for any reason.

The customer's protection scheme should be designed to detect faults on the customer's system. The customer's protection scheme must be designed to detect faults and abnormal conditions on the Central Hudson System. The customer's generation must be automatically disconnected for these conditions.

The customer's protection and control schemes must be designed to allow the generator to operate only within the limits specified by Central Hudson for frequency, voltage, wave shape, and voltage and current harmonic content. Nominal frequency must be 60 Hertz. Nominal voltage, at the point of delivery, shall be compatible with the Central Hudson System scheduled voltage. Voltage output must be free of any distortions or spikes which will adversely affect the quality of service to other Central Hudson customers.

In addition, for larger generators, typically those interconnected with the Central Hudson transmission system, the customer's system must be designed, maintained and operated to Central Hudson's "Transmission Planning Criteria" and to all applicable NYISO (New York Independent System Operator), NYSRC (New York State Reliability Council), NPCC (Northeast Power Coordinating Council) and NERC (North American Electric Reliability Council) standards and criteria. This includes the interconnection, generator and plant auxiliary systems.

The customer must design their interconnection scheme for the same level of reliability that Central Hudson designs into its generation, transmission, and distribution protection. This means that the customer's protection scheme must be of a "Fail Safe" design. In other words, the customer's protection scheme should be designed to isolate the generator from the Central Hudson System even when any one of the customer's protective or interrupting devices fails to operate. It is the customer's responsibility to insure that their installation and all electric equipment conform to all applicable codes, such as:

- a. National Electrical Code (ANSI/NFPA 70)
- b. National Electrical Safety Code (ANSI C2)
- c. Local Ordinances

All wiring must be inspected by the New York Board of Fire Underwriters or other approved inspection agencies. A certificate of compliance must be submitted to Central Hudson prior to the final approval for interconnection.

The final task that must be completed prior to granting final approval for interconnection, is the successful completion of the functional testing of

the generator control and interconnection protection schemes. These tests are very important. They demonstrate that the control and protection schemes, together with the automatic equipment, operate as designed. It is the customer's responsibility to arrange for the functional tests to be performed. Central Hudson will witness the functional tests. At the customer's expense, Central Hudson may perform the functional tests.

2. Maintenance & Operations

Maintenance and testing of the customer's protective devices must be performed by the customer at least once every 4 years. The results of this maintenance and testing must be reported to Central Hudson.

For all generation installations, the customer must maintain an Operating Log. This log should be a record of all pertinent information concerning the operation of the generator. It should include, as a minimum, the date and times the generator goes on line and off line, a record of all relay and breaker operations, and a record of all maintenance on protection equipment. This log, or a copy, must be presented to Central Hudson, upon request, with the results of the customer's scheduled maintenance. At all other times, this log must be readily available to Central Hudson. Central Hudson reserves the right to inspect the customer's installation at any time upon reasonable notice to the customer.

3. Data Requirements

The customer must provide data on the proposed interconnection protection and generator control schemes. This includes all data necessary for Central Hudson to review the installation and to determine if all interconnection protection and control requirements have been met.

It is strongly recommended that the customer submit this data for review and approval BEFORE any equipment is purchased. This will enable the customer to finalize a design which is not restricted by the need to design around or replace an already purchased piece of equipment. A complete set of data must be submitted to Central Hudson before approval of the interconnection can be granted. The more complete and consistent the data, the faster the review process will proceed. The customer should not be concerned with submitting too much information.

4. Reinforcement Costs (Dedicated Facilities)

Based on the review of the generator installation, it may be determined that reinforcements to the Central Hudson System will be necessary. This may include changes to Central Hudson's substation and/or line protection. It may also include the addition of equipment or the upgrade of existing equipment. The customer will be responsible for all engineering, installation, and maintenance (and removal if applicable) costs associated with this reinforcement.

5. Protection of Customer Equipment

The customer is reminded that Central Hudson is primarily concerned with the protection of the interconnection and its own equipment. Central Hudson will not review the protection of the customer's generator or other equipment. That responsibility is solely the customer's. Note that customer equipment protection should protect against damage caused by faults and abnormal conditions on the Central Hudson System as well as faults and abnormal conditions on the customer's system.

II. SPECIFIC INTERCONNECTION PROTECTION REQUIREMENTS

Central Hudson has specific requirements which fall under four areas:

- A. System Design Requirements
- B. Quality of Service
- C. Testing
- D. Information Requirements

This section documents these requirements.

A. SYSTEM DESIGN REQUIREMENTS

These requirements are necessary to insure the public's safety and Central Hudson employees' safety, as well as to protect the equipment of other customers and Central Hudson.

1. "FAIL SAFE" Interconnection Protection Scheme

The protection scheme must be designed so that it is able to sense any type of fault or system abnormality, such as an open conductor, and isolate the customer's generator from the Central Hudson System even when any one of the sensing or interruptive devices has failed to operate.

Table 1 is useful to determine if a particular scheme satisfies the "Fail Safe" requirement. Figures' 2 and 3 are sample one line diagrams showing typical interconnection protection schemes with a properly filled out Table 1 for each one line diagram. These one line diagrams are given strictly as examples and do not include the necessary protection for the customer's equipment. Refer to Table 2 for a list of ANSI/IEEE standard device numbers and their function. The specific design of the protection system depends on the generator type, size, the customer's own load level, and the type of supply feeder.

2. Primary and Back-up Systems

To insure a "Fail-Safe" system, as described above, it is important to provide as much separation between the primary and back-up systems as is practical. This includes insuring that no common auxiliary devices (such as lockout relays, programmable controllers, etc.) exist and that primary and back-up protection and control systems are separately fused.

This same guideline for the separation of primary and back-up systems is used by Central Hudson in the design of its generation, transmission, and distribution protective systems. This type of design increases the reliability of the overall protection system. The customer is required to design their installation to Central Hudson's design guidelines so that the high level of safety and reliability of the Central Hudson System can be maintained.

3. Disconnect Switch *

A manual lockable disconnect switch shall be installed by the customer. The purpose of this switch is to lock out the customer's generation for any of the following reasons:

- a. Emergency conditions on the Central Hudson System, or
- b. Inspection of Customer's System by Central Hudson reveals a hazardous condition, or
- c. The customer has failed to provide proper maintenance of his protective devices, or
- d. The customer's system interferes with Central Hudson equipment or Central Hudson's other customers' equipment.

The disconnect switch shall be installed at a location visible and easily accessible to Central Hudson at all times. The disconnect switch should be of the load break type. The disconnect switch must show a visible disconnection. A Central Hudson standard lock is to be used to lock the disconnect switch.

* For large generator installations this requirement is generally met by the inclusion of circuit breakers and circuit breaker disconnect switches.

4. Effectively Grounded Sources

When operating, all customer generation must be an effectively grounded source to the Central Hudson System. When not operating, the customer's equipment must not be a ground source to the Central Hudson System. Figure 1 presents several different methods to effectively ground a source; other methods are available.

The vast majority of Central Hudson distribution feeders are multi-grounded neutral, four wire systems. Phase to ground connected load is routinely supplied. During a phase to ground fault on the Central Hudson System, the customer's generator can become isolated with the phase to ground fault. This can occur if the Central Hudson source opens before the customer's interconnection protection scheme detects the fault condition and isolates the customer's generation from the Central Hudson System. If the generator is not effectively grounded during the period that the customer's generation is isolated with the phase to ground fault, the neutral can shift resulting in an overvoltage on the two remaining unfaulted phases. This overvoltage can reach 173% of normal. This subjects phase to ground connected load, isolated with the customer's generation, to this overvoltage. This high voltage could damage Central Hudson and/or other customer equipment. To avoid the possible overvoltage due to this neutral shift, Central Hudson requires that the customer's generator feed into the Central Hudson System as an effectively grounded source.

Generally, a source is effectively grounded if the ratio of its zero sequence impedance to positive sequence impedance is less than three (3). The designer of the generator installation should keep in mind that the installation's equipment will provide a path for a portion of the zero sequence fault current for all phase to ground faults on the circuit. In order to

minimize the fault current through the customer's equipment, it is recommended that the system be designed to minimize the zero sequence current (i.e. larger zero sequence impedance) and still meet the effectively grounded requirement. This will also minimize the effect on the existing Central Hudson fusing and substation ground relaying.

The installation of an appropriate sized reactor in the neutral of the step-up transformer can be used to limit fault current and still satisfy the effectively grounded source requirement. The reactance of the neutral reactor should be selected such that when the substation breaker or line recloser is open, the zero sequence to positive sequence impedance ratio at the point of interconnection is less than three (3). This limits the neutral current, due to load unbalances and phase to ground faults, while still limiting the phase to ground voltage, on unfaulted phases, to acceptable levels during phase to ground faults.

5. Station Batteries

Station battery installations must be designed and tested in accordance with applicable ANSI/IEEE standards:

Sizing ANSI/IEEE 485

Installation ANSI/IEEE 484

Maintenance ANSI/IEEE 450

6. Use of Programmable Controllers

In some instances, the customer may wish to utilize a programmable controller for much of the site's control functions. This is generally acceptable, however, the following points must be considered when designing the installation:

1. To maintain a "Fail-Safe" interconnection protection scheme, all trip paths CANNOT be dependent upon the correct operation of the programmable controller.
2. The operation of the programmable controller during a complete or partial loss of voltage must be considered.
3. The speed of operation and design of the programmable controller must be consistent with accepted protective relaying practices.

7. Telemetry

If the customer's generation is greater than approximately 1.0 MW, remote monitoring of the site and telemetry to Central Hudson's Control Center is required. Remote monitoring may also be required on some smaller sites.

As a minimum, the following monitoring points will be required:

1. instantaneous MW's
2. instantaneous MVAR's
3. MW-hr's at the end of each hour
4. circuit breaker status

In addition to these, other monitoring/control points may be required. These additional points may include the control of a breaker, monitoring of voltage, etc. All remote monitoring/control equipment must be compatible with Central Hudson's SCADA (Supervisory Control and Data Acquisition) system.

It is the customer's responsibility to pay for the installation, operation, and maintenance of this equipment. It is also the customer's responsibility to arrange for and pay for the required communications circuit from the customer's site to Central Hudson's Control Center.

B. QUALITY OF SERVICE

These requirements are necessary to insure the quality of service to other customers and protect Central Hudson's and other customers' equipment.

1. Connection to the Central Hudson System

Synchronous generators, in general, must have automatic synchronizing facilities installed to prevent out-of-phase closing into the Central Hudson System. This is required for all synchronous generators greater than 400 kVA. For smaller machines, this requirement may be waived if it can be shown by calculation, and verified at the time of functional testing, that the voltage effect on the Central Hudson System is no worse than what is acceptable during motor starting, based on the "Central Hudson Voltage Flicker Limits, Border Line of Visibility Curve," shown in the attached Figure 8.

Induction generators can be connected as a motor and motored up to synchronous speed if the initial voltage drop is acceptable based on Figure 8. Figure 8 also applies to induction generators connected at or near synchronous speed since a voltage dip is present due to inrush magnetizing current. The inrush current is similar in magnitude to starting locked-rotor inrush current, but of shorter duration. The customer should supply calculations to verify that the voltage dip due to the starting is within "Central Hudson Voltage Flicker Limits".

Line-commutated inverters do not require synchronizing equipment. Self-commutated inverters, however, do require synchronizing equipment unless it can be shown by calculation, and verified at the time of functional

testing, that the effect on the Central Hudson System is no worse than during motor starting.

2. Disconnection from the Central Hudson System

Generator disconnection from the Central Hudson System should be done so that the voltage flicker and power surges on the Central Hudson System are minimized.

On Central Hudson's circuits with automatic reclosing (which most have), the customer's generator must disconnect immediately after the tripping of the circuit; definitely before the reclosing operation. Since the minimum dead time, before reclosing, on the Central Hudson System is 1.5 seconds, **the generator must definitely be disconnected in less than 1.5 seconds to avoid out-of-phase reclosing.** Out-of-phase reclosing can damage the customer's equipment as well as Central Hudson's and other customers' equipment.

In addition, depending on the size of the generator and the magnitude of the load that it may become isolated with, it may be necessary to install dead-line sensing, direct transfer trip, both, and/or other schemes defined by Central Hudson. Dead-line sensing blocks reclosing if voltage is sensed on the generator side of the Central Hudson disconnection. With a direct transfer trip scheme, the generator breaker is sent a signal to trip when the Central Hudson substation breaker or line recloser opens. If the generator could sustain operation after system disconnection for longer than 1.5 seconds, or the load which could become isolated with the generator is of such a magnitude that the generator could possibly operate isolated, then dead-line sensing may be required on the auto-reclosing device. If the

probability of this situation occurring is very high, it may be necessary to also require direct transfer trip.

If the load which could become isolated with the generator is much smaller than the generator capacity, it may be necessary to require direct transfer trip to avoid the possibility of the generator producing damaging overvoltages during these conditions.

In such cases, the customer will be required to pay for the expense of engineering, installing, operating, and maintaining such equipment.

3. Induction Generators

The VAR requirements of induction generators are externally supplied. These VAR requirements cause reactive power flow, which can adversely affect the Central Hudson System. Due to the adverse effects of reactive power flow, and to voltage drop/flicker considerations, induction generators will generally be limited to a maximum of 400 kVA.

If additional capacitors are required on the Central Hudson System to limit the adverse effects of reactive power flow, the capacitors shall be installed at the customer's expense.

The installation of capacitors for reactive power supply at or near an induction generator may cause the induction machine to become self excited, when isolated from the Central Hudson System. As load approaches generation levels on circuits with induction generators, the probability of accidental self-excitation increases. Under/over frequency and under/over voltage protection schemes, when designed and set properly, can automatically disconnect the customer if this condition occurs.

4. Synchronous Generators

Synchronous generators are generally required to operate at unity power factor. Synchronous generators must include actively controlled power and power factor schemes if not equipped with a loss of synchronization protection function.

5. Harmonic Limits

The maximum harmonic limits for electrical equipment shall be in accordance with the most current version of IEEE 519. The objective of IEEE 519 is to limit the maximum individual frequency voltage harmonic to 3% of the fundamental frequency and the voltage Total Harmonic Distortion (THD) to 5% on the utility side of the PCC. In addition, any voltage fluctuation resulting from the connection of the Customer's energy producing equipment to the utility system must not exceed the limits defined by the maximum permissible voltage fluctuations border line of visibility curve, Figure 10.3 identified in IEEE 519-1992. This requirement is necessary to minimize the adverse voltage effect upon other customers on the utility system.

6. Limitation of DC Injection

The customer's generator source and its interconnection system shall not inject dc current greater than 0.5% of the full rated output current at the point of connection of the generator.

C. TESTING

1. Testing of Interconnection Protective Devices and Functions

Setting and testing of the interconnection protective devices must be performed before the final functional testing of the installation. The setting and testing is most often performed at the installation site. Qualified individuals must perform this setting and testing. The name, address and telephone number of the firm which performs this work must be submitted, by the customer, to CHG&E prior to the time when a decision is to be made regarding acceptance of the installation.

Periodic testing of the interconnection protective devices must be performed at least once every four (4) years unless more frequent test periods are required by Area, Regional and/or North American reliability criteria. The results of the periodic testing should be recorded and reported to CHG&E. The failure to report may result in the removal of the customer's generation from the CHG&E electrical delivery system until the requirement is satisfied.

2. Preliminary Testing

Prior to the functional test, the customer should perform as a minimum, the following testing (if applicable) at their site:

1. Shop test of all interconnection protective devices or functions
2. Setting of all interconnection protective devices or functions
3. Ratio test of all instrument transformers
4. Polarity check of all instrument transformers
5. Saturation check of all current transformers (CTs)
6. Wire check of all AC circuits

7. Megger test instrument transformers to verify insulation and secondary circuit integrity.
8. Point-to-point wire check all DC control circuits associated with the interconnection protective devices and functions

In addition, the customer should pre-test as much of the functional test procedure as possible prior to CHG&E witnessing the final functional test. At the conclusion of the final functional test, immediately following the energization of the interconnection, AC voltages, currents and phase angles should be measured in all interconnection protective devices to verify proper connections.

3. Functional Testing

A functional test procedure is designed to serve two purposes. First, it develops specific tests to ensure the proper connection and operation of the interconnection protection devices and functions. Second, it ensures that future periodic testing can be conducted in a similar manner that allows future periodic test results to be compared to initial test results to analyze protective system performance over time. The customer is responsible for the development of the functional test procedure. Following development, the test should be forwarded to CHG&E for review and acceptance. The functional test procedure must, at a minimum, verify that:

1. All end devices, such as circuit breakers, contactors and switches, operate for all trip initiating conditions.
2. All interconnection protective relays and devices respond correctly, per their settings, to input conditions.
3. The interconnection protective system will be able to detect and isolate the customer's source of generation for an open conductor

condition on the CHG&E electrical system. (This condition can be simulated by CHG&E opening one cutout on the electrical system supplying the customer's generator facility.)

4. The customer's source of generation will disconnect for a complete loss of AC power.
5. The ground source will isolate from the CHG&E electrical system when the customer's source of generation is off line.

Figure 7 has been provided as an example of a sample functional test procedure.

4. Future Testing (Non-Periodic Testing)

If modifications are made to the interconnection protective scheme following the successful completion of the functional test, the customer must resubmit to CHG&E, for acceptance, a new functional test procedure. Following acceptance of the revised functional test, the portion of the test addressing the field modifications must be conducted.

If any interconnection protective devices fail or are discovered to be defective during routine maintenance, the customer must notify CHG&E immediately. At this time, an appropriate course of action will be determined. CHG&E reserves the right to inspect the customer's interconnection protective equipment. If the equipment is found to be in a state of disrepair, an appropriate action, up to and including the disconnection of the customer's generating facility from the CHG&E electrical system will be taken.

D. INFORMATION REQUIREMENTS

The following information is required to allow CHG&E to adequately review and assess compliance of the customer's interconnection protective scheme design with CHG&E's interconnection standards. This information must be submitted by the customer for CHG&E review and acceptance:

1. One Line Diagram & Table 1.
2. Detailed Specifications of the Interconnection Protective Equipment
3. Three Line Diagrams (AC Relay and Metering Schematics)
4. Control Diagrams (DC Control Schematics and PLC Logic Diagrams and Cross Reference Tables)
5. Interconnection Equipment Data Sheets
6. Written Functional Test Procedure

1. One Line Diagram & Table 1.

The One Line Diagram and the completed Table 1 describe the interconnection protective system design from the customer's generator to the CHG&E electrical system (typically the Point of Common Coupling (PCC)). The One Line Diagram should include, as a minimum:

1. A lockable, visible break, load break disconnect switch (if applicable).
2. Transformer(s) size(s), voltages and connections.
3. Circuit breaker(s), contactor(s) and switch(es) ratings and types.
4. Proposed Protective Function Devices identified by ANSI/IEEE Standard C37.2 device numbers (refer to table 2).
5. All interconnection protection function trip paths.

6. Instrument Transformers (Voltage and Current) voltages, connections, ratios and number.
7. Generation Source – Type, connections, capacity and power factor
8. Grounding Resistor(s) and/or Reactor(s) – Size, type, ratings
9. AC/DC Filtering Devices – Size, type, ratings
10. All Permissive and/or control devices in the trip paths of the interconnection automatic isolation (circuit breakers, contactors, switches) devices.

In addition, the customer must supply a brief description of the intended operation and operational modes of the generation source. Figures 2 and 3 are included as sample One Line Diagrams with associated Table 1's correctly populated. These One Line Diagrams are provided strictly as examples and do not address the necessary protection for the customer's equipment.

2. Detailed Specifications of the Interconnection Protective Equipment

The customer must submit detailed specifications of the equipment associated with the interconnection protective system. Such information should include:

1. Equipment instruction and installation manuals
2. Device settings and calculations

In selecting protective devices, the customer should keep in mind that the following requirements should be met:

1. All interconnection protective functions should rely upon non-volatile memory design and include re-settable or retrievable target information.

2. Devices incorporating the interconnection protective functions should include AC and DC test switches to facilitate functional and periodic testing.
3. All interconnection protective devices should be designed and tested to appropriate industry standards such as:
 - Insulation Test Voltage (IEC 255-5)
 - Impulse Voltage Withstand (IEC 255-5)
 - Surge Withstand Voltage (ANSI C37.90.1)
 - Fast Transient Voltage Withstand (ANSI C37.90.1)
 - EMI Volts/Meter Withstand (ANSI C37.90.2)
 - Electrostatic Discharge (IEC 255-22-2)

3. Three Line Diagrams

The customer must submit all Three Line Diagrams (Relay and Metering Schematics) of the equipment associated with the interconnection protective system. Three Line Diagrams should depict all connections (including device terminal numbers), ratings and sizes of the customer's:

1. Generator source(s).
2. Instrument Transformers (including polarity connections).
3. Transformer(s).
4. Interconnection system automatic disconnect equipment (circuit breakers, contactors and switches).
5. Generator(s) AC control circuitry.
6. Interconnection Protective Devices

The customer is reminded that all information depicted on the Three Line Diagrams must be consistent with the design as depicted on the One

Line Diagram. Figure 4 has been included as a sample Three Line Diagram for a small, simple installation.

4. Control Diagrams

The customer must submit all Control Diagrams (DC Control Schematics) of the equipment associated with the interconnection protective system. Control Diagrams depict all logic used to control the interconnection protective devices. If Programmable Logic Controllers are used for these functions, a copy of the ladder logic and reference table(s) must be included. Figure 5 has been included as a sample Control Diagram for a small, simple installation.

5. Interconnection Equipment Data Sheets

The customer must submit all technical data associated with the interconnection protective system. This generally includes information regarding generators, transformers, grounding devices and filtering devices and is normally supplied to CHG&E at the time the customer submits their application. Table 3 is included as a sample fact sheet, which includes an information request for several of these devices.

6. Functional Test Procedure

The customer must submit a functional test procedure as described in Section II.C.3. for review and acceptance by CHG&E. Figure 7 is included as a sample Functional Test Procedure.

E. METERING

The need for additional revenue metering or modifications to existing metering associated with the customer's generator(s) and load will be consistent with revenue metering requirements adopted by the New York State Department of Public Service (PSC).

Table 1

Identification of "FAIL SAFE"
Interconnection Protection Scheme

Central Hudson System Disturbances

Abnormal Conditions	<u>Primary Protection</u>		<u>Back-up Protection</u>	
	Sensing Device	Interrupting Device	Sensing Device	Interrupting Device

Phase to ground
Fault

Phase to phase
Fault

Three phase
Fault

Open conductor

Isolation With Part of Central Hudson System

Isolation Conditions	<u>Primary Protection</u>		<u>Back-up Protection</u>	
	Sensing Device	Interrupting Device	Sensing Device	Interrupting Device

Generation
less than load

Generation
greater than load

Table 2

ANSI/IEEE C37.2 Standard Device Numbers

2	Time Delay Starting or Closing Relay
25	Synchronizing or Synchronism-check Device
27	Undervoltage Relay
32	Directional Power Relay
46	Reverse-phase, or Phase-balance, Current Relay
47	Phase Sequence Voltage Relay
50	Instantaneous Overcurrent, or Rate-of-rise, Relay
51	AC Time Overcurrent Relay (Phase)
51N	AC Time Overcurrent Relay (Neutral)
51V	Voltage Supervised or controlled, Time Overcurrent Relay
52	AC Circuit Breaker
55	Power Factor Relay
59	Overvoltage Relay (Phase)
59N	Overvoltage Relay (Zero Sequence)
62	Time Delay Stopping or Opening Relay
81	Frequency Relay
86	Locking-out Relay
87	Differential Protective Relay
89	Line Switch
94	Tripping or Trip-free Relay

Table 3.

Sample Interconnection Equipment Data Sheets

Customer:

Name: _____ Phone: (____) _____

Address: _____ Municipality: _____

Consulting Engineer or Contractor:

Name: _____ Phone: (____) _____

Address: _____

Estimated In-Service Date: _____

Existing Electric Service:

Capacity: _____ Amperes Voltage: _____ Volts
Service Character: ()Single Phase ()Three Phase
Secondary 3 Phase Transformer Connection ()Wye ()Delta
Transformer Impedance _____ %Z

New Electric Service (If Applicable):

Capacity: _____ Amperes Voltage: _____ Volts
Service Character: ()Single Phase ()Three Phase
Secondary 3 Phase Transformer Connection ()Wye ()Delta
Transformer Impedance _____ %Z

Location of Protective Interface Equipment on Property:

(include address if different from customer address)

Energy Producing Equipment/Inverter Information:

Manufacturer: _____
Model No. _____ Version No. _____
()Synchronous ()Induction ()Inverter ()Other _____
Rating: _____ kW Rating: _____ kVA
Rated Output: _____ VA Rated Voltage: _____ Volts
Rate Frequency: _____ Hertz Rated Speed: _____ RPM
Efficiency: _____% Power Factor: _____%
Rated Current: _____ Amps Locked Rotor Current: _____ Amps
Synchronous Speed: _____ RPM Winding Connection:
Min. Operating Freq./Time:
Generator Connection: ()Delta ()Wye ()Wye Grounded
System Type Tested (Total System): ()Yes ()No; attach product literature
Equipment Type Tested (i.e. Inverter, Protection System):
()Yes ()No; attach product literature
One Line Diagram attached: ()Yes
Installation Test Plan attached: ()Yes

For Synchronous Machines:

Submit copies of the Saturation Curve and the Vee Curve

() Salient () Non-Salient

Torque: _____ lb-ft Rated RPM: _____

Field Amperes: _____ at rated generator voltage and current
and _____ % PF over-excited

Type of Exciter: _____

Output Power of Exciter: _____

Type of Voltage Regulator: _____

Direct-axis Synchronous Reactance (X_d) _____ ohms

Direct-axis Transient Reactance (X'_d) _____ ohms

Direct-axis Sub-transient Reactance (X''_d) _____ ohms

Quadrature-axis Synchronous Reactance (X_q) _____ ohms

Quadrature-axis Transient Reactance (X'_q) _____ ohms

Quadrature-axis Sub-transient Reactance (X''_q) _____ ohms

Zero Sequence Reactance (X_0) _____ ohms

Negative Sequence Reactance (X_2) _____ ohms

Field Winding Open Circuit Transient Time Constant (T') _____ seconds

Field Winding Short Circuit Transient Time Constant (T'') _____ seconds

Field Winding Short Circuit Subtransient Time Constant (T''') _____ seconds

Armature Winding Transient Time Constant (with field winding shorted) (T') _____ seconds

Damper (Amoritisseur) Winding? () Yes () No

Neutral Grounded () No () Yes _____ ohms (resistive) _____ ohms (reactive)

For Induction Machines:

Rotor Resistance (R_r) _____ ohms Exciting Current _____ Amps

Rotor Reactance (X_r) _____ ohms Reactive Power Required:

Magnetizing Reactance (X_m) _____ ohms _____ VARs (No Load)

Stator Resistance (R_s) _____ ohms _____ VARs (Full Load)

Stator Reactance (X_s) _____ ohms

Short Circuit Reactance (X''_d) _____ ohms Phases:

Frame Size: _____ Design Letter: _____ () Single

Temp. Rise: _____ °C. () Three-Phase

Neutral Grounded () No () Yes _____ ohms (resistive) _____ ohms (reactive)

For Inverters:

Manufacturer: _____ Model:

Type: _____ () Forced Commutated () Line Commutated

Rated Output: _____ Amps _____ Volts

Efficiency: _____ %

Signature:

CUSTOMER SIGNATURE

TITLE

DATE