

**Technical Requirements
for
Distributed Generation Connection**

Distributed Generation Connection Requirements

SECTION 1: INTRODUCTION

1.1 General Purpose

This document defines the requirements for connecting distributed generation to CHELCO's distribution system. The requirements established in this document are intended to assure that facilities connected to the distribution grid do not have an adverse effect on reliability of service to other members and to assure that public safety as well as the safety of persons working on the distribution system is maintained.

It is recognized that while this document does provide guidance to the technical issues that must be considered it should not be considered as an all-encompassing document as specific projects must be reviewed on an individual basis. This document should not be considered as a design specification manual and, therefore, all final designs are subject to the approval of CHELCO.

Further, this document only covers the technical requirements of connecting facilities to the system. There is no attempt to address legal matters or liability issues. Such issues would normally be addressed in an agreement between parties.

1.2 Application of this Document

The requirements set forth in this guide apply to parties, herein called the Project Sponsor, desiring to connect generation to CHELCO's distribution system.

SECTION 2: INTERCONNECTION STUDIES AND SPONSOR RESPONSIBILITIES

2.1 General

Distributed generation that meets all requirements listed in this document will be subject to engineering studies prior to installation. Engineering studies often must be performed to determine specific requirements. A number of factors determine if a study is required, including the size and design of the generation being installed, the planned method of operation, location of the planned site on the distribution system, and loading on the distribution system.

Isolated Generation

No studies will be required for distributed generation isolated from the distribution system.

Paralleled Generation

No studies will be required for distributed generation with a capacity of 10 kW or less.

A Facility Study will be required for all generation with a capacity greater than 10 kW. If the System facility Study shows that upgrades/modifications to the distribution system are needed, a Facilities Study deposit will be required.

A fee schedule has been established to cover the cost of the studies. The fee varies based on the type of study. The Project Sponsor is responsible for the cost of all studies.

2.2 Project Sponsor Requirements:

It is the responsibility of the Project Sponsor to obtain all necessary data related to his generator and associated equipment as identified on the application and study forms. Studies cannot commence until the Project Sponsor provides complete technical data.

SECTION 3 GENERAL CONNECTION REQUIREMENTS

3.1 General

The facilities must meet all applicable safety and code standards as required by Federal, State and local agencies. Additionally, the connecting facility must comply with IEEE 1547, as well as all applicable standards from North American Electric Reliability Corporation (NERC) and other governing agencies.

All cost associated with the required equipment shall be borne by the Project Sponsor. Specific requirements are identified in the required studies.

3.2 Point of Common Coupling

The Point of Common Coupling (PCC) is defined as the location where the distributed generation equipment and CHELCO's distribution system are electrically interconnected. The requirements defined in the document must be met at the PCC. It is at this point that all performance standards must be met.

3.3 Access and Documentation Requirements

The Project Sponsor agrees to maintain and provide any documentation that is required for reporting to governing agencies. The Project Sponsor agrees to provide access to facilities to the extent required for CHELCO to comply with such agencies.

3.3 Grounding:

The site of the PCC shall have a ground grid for the purpose of solidly grounding all metallic structures. This grid shall limit potential gradients that will ensure the safety of personnel and equipment during faulted conditions in and adjacent to the PCC.

3.4 Equipment Ratings and Requirements

Equipment installed at the PCC shall be suitable for the intended purpose and rated accordingly. Consideration shall be given to load flow, load interruption, and fault interruption.

3.5 Protection of Facilities (General)

Intertie protective relaying will be required for generation that is operated in parallel to the distribution system. The protection requirements vary with the type, size, and mode of operation of the distributed generation. Specific requirements are addressed in greater detail elsewhere in this document.

The objective of the protective relaying system is to provide protection to equipment through the isolation of parts of the system that are damaged or subjected to abnormal conditions. While protective relaying systems cannot assure public safety, properly working protective systems do provide some measure of safety and therefore it is essential that protective systems are coordinated and functioning properly.

Relaying required to protect the generator(s) is the sole responsibility of the Project Sponsor. Existing protective relaying may provide some inherent protection of generation equipment. However, it should not be relied upon to do so.

The protective relaying schemes and the settings placed on those relays must coordinate with relaying on the distribution system. The application of protective relays and the settings placed on protective relays

must allow disturbances to be cleared in a timely manner. Considering these factors, the selection of the protective relays and the settings applied to those devices are subject to the approval of CHELCO. Likewise, CHELCO will work with the Project Sponsor to coordinate protective relaying to allow the isolation of individual generator units rather than isolating the entire facility when it is appropriate to do so. Temporary distribution conditions may require the Project Sponsor to make temporary changes to settings applied to protective relays to assure coordination and to provide adequate protection. The Project Sponsor shall make these changes as necessary to assure system reliability.

3.6 Quality of Service (General)

The installation of the distributed generation shall not cause the degradation of the quality of service provided to other consumers. Specific limits and requirements are identified in a separate section in this document. The Project Sponsor agrees to meet those requirements at the time of installation and to make modifications as necessary in the future to maintain those requirements.

Failure to meet and/or maintain these requirements may result in the facility being disconnected from CHELCO's distribution system.

3.7 Future Changes

The Project Sponsor shall notify CHELCO of planned changes to the facility that may affect the distribution system. Changes to the loading as well as changes to load characteristics may have an impact on the distribution system. Significant changes may require additional engineering studies to be performed.

Changes to the distribution system may require modifications to the Project Sponsor's facilities due to fault availability, stability, or other issues. The Project Sponsor shall make necessary modifications to facilities and/or the manner in which the facility may operate. Such modifications shall be made at the Project Sponsor's expense.

Failure of the Project Sponsor to make required changes may result in the facility being disconnected from CHELCO's distribution system.

SECTION 4: SPECIFIC CONNECTION REQUIREMENTS

4.1 General

Three types of generation are discussed in this section:

- Isolated
- Momentarily Paralleled
- Paralleled (Non Exporting & Exporting)

Specific issues relevant to each of these are addressed in this section.

4.2 Isolated Generation

Isolated generation is considered to be standby generation that is not operated in parallel to the distribution grid. As such, the generation is only utilized when the distribution system is disconnected from the facility. A "break before make" transfer switch shall be installed on the load side of the meter. The transfer device must provide a means for visual inspection by distribution workers of the disconnect-transfer contacts without the use of tools to remove covers, etc.

4.3 Momentarily Paralleled Generation

Generation that is classified as being momentarily paralleled supplies power while being connected to the distribution system for no more than 100 milliseconds. Unless specific conditions warrant the necessity, no special protection schemes will be required. However, the Project Sponsor is required to meet all power quality requirements defined in this guide. Furthermore, the Project Sponsor is responsible for all synchronization to the distribution system and for assuring that quality of service to other consumers is not adversely affected during the transition.

As with isolated generation, a transfer switch installed on the load side of the meter maybe required. The transfer device must provide a means for visual inspection by distribution workers of the disconnect-transfer contacts without the use of tools to remove covers, etc.

4.4 Paralleled Generation

Generation that is operated in parallel to CHELCO's distribution system is defined as generation that is supplying power while being connected to the distribution system for more than 100 milliseconds. Generation of this type may be exporting or non-exporting. By definition, exporting is generation that provides the load requirements of the Project Sponsor and has excess power to flow onto the distribution grid. Non-exporting is defined as generation that can provide only the load of the Project Sponsor and does not result in power flowing onto the distribution system. Whether or not the facility is capable of exporting power greatly affects the specific requirements for connecting to the grid.

Topics related to the required protection are discussed in the following sections.

Isolation Switch

The installation of a switch shall be installed at the point of common coupling (PCC) for the purposes of isolation maybe required.

- This switch shall be capable of being locked in the closed and open positions.
- Switch position must be capable of being verified upon visual inspection without the use of tools to remove covers, etc.
- On three-phase systems, this switch shall normally be a gang-operated device.
- In the event that the Project Sponsor owns the device, CHELCO shall be granted access for the purposes of locking open the device for the personal protection of employees.

Synchronization, Inadvertent Energizing, and Utility Reclosing

The distributed generation shall under no circumstance energize the PCC after it has been de-energized for any reason. Therefore, protective relaying and/or control schemes must be installed that will detect and prevent the Project Sponsor from closing onto a de-energized (dead) distribution line.

Synchronization of the generator to the distribution grid is the responsibility of the Project Sponsor. Synchronization is required to be automatic or manually supervised by a sync-check relay.

The following table shows the synchronization parameter limits for synchronous interconnection to the distribution grid as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Generator KVA	Frequency Difference (Hz)	Voltage Difference	Phase Angle Diff
0-500	0.3	10%	20°
>500-1500	0.2	5%	15°
>1500-10,000	0.1	3%	10°

It is CHELCO’s practice to use automatic reclosing on distribution circuits. Therefore, it is imperative that the Project Sponsor remove all generation should the distribution line serving the facility become de-energized. CHELCO cannot and does not guarantee that connected equipment will not be damaged during reclosing actions. Therefore, it is recommended that an interlocking scheme be in place to prevent the inadvertent energizing of the distributed generation facilities.

Intertie Protection Requirements

When generation is operated in parallel to the distribution system, intertie protective relaying will be required. The entire cost of the intertie protection shall be borne by the Project Sponsor. The intertie protection shall normally consist of the following:

- Anti-Islanding Protection
- Fault Current Protection (when required)
- Reverse Power (when non exporting)

Power Quality Requirements related to protection shall be met at the PCC. The intertie protection will be set to meet those requirements unless the Project Sponsor can demonstrate that protective settings on individual generators allow the requirements to be met at the PCC. In those instances, the intertie protection may be set to coordinate as backup, allowing generation to be isolated without opening the intertie breaker.

Anti Islanding

Distributed generation is not permitted to “island” the distribution grid. This occurs when the distributed generation continues to energize part of the distribution grid even though power from CHELCO is not present. An example of islanding is when a utility breaker that normally feeds radial loads is opened and the generator attempts to support those radial loads.

When the distributed generation is small compared to the load on the isolated section, the frequency and voltage will decay and the condition can be detected with voltage and frequency relays. Note: the aggregate load of all distributed generation must be considered.

If the distributed generation capacity or aggregated capacity is about equal to the load on the isolated section, then other relaying schemes (possibly including transfer trip schemes) may be required. Note: such schemes usually require communication equipment.

Fault Current

Additional fault protection, beyond the anti-islanding requirements, is required when the distributed generation is capable of supplying a significant amount of fault current to the utility grid – referred to as

the “stiffness” of the generation. While each case must be reviewed, the general rule of thumb for determining the need for this inertia protection is as follows:

- When the stiffness ratio is less than 10, the DG facility must have current-based phase protection and current or voltage-based ground protection.

$$\text{Stiffness Ratio} = (\text{SC KVA (distribution grid)} + \text{SC KVA (DG)}) / \text{SC KVA (DG)}$$

Note: In addition to fault current sensing relays, protective schemes may be required to protect the distribution system from adverse effects of neutral shifts caused by a ground on an ungrounded transformer.

Reverse Power

Reverse power protection may be required at the inertia to prevent inadvertent power flow onto the distribution system.

SECTION 5: SCADA, METERING, AND COMMUNICATIONS

5.1 SCADA

Remote monitoring through SCADA is not normally required. However, monitoring may be required in certain instances. These instances are generally limited to locations where the DG aggregated capacity is 250kVA or more, or where the DG penetration ratio is significant.

All costs associated with SCADA monitoring of the distributed generation facilities shall be borne by the Project Sponsor.

5.2 Communication

Special communication systems are not required unless a SCADA system is installed or protective relaying schemes require communication between devices. The required communication equipment will depend upon location and existing infrastructure.

All costs associated with communications equipment required for the distributed generation facilities shall be borne by the Project Sponsor.

5.3 Metering

Bi-directional metering may be required if the power flow is two-way. The revenue metering shall be owned by CHELCO and shall meet the current specifications of CHELCO.

All costs associated with metering of the distributed generation facilities shall be borne by the Project Sponsor.

SECTION 6: POWER QUALITY AND DISTURBANCE CLEARING

6.1 General

The connection of a distributed generation facility shall not have an adverse effect on the distribution system or degrade the quality of service to existing member. To assure that an adverse effect on service is not experienced, the following parameters are established related to performance. It is understood that these limits are taken at the point of common coupling (PCC). Note: In instances where a dedicated substation is provided to serve the end user, it may be appropriate for these limits to be applied to the high voltage side of the substation transformer.

6.2 Voltage and Flicker

Normal voltage excursions (steady state) shall be limited to $\pm 5\%$ at the PCC.

Voltage variations due to motor starting or other sudden load changes shall be limited based on the frequency of occurrence and shall conform to limits in IEEE 519-1992. Fluctuations that occur at a frequency of less than eight (8) per hour shall conform to the Irritation Curve (IEEE 519-1992 Maximum Permissible Voltage Fluctuation) but in no case shall fluctuations exceed 3%. Fluctuations that occur at a frequency greater than eight (8) per hour shall conform to the Visibility Curve (IEEE 519-1992 Maximum Permissible Voltage Fluctuation).

Voltages at the PCC shall be reasonably balanced and shall not exceed 1.5% unbalance. Voltage unbalance is defined by the maximum deviation from the average of the voltages.

The following table shows the required response to abnormal voltage conditions as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Voltage Range % of Base Voltage	Max Clearing Time (seconds)
$V < 50$	0.16
$50 \leq V < 88$	2.00
$110 < V < 120$	1.00
$V \geq 120$	0.16

Note: For Distributed Generation > 30 KW, the clearing time and set points shall be field adjustable. The default setting is given.

6.3 Harmonic Limits

The following table shows the acceptable harmonic limits as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

Maximum Harmonic Current Distortion in Percent of Current*

Individual Harmonic Order h (odd harmonics)	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	Total demand distortion (TDD)
Percent %	4.0	2.0	1.5	0.6	0.3	5.0

Note: Even harmonics are limited to 25% of the odd harmonics shown above.

* Current is defined as the greater of the maximum load current without the distributed generation, or the rated current capacity of the distributed generation.

6.4 Frequency Disturbances

The following table shows the parameters within which the distributed generation shall cease to energize the utility grid as stated in IEEE 1547 when this document was written. Should IEEE 1547 be changed, the latest version of IEEE 1547 is applicable.

DR Size	Frequency Range (Hz)	Clearing time
≤ 30 kW	> 60.5	0.16 seconds
	< 59.3	0.16 seconds
> 30 kW	> 60.5	0.16 seconds
	Adjustable set point between $\{59.8-57.0\}$	Adjustable from 0.16 seconds to 300 sec.
	< 57.0	0.16 seconds

Note: For Distributed Generation > 30 KW, the clearing time and set points shall be field adjustable. The default setting is given.

SECTION 7: COMMISSIONING AND MAINTENANCE

7.1 General

Prior to placing the distributed generation on the distribution grid, the facility must be properly commissioned to assure that all systems are functioning correctly. In addition, periodic maintenance must be performed to assure that the systems remain functioning properly.

7.2 Initial Testing and Inspection

The Project Sponsor may not connect the generation to the distribution grid until all testing has been completed and CHELCO provides authorization to do so. The following commissioning testing must be completed prior to energizing:

- Verification of functionality of protective relaying schemes.
- SCADA and metering verification.
- Synchronization scheme verification (and inadvertent energizing protection).
- Verification of interlocks used in protective schemes.

Qualified persons must perform all tests. CHELCO reserves the right to witness or oversee any of the acceptance testing that may affect the reliability or performance of the distribution grid.

7.3 Maintenance

Regular maintenance shall be performed on the distributed generation facilities in manners consistent with industry practices.

CHELCO reserves the right to oversee the maintenance that is performed on equipment that may have an adverse effect on system reliability or performance. CHELCO shall be notified when planned maintenance is scheduled. The Project Sponsor shall make available to CHELCO maintenance records as needed to demonstrate compliance.

CHELCO has the right to require the Project Sponsor to perform such actions as necessary to resolve power quality complaints that could be attributed to the facility.

