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Thanks to these team members:

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Preferred Service Arrangement Customer’s Termination Facility ≤ 500 Feet From PG&E Splice Box

Figure A3-2 Underground Primary Service from Underground Distribution  
Non-Preferred Service Arrangement Customer’s Termination Facility > 500 Feet From PG&E Splice Box

Figure A3-3 Underground Primary Service from Overhead Distribution  
Preferred Service Arrangement Customer’s Termination Facility ≤ 500 Feet From PG&E Pole

Figure A3-4 Underground Primary Service from Overhead Distribution  
Non-Preferred Service Arrangement Customer’s Termination Facility > 500 Feet From PG&E Pole

Figure A3-5 Overhead Primary Service from Overhead Distribution Preferred Service Arrangement

Figure A3-6 Advanced Electric Systems GC-1000 (grid intertie inverter)  
No batteries, no transfer or bypass switching

May 1, 2003
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Expanded E-NET Typical Electrical Single-Line Drawing

Rule 21 Example of Single-Line Drawing

Document 053826  Requirements for Distribution Feeder with Synchronous Generating Equipment

Document 058779  Pole-Top Primary Metering Installation, Cluster Mounted (12 or 21 kV Line)

Document 060559  Disconnect Switches for Interconnection with Small Power Producers and Cogenerators

Document 066195  25 kV Underarm Sidebreak Switch

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List of Eligible Inverters

Siemens Safety Switch Cross-Reference Guide Type VBII

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**Section 1**

**General Information**

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**Notice: Document Subject to Change**

The information and requirements in this manual are subject to change over time. The online version of the *Distribution Interconnection Handbook*, located at http://www/TechLib/, will be updated as quickly as possible when changes occur. The bound manual will not be reprinted until the next scheduled print date regardless of changes in the process or requirements.

### 1.1. Purpose

The purpose of this manual is to provide information on how to interconnect generating facilities or distributed generation (DG) to Pacific Gas and Electric Company’s (PG&E’s) electrical distribution lines. This information is presented by PG&E in an effort to maintain safe, uniform, and reliable service to generating facilities and customers.

This manual is based on the applicable Federal Energy Regulatory Commission (FERC) and California Public Utilities Commission (CPUC) rules and tariffs (e.g., Electric Rules 2, 21, and 22), as well as accepted industry practices and standards contained within the Applicable Reliability Criteria.

There are four types of interconnection. They are included in the following two categories:

- **Retail**
  - Standard E-NET
  - Expanded E-NET
  - Rule 21

- **Wholesale**
  - Wholesale Distribution Tariff (WDT)
    (The Wholesale category will not be discussed in this handbook.)

### 1.2. Retail (Under CPUC Jurisdiction)

Retail interconnection occurs when there is no export of power sales to the California Independent System Operator (CAISO)-controlled system grid.

There are three types of interconnection in the retail category:

- Standard E-NET

To apply for Standard E-NET interconnection, all of the following conditions must apply for:

---

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– Generating systems that are 10 kilowatts (kW) or less.
– Residential and small commercial customers.
– Photovoltaic (PV) systems or wind systems or a hybrid of both.
– For incidental export of power to PG&E’s distribution lines.
  (For more detailed information, please see Section 2, “Standard E-NET Interconnection,” of this handbook).

• Expanded E-NET
  To apply for Expanded E-NET interconnection, all of the following conditions must apply for:
  – Generating systems that are greater than 10 kW and up to 1 megawatt (MW).
  – Residential, medium, and large commercial (peak demand of at least 20 kW) and all agricultural customer-generators.
  – PV or wind systems or a hybrid of both.
  – Incidental export of power to PG&E’s distribution lines.
    (For more detailed information, please see Section 3, “Expanded E-NET Interconnection,” of this handbook).

• Rule 21
  To apply for Rule 21 interconnection, all of the following conditions must apply for:
  – Any types of generating systems but the sizes can be limited based on the capabilities of distribution circuits.
  – All types of customers.
  – Parallel generation for a customer’s site use.
  – No export of power to PG&E distribution lines.
    (For more detailed information, please see Section 4, “Rule 21 Generating Facility Interconnection,” of this handbook).

1.3. Time Frames and Fees

Table 1-1 outlines the interconnection process. Please see Section 2 to Section 4 of this Distribution Interconnection Handbook for detailed information on each interconnection category.
Table 1-1 Interconnection Process

<table>
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<td>Standard E-NET (Section 2)</td>
<td>PV/wind or a hybrid of both &lt;br&gt; No cost to the customer for initial review if PG&amp;E determines that the proposed project qualifies as a simplified interconnection</td>
<td>No cost to the customer if PG&amp;E determines that a supplemental review is required.</td>
<td>No cost to the customer if PG&amp;E determines that an additional detailed study is required.</td>
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<tr>
<td>Expanded E-NET (Section 3)</td>
<td>PV/wind or a hybrid of both &lt;br&gt; 10 business days &lt;br&gt; No fees collected</td>
<td>10 business days &lt;br&gt; No fees collected</td>
<td>The local division Planning department determines the need for a detailed study. &lt;br&gt; No fees are collected if PG&amp;E determines that a detailed study is needed.</td>
</tr>
<tr>
<td>Rule 21 (Section 4)</td>
<td>Any type of generation &lt;br&gt; 10 Business Days &lt;br&gt; $800 fee collected</td>
<td>10 business days &lt;br&gt; $600 fee collected</td>
<td>The local division Planning department determines the need for a detailed study. &lt;br&gt; Fees are collected if PG&amp;E determines that a detailed study is needed.</td>
</tr>
</tbody>
</table>

1.4. Single Point of Contact

PG&E’s interconnection Services group is the single point of contact for processing all DG interconnection to PG&E’s distribution lines. Following are the contact information:

- Frank Salguero (8) 223–2284
- Art McAuley (8) 223–6924
Section 2
Standard E-NET Interconnection

2.1. Introduction

Standard E-NET is an energy net metering service for customers who have installed a solar (photo voltaic or PV) or wind turbine generator or a hybrid of both, with a capacity of 10 kW or less, and have interconnected the facility to the Pacific Gas and Electric Company’s (PG&E) electric distribution grid system.

Customers who meet the above criteria qualify for Standard E-NET, if they are:

- Residential, or
- Commercial customers with a peak demand of 20 kW or less.

The Standard E-NET program allows customers to install their own generating facilities or distributed generation (DG), which is interconnected to and operates in parallel with PG&E’s electric grid.

2.2. Purpose

The primary purpose of this generation interconnection service is to allow customers to offset part or all of their electric loads. These customers may continue to purchase power from PG&E’s electric grid, as well as deliver incidental power to the grid. This is conforming with CPUC Code 2727.

An E-NET customer’s electric meter may run forward (to account for purchases from the grid) and backward (to account for deliveries to the grid).

2.3. Standard E-NET Eligibility

Standard E-NET customers can access information about the program on PG&E’s website: http://www/TechLib/.

PG&E’s website currently has E-NET forms and links to the relevant rules. These rules apply to those residential or small commercial customers with peak demand loads of less than 20 kW, who want to install facilities with a capacity of 10 kW or less.

This standard E-NET service is only applicable to customers who install PV or wind generating systems to offset part or all of their electrical requirements. The customer must be a residential or a small commercial customer, with less than 20-kW-maximum-billing demand for at least 9 of the most recent 12 months.

For more information, please refer to the tariff and:

2. Section 2827 of the California Public Utilities Code at:

Note: Customers wishing to export power to the grid are not allowed to participate in the E-NET program and will be assigned the appropriate rate schedule.

2.4. Application and Agreements

2.4.1. Application Form and Fees

The customer needs to submit a Standard E-NET application. Standard E-NET applications may be obtained in the following ways:

- Call PG&E’s Generation Hotline at (415) 972-5676 and leave a voicemail message.
- Send an email to Gen@pge.com.
- Copy from this handbook (Attachment 12).

Return the completed application to:

Pacific Gas and Electric Company
Attn: Generation Interconnection Services Section (GIS)
P.O. Box 770000
Mail Code B13J
San Francisco, CA 94177

Or, email the application to Gen@pge.com.

2.4.2. E-NET Forms and Application Process

The applicant must provide the following documents:

2.4.2.1. Completed Application Form

Please see Attachment 12 for the details and instructions for filling out the application form “Application for Interconnecting Residential or Small Commercial Net Energy Metering (E-NET) Customers with Solar or Wind Electric Generating Facilities of 10 Kilowatts or Less,” (Form 79-994).

Applicants must submit an application form complete with all required information before PG&E will process the application.

2.4.2.2. Single-Line Diagram and Project Details

A single-line diagram must accompany the application. This drawing must meet National Electric Code (NEC) or
have a drawing with a Professional Engineering Stamp or C10 license.

For an example of a single-line diagram please refer to Figure 2-1 on Page 2-7.

In the interest of assisting PG&E in its goal to deliver safe, uniform service, the following guidelines are recommended for transmitting electronic drawing files for architectural, mechanical, and civil site plans:

- The PG&E electronic drawing tool is AutoCAD R14, .DWG format. All submitted electronic drawings must be completely readable and compatible with AutoCAD release 12 or above.
- Drawings should be sent on 3.5-inch diskettes, CDs, or as attached email files.
- The “Pack & Go” feature of AutoCAD should be used, if available.
- Drawings for large projects should be sent in a zipped format.
- The use of layering is encouraged and should be preserved when transferring files to PG&E.
- All drawings should be saved in model space instead of paper space.
- Drawing plans should be two dimensional, with the “Z” elevation at zero.
- Any External Reference Files (Xref) or drawing updates should maintain a consistent insertion point.
- All related drawing files should be included.

If you have any questions, please contact your local PG&E representative.

2.4.2.3. Signed Agreement

The applicant must provide a signed copy of the “Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1000 KW or Less, Other than Residential or Small Commercial Facilities of 10 KW or Less” (Form 79-978, in Attachment 12).

Please review the agreement checklist, which provides instructions for completing the agreement.
2.4.2.4. **Proof of Insurance Coverage**

The customer must provide a copy of the declaration page of all risk property insurance and comprehensive personal liability insurance that is currently in effect.

2.4.2.5. **Approved Building Permit**

Before performing a preparallel inspection, PG&E requires proof that the installation has passed a building inspection by local authorities.

2.4.2.6. **Electric Vehicles**

The E-9 rate is mandatory for applicants with electric vehicles. A completed E-9 Checklist “All Customers Selecting The Schedule E-9 Rate Must Complete the Following Qualifying Checklist,” must be included with the application. The E-9 Checklist is located in Attachment 12 of this manual.

2.4.2.7. **Timeline**

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</tbody>
</table>

The turnaround time for PG&E to approve the application is 10 days.

PG&E uses an automated system, the E-NET Online System (ENOS), to track the timeline of the application.

2.5. **Requirements**

2.5.1. **Protective Devices**

For Standard E-NET, PG&E requires inverters that are certified by Underwriters Laboratories’ Standard UL 1741 and listed on the California Energy Commissioner’s (CEC) eligible list.
For more information, please refer to the following link:

When interconnecting facilities to the PG&E distribution system, it is important to minimize the potential hazard to life and property. A basic safety rule requires automatic detection and isolation of an abnormal condition within a reasonable time. Please refer to the CPUC Electric Rule 2 Description of Service at:

Moreover, the interconnection of a new facility to the PG&E distribution system must not degrade any of the existing PG&E protection and control schemes nor lower the existing levels of safety and reliability to other customers.

Also, as a general rule, neither PG&E nor the customer should depend on the other for the protection of their respective equipment.

**Note:** As specified in CPUC Rule 21, PG&E’s minimum protection requirements are designed and intended to protect the PG&E power system only.

The customer is responsible for the costs of PG&E’s installation of any protective equipment necessary to ensure safe and reliable operation of both PG&E’s and the customer’s facilities. The need for protective equipment will vary, depending on the facility’s location within a PG&E circuit.

### 2.5.2. Manual Disconnect Switch

A manual disconnect switch is required for all generation facilities larger than 1 kW. The customer must provide a disconnect device to electrically isolate the PG&E system from the customer’s generating facilities. This disconnect device may be located on either side of the main switch.

**Note:** PG&E’s safety specifications require that the switch be visible and in close proximity (10 feet or less) to the main utility meter panel.

In accordance with PG&E’s safety rules and practices, the device must be used to establish a visually open, working clearance boundary when performing maintenance and repair work.

The disconnect device also must be accessible and lockable in the open position. In addition, the manufacturer and model number of the disconnect device must be among those approved for use by PG&E, as listed in Engineering Document 060559, “Disconnect Switches For Interconnection With Small Power Producers And Cogenerators.” A copy of this document is located in Attachment 3 of this manual.
The disconnect switch must be a blade-type switch (“knife switch”). In keeping with the technical requirements of Rule 21, PG&E does not accept or approve the pull-out switches commonly used in air-conditioning units and spas.

Additionally, the customer is solely responsible for the maintenance of all fuses in fused, blade-type disconnect switches.

2.5.3. **Single-Line Drawing or Schematics**

The applicant must provide a single-line drawing of the actual installation, showing all of the following items:

- System devices, connections, and ratings.
- Location of the disconnect switch.
- The manufacturer’s name, the model number, and the ampere rating of the disconnect switch.

Please refer to Figure 2-1 on Page 2-7.
2.5.4. **Subdivision**

Subdivision developers offering solar generating systems must apply for interconnection for the subdivision as a whole, rather than submit individual, single-home applications.

To avoid delay, the developer must submit an application form for the subdivision and a master drawing at least six months before the requested interconnection.
2.5.5. Metering Requirements

Standard E-NET installations are designed to operate in parallel with the PG&E system.

The disconnect requirements are specified by PG&E and are listed in Engineering Document 060559, “Disconnect Switches For Interconnection With Small Power Producers And Cogenerators,” (Attachment 3).

As specified in Rule 21, the generating facility is required to have an accessible disconnect switch that is lockable in the open position. The disconnect switch must be located 10 feet or less from the main utility meter panel and must be observable from the panel.

Generating facilities under the Standard E-NET program may deliver minimum power only with rated inverter that is approved on this application.

In accordance with the CPUC-approved tariff, generators that meet the following conditions may use a meter without a detent to net the usage (net kilowatt hours \([\text{kWh}] = \text{kWh usage} – \text{kWh generation}):

- The generating system has an inverter rating of 10 kW or less.
- The system connects to PG&E’s secondary-service voltage.
- The system meets PG&E’s E-NET rate schedule.

Only electromechanical or solid-state programmable revenue meters are used for Standard E-NET.

A bidirectional meter measures and records the inadvertent generation of excess power from an E-NET customer.

In the event that the installation of a dual meter-socket adapter is necessary, customers are required to have adequate meter working space. A meter working space is defined as an area in front of the meter or the meter enclosure. The purpose of the meter working space is to provide safe access to the metering equipment.

The meter working space must be:

- Clear and level.
- At least 36 inches by 30 inches in area.
- Kept clear of debris and unobstructed at all times.
- Located so that the centerline of the meter is at least 10 inches from any adjacent sidewall or other protruding obstruction.
- Located so there is no intrusion by landscaping, structures, or stored material.
Installed meters must also meet the height requirements specified in Table 2-2 on Page 2-9.

Table 2-2 Installed Meter Height Requirements

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<td>Individual, field-installed meter panels (i.e., not part of an assembly, such as a switchboard).</td>
<td>A minimum of 48 inches to a maximum of 66 inches as measured from the centerline of the meter to the standing surface.</td>
</tr>
<tr>
<td>Free-standing, manufactured, meter-panel enclosures, multimeter panels, or assemblies where a minimum of a 36-inch to a maximum of a 75-inch socket is placed in a factory-assembled structure (e.g. meter pedestal).</td>
<td>Please refer to the Electric and Gas Service Requirements manual (Greenbook)</td>
</tr>
<tr>
<td>Agricultural and other pole-mounted services.</td>
<td>The height from the ground to the top of the meter-socket enclosure must be 72 inches. However, the meter height may be reduced to 48 inches if the service-entrance conduit attached to the pole is made of galvanized, rigid steel, or PVC Schedule 40, and is at least 2 inches in diameter.</td>
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2.5.6. Telemetering Requirements

Communication circuits between PG&E and customer generation facilities may be required for protection, Supervisory Control and Data Acquisition (SCADA), revenue metering and voice communications. When external communication circuits are installed, the responsible party should make sure that the high voltage protection (HVR) on these circuits meets all applicable standards.

If the meter is read via a telephone line, the customer is responsible for installing the line and establishing service. If a land line is unavailable and cellular signals are acceptable, then a cellular phone may be used.

If the meter’s telephone line cannot be dedicated to the meter, the customer, with approval from PG&E’s local metering group, may arrange to use a line sharing switch.

The telephone-line termination in switchboards, panels, pole-mounted meters, and pedestals must be located as follows:

- Within 5 circuit-feet of the centerline of the meter.
- Between a minimum of 18 inches and a maximum of 72 inches above the finished grade.

When cellular phones are used, the same location requirements apply to the power supply when measured from the load side of the meter and located outside PG&E’s sealable section.
2.5.7. Operation Requirements

For PG&E’s operating requirements, the customer must ensure that the PG&E-approved disconnect is accessible at all time to PG&E employees.

For some PG&E work procedures, such as scheduled maintenance and outages, PG&E employees may require that this disconnect be opened and locked for the employees’ safety.

2.5.8. Other Technical Requirements

- If the generating facility exceed the operating capabilities of distribution lines, PG&E’s Planning department may use requirements in Rule 21 to evaluate an application before providing an approval to operate a generating system (please see: http://www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf Section J):

- Approval is based on the following criteria:
  – 15% Rule – The applicant’s generating system combined with existing generation does not exceed 15% of the maximum loading of the line section.
  – Overloading – PG&E’s equipment and line rating are not overloaded by the applicant’s generating system.
  – Voltage operating levels – the applicant’s generating system does not create a voltage drop or rise that goes above or below the allowable operating-voltage bandwidth specified in Rule 2.

- System Upgrades – Upon review by engineering employees, PG&E may require a system upgrade to allow the system to accommodate the interconnection of the generating facility.

Please refer to CPUC Code 2827 for the delineation of cost responsibilities of the system upgrade versus the installation of the interconnection facilities.

2.5.8.1. Preparallel Inspection

Before giving a final approval for interconnection, PG&E requires a preparallel inspection.

A PG&E field crew will schedule a date with the customer or the customer’s representative to perform the preparallel inspection. The customer must complete the “Preparallel Inspection Checklist” in Attachment 12.
3.1. Introduction

Expanded E-NET is an energy net metering service for customers who install a photovoltaic (PV) or wind turbine generator or a hybrid of both, with a capacity above 10 kW and up to 1,000 kW, provided the facility is interconnected to the Pacific Gas and Electric Company’s (PG&E) electric distribution grid system.

Customers who meet the following criteria will qualify for Expanded E-NET interconnection:

- Residential.
- Commercial customers who have a peak demand equal to, or greater than, 20 kW.
- Any agricultural customer.

The Expanded E-NET program allows customers to install their own generators, which are interconnected to and operate in parallel with PG&E’s electric grid.

3.2. Purpose

The primary purpose of Expanded E-NET interconnection is for customers to offset part or all of their electric loads. These customers may continue to purchase power from PG&E’s electric grid, as well as deliver incidental power to the grid.

An Expanded E-NET customer’s electric meter may run forward (to account for purchases from the grid) and backward (to account for deliveries to the grid).

3.3. Expanded E-NET Eligibility

The passage of California State Assembly Bill 29X on April 11, 2001, has expanded the eligible customer classes for service under Standard E-NET. Bill 29X has been extended indefinitely. For details, please see the information on the following website:


Section 2827 of the California Public Utilities Code provides the rules, requirements and schedules to eligible customer-generators. For more information, please see website:

3.4. Application and Agreements

3.4.1. Application Form/Fees

To apply for Expanded E-NET interconnection, the customer must submit an E-NET application.

Expanded E-NET applications can be obtained in several ways:

- Call PG&E’s Generation Hotline at (415) 972-5676 and leave a voicemail message.
- Send an email to Gen@pge.com.
- Copy from this handbook (Attachment 12).

Return the completed application to:

Pacific Gas and Electric Company
Attn: Generation Interconnection Services Section (GIS)
P.O. Box 770000
Mail Code B13J
San Francisco, CA 94177

Or, email the completed application to Gen@pge.com.

3.4.2. Expanded E-NET Forms and Process

The applicant must provide the following documents:

3.4.2.1. Completed Application Form

Please see Attachment 12 for instructions on filling out the application form, “Generating Facility Interconnection Application” (Form 79-974).

In addition to submitting the fully completed application form, the applicant must provide a copy of a current PG&E bill before PG&E can process the application.

3.4.2.2. Single-Line Diagram and Project Details

A single-line diagram must accompany the application. This drawing must meet National Electric Code (NEC) or have a drawing with a Professional Engineering Stamp or C10 license.

In the interest of assisting PG&E in its goal to deliver safe, uniform service, use the following guidelines for transmitting electronic drawing files for architectural, mechanical, and civil site plans:

- The PG&E electronic drawing tool is AutoCAD R14, .DWG format. All submitted electronic drawings must be completely readable and compatible with AutoCAD release 12 or above.
• Drawings should be sent on 3.5-inch diskettes, CDs, or attached email files.
• The “Pack & Go” feature of AutoCAD should be used, if available.
• Drawings for large projects should be sent in a zipped format.
• The use of layering is encouraged and should be preserved when transferring files to PG&E.
• All drawings should be saved in model space instead of paper space.
• Drawing plans should be two dimensional, with the “Z” elevation at zero.
• Any External Reference Files (Xref) or drawing updates should maintain a consistent insertion point.
• All related drawing files should be included.

If you have any questions, please contact your local PG&E representative.

3.4.2.3. Signed Agreement

The applicant must provide a signed copy of the “Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1000 KW or Less, Other than Residential or Small Commercial Facilities of 10 KW or Less” (Form 79-978, in Attachment 12).

Please review the agreement checklist, which provides instructions for completing the agreement.

3.4.2.4. Proof of Insurance Coverage

Please refer to the Interconnection Agreement Form 79-978, which can be found in Attachment 12.

3.4.2.5. Approved Building Permit

Before performing a parallel inspection, PG&E requires proof that the installation has passed a building inspection by local authorities.

Note: The system must not be operated until the customer has received a written approval from PG&E.

3.4.2.6. Electric Vehicles

The E-9 rate is mandatory for applicants with electric vehicles. A completed E-9 Checklist “All Customers
3.4.2.7. Preparallel Inspection

To ensure that the system has been installed in accordance with the originally submitted specifications, PG&E must perform a final inspection of the system before operation begins.

After a satisfactory inspection, the customer will receive a written approval from PG&E to operate the system in parallel with PG&E’s grid.

3.4.2.8. Timeline

There are no review or study fees for Expanded E-NET interconnection.

Table 3-1 Review and Approval Process Time Frames

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 days</td>
<td>Application Completeness</td>
</tr>
<tr>
<td></td>
<td>PG&amp;E must verify that the following items with sufficient detail are received before conducting the initial review:</td>
</tr>
<tr>
<td></td>
<td>- The project name and location.</td>
</tr>
<tr>
<td></td>
<td>- A single-line drawing.</td>
</tr>
<tr>
<td></td>
<td>- The generating facilities type, size, and data.</td>
</tr>
<tr>
<td></td>
<td>- A list of protective devices.</td>
</tr>
<tr>
<td></td>
<td>- The type and mode of a disconnect switch.</td>
</tr>
<tr>
<td></td>
<td>- Please indicate on the application or drawing any installed California Energy Commission (CEC)-certified equipment.</td>
</tr>
<tr>
<td>10 days</td>
<td>Initial Review</td>
</tr>
<tr>
<td></td>
<td>Engineering review using the “Initial Review Process.”</td>
</tr>
<tr>
<td></td>
<td>Please see “Sample of the Initial Review Process,” in Attachment 5.</td>
</tr>
<tr>
<td>10 additional days, total of 20 days from receipt of completed application</td>
<td>Supplemental Review Process</td>
</tr>
<tr>
<td></td>
<td>After the supplemental review, if PG&amp;E determines that the application is not qualified for simplified interconnection, PG&amp;E will determine a time schedule and the cost for an interconnection study.</td>
</tr>
<tr>
<td>To be determined, as required based on supplemental review.</td>
<td>Interconnection Study</td>
</tr>
<tr>
<td></td>
<td>PG&amp;E will determine the timeline and the cost for an interconnection study on a case-by-case basis.</td>
</tr>
</tbody>
</table>
3.4.2.9. Application Completeness

Before proceeding with technical evaluation, PG&E has 10 days, from the day of the receipt of the application, to evaluate if the applicant has provided complete information.

A completed application must have the following items:

- The project’s name and location.
- A single-line drawing of the project.
- The generator type, size, and data.
- A list of protective devices and test reports for new relays.
- The type and mode of the disconnect switch.

(For more information about completing an application, please see Section C.1.b. at: http://www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf.)

3.4.2.10. Initial Review

If PG&E deems the application is complete, PG&E has 10 business days to perform the initial review.

At any time that PG&E deems the application is incomplete, the 10-day clock for the initial review phase stops. However, as soon as the applicant provides the missing information and PG&E deems the application is complete, a new 10-day clock starts.

If PG&E determines that the application qualifies for a simplified interconnection, PG&E will provide a written description of the requirements, as well as the agreements described in Section 4.3. (“Rule 21 Agreement”).

3.4.2.11. Supplemental Review

During the initial review, if PG&E determines that the application does not qualify for a simplified interconnection, PG&E will perform a supplemental review.

PG&E will provide one of the following items after the supplemental review:

- The interconnection requirements beyond those for simplified interconnection.
- An interconnection-study schedule.
If a supplemental review is required, PG&E must complete the supplemental review within 20 business days of the receipt of a completed application.

For more details, please see Section 4, “Rule 21 Generating Facility Interconnection.”

3.4.2.12. Interconnection Study

If an interconnection study is needed, PG&E will determine the timetable on a case-by-case basis.

3.5. Requirements

The requirements for Expanded E-NET are based on Rule 21.

This section describes the specific requirements that may be applicable, on a case-by-case basis, to any retail generators that do not meet one or more of the simplified interconnection criteria set by the California Energy Commission (CEC) Rule 21, here referred to as CPUC’s “Rule 21-Generating Facility Interconnections.”

For the complete text of Rule 21 please see:

3.5.1. Interconnection Requirements

When interconnecting facilities to the PG&E distribution system, it is important to minimize the potential hazard to life and property. A basic safety rule requires the automatic detection and isolation of abnormal system troubles within a reasonable time.

Important system problems are fault conditions, such as a short circuit.

3.5.2. Protection and Control Requirements

Interconnection of a new facility to the PG&E distribution system must not degrade any of the existing PG&E protection and control schemes nor lower the existing levels of safety and reliability to other customers.

Also, as a general rule, neither PG&E nor the customer should depend on the other for the protection of their respective equipment. PG&E’s protection requirements are designed and intended to protect the PG&E electric system only.¹

In view of these objectives, PG&E requires that the protective equipment be able to automatically detect and rapidly isolate faulty equipment. Therefore, the application and implementation of the interconnection protection must limit interruptions only to the faulty equipment or section, so that a minimum number of customers are affected by any outage.

¹ Please refer to CPUC Rule 21 for additional information.
The customer may need to install high-speed\textsuperscript{2} protective equipment to rapidly isolate trouble and to minimize equipment damage and the potential impact to system stability.

PG&E system protection group reviewing the customer’s protection system will determine, on a case-by-case basis, if the customer’s generator needs high-speed fault clearing.\textsuperscript{3}

Additional interconnection protection requirements are discussed in Section 3.9., “Machine-Based Generation,” on Page 3-11. PG&E performs system studies to determine, on a case-by-case basis, if the system configurations or types of generating facilities need additional protection requirements.

The specific requirements for interconnection depend on the following factors:

- The generating facilities size and type.
- The number of generating facilities.
- Feeder characteristics (i.e., voltage, impedance, and ampacity).
- The ability of the existing protective equipment at the local PG&E distribution system to function adequately with the proposed interconnection facility (i.e., identical generator projects connected at different locations in the PG&E system can have widely varying protection requirements and associated costs. These differences are caused by different feeder configurations, fault duties, and the existing protection schemes.)

The customer must install, at a minimum, a disconnecting device or switch with load- and/or fault-interrupting capability, as needed, at the point of interconnection.

Typically, the customer needs additional protective relays to adequately protect the generator’s facility. Customers are responsible for protecting their own systems and equipment from faults or interruptions originating on either PG&E’s side or customer’s side of the interconnection.

The system-protection facilities are at the customer’s expense, and must be installed, operated, and maintained in accordance with all the applicable regulatory requirements and in accordance with the design and application requirements of this handbook.

The protective relays used in isolating the generator from the PG&E electric system at the point of interconnection must meet the following requirements:

\textsuperscript{2} The term “high-speed”, or “pilot” protection refers to any type of communication-assisted protection, for example, conventional current-differential protection or direct-transfer trip application.

\textsuperscript{3} Please refer to Attachment 6 for the requirements for pilot protection, including the associated transfer trip equipment, communication circuit monitoring, and the commissioning test.
• The devices must be approved by PG&E.

• The devices must be set to coordinate with the protective relays at PG&E’s line circuit breaker terminals for the line to which the generator is connected.

Based on the proposed station configuration or the type of interrupting device closest to the point of common coupling to PG&E’s facilities, PG&E may impose additional requirements (i.e., the exact type and style of the protective devices) on the customer.

**Note:** PG&E will coordinate with the generator or its representatives on the installation of any additional protective equipment that may be required. The generator is responsible for the costs of the additional protective equipment.

To ensure that the customer’s facility is adequately protected, PG&E recommends that the customer acquire the services of a qualified electrical engineer to review the electrical design of the proposed generation facility.

### 3.6. Manual Disconnect Switch

#### 3.6.1. General

The customer must provide and install a manual disconnect switch, which PG&E will operate, to isolate PG&E’s distribution system from the customer’s generating facility.

To establish a visually open working clearance in accordance with PG&E’s safety rules and practices, the manual disconnect must be opened during all maintenance and repair work. For interconnections of 2.4 kV and above, the disconnect switch must be located at the point of interconnection with PG&E. The disconnect switch must be gang-operated, three-pole and lockable.

If the disconnect switch will be located on PG&E’s side of the interconnection point, PG&E must install it at the customer’s expense.

If the disconnect switch will be located on the customer’s side, it must be furnished and installed by the customer. If the disconnect device is in the customer’s substation, it must be located on the substation’s dead-end structure and have a PG&E-approved operating platform. The customer must use only PG&E-approved devices.

PG&E must inspect and approve the installation before parallel operation is allowed.

The disconnect switch must not be used to make or break parallels between the PG&E electric system and the customer’s generating
system. The device’s enclosure and operating handle (when present) must be kept locked at all times, using PG&E padlocks. The disconnect switch must be visible and easily accessible to PG&E employees. When installed on the customer’s side of the interconnection, the switch must be installed close to the metering. It must be identified with a PG&E-designated switch-number plate.

3.6.2. Specifications

The manual disconnect switch must meet the following requirements:

- Be rated for the voltage and current requirements of the particular installation.
- Be gang-operated.
- Be weatherproofed or designed to withstand exposure to weather.
- Be lockable in both the opened and closed positions with a standard PG&E lock, except for the low-voltage (0 to 600 V), fused disconnect switches with interlocks listed in the PG&E Engineering Document 060559, “Disconnect Switches for Interconnection with Small Power Producers and Cogenerators.” (See Attachment 3.)

The interlock feature allows the customer to open a locked, fused disconnect switch, but not to close it, so that the customer’s system can be isolated for maintenance without PG&E’s assistance. A fused disconnect switch with an interlock must be unlocked by PG&E before it can be closed.

3.6.3. Low-Voltage Disconnects (0 to 600 Volts)

Low-voltage disconnect switches are rated as “general duty” (240 V) and “heavy duty” (600 V).

PG&E-approved low-voltage disconnects are identified in Engineering Document 060559, “Disconnect Switches for Interconnection with Small Power Producers and Cogenerators.” (See Attachment 3.)

3.6.4. Medium-Voltage Disconnects (600 Volts to 25 kV)

PG&E’s requirements for medium-voltage disconnect switches rated up to 25 kV are specified in Engineering Document 066195, “25 kV Underarm Sidebreak Switch.” (See Attachment 3.)
3.7. Review and Study Requirements

For Expanded E-NET interconnection, the customer must provide PG&E with electrical drawings for review before procuring the equipment. The customer must provide the following drawings:

- Single-line meter and relay diagrams listing the major protective equipment.
- Schematic drawings, such as 3-line alternating current (ac), and tripping schemes (direct current [dc]) for all PG&E-required relays.

PG&E reviews all generating-facility applications for simplified interconnection, using Rule 21’s initial review process. Following the initial review, PG&E performs a supplemental review and, if required, an interconnection study.

3.8. Inverter-Based Generating System

In addition to having an Underwriters Laboratories Standard UL 1741 certification, an inverter-based generating facility must meet the “non-islanding” criteria specified in the CPUC’s “Rule 21- Generating Facility Interconnections,” which can be found at: http://www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf or in Attachment 11.

A PG&E-approved single inverter must meet the following criteria:

- Have an Underwriters Laboratories Standard UL 1741 certification.
- Be on the California Energy Commission (CEC)-eligible list. Please refer to the following website for the CEC-eligible list: http://www.consumerenergycenter.org/buydown/eligible_inverters.html.
  Or
- Have met all the criteria set by the CEC Rule 21, Section “J,” as tested by a nationally recognized testing laboratory (NRTL) acceptable to PG&E and the test reports must have been approved by PG&E.

PG&E requires additional testing for multiple units unless the generator has received an earlier approval.

Separate single-unit or multiple-unit inverters that do not meet Underwriters Laboratories Standard UL1741 or have not been adequately tested will not be granted commercial operation status and the customer is not permitted to interconnect to the system.

PG&E reserves the right to disconnect previously certified interconnected units when Underwriters Laboratories (UL) decertifies the units. PG&E may implement an acceptable mitigation procedure for recertification at the customer’s expense.
Therefore, it is critical that the interconnecting applicant understands all of PG&E’s technical requirements before the applicant does an engineering design or procures material.

At PG&E’s discretion, noncertified inverters may be interconnected if the applicant meets the additional requirements. The additional requirements may include, but are not limited to, those listed in Table 3-3, “Standard Device Numbers,” on Page 3-20.

3.9. Machine-Based Generation

In addition to customer-owned generator protection (such as voltage and frequency relays), the following equipment may be required for machine-based generating facilities:

- Phase and ground fault detection schemes to detect faults on the PG&E system (less likely to be required for induction units). See Notes 1 and 2 below.
- An anti-islanding scheme (less likely to be required for induction units).
- A reclose-blocking scheme (less likely to be required for induction units).
- A transfer-trip scheme (less likely to be required for induction units).

The power quality requirement (see Attachment 10, “Rule 2”) may also apply to machine-based generating facilities.

Notes

1. A “reverse-power” function is unacceptable as a substitute for fault detection. An “under-power” function may be a viable substitute for some fault-detection schemes. A utility-grade device with three, independent, current-measuring elements may be required for the generator.

2. An “under-power” function cannot be applied when “inadvertent export” is a possibility.

3.10. Testing and Maintenance Requirements

The customer must provide PG&E with test reports (Form G2-2, “Relay Test Report,” in Attachment 12) for the particular types of protective devices applied as outlined in Table 3-2, “Generator-Protection Devices,” on Page 3-15, before PG&E will allow the facility to parallel.
When the customer uses tele-protection (protection provided via telephone), the customer must ensure that the communication circuits are tested. The customer must also verify that the scheme’s operation is operating properly before a generating facility may be released for commercial operation. Testing for communication-assisted protection includes end-to-end satellite testing and verifying the communication between the interconnected terminals. Please see Attachment 6, “Telemetering and Transfer Trip,” for more information.

Generation customers should refer to Section 4.5., “Preparallel Inspection,” on Page 4-6, for information regarding preparallel inspections, and to Attachment 6 for information about communication-assisted line protection.

Every four years, after the initial testing, the customer must submit written test reports from a qualified testing firm to PG&E, documenting that the relays are operable and within calibration. PG&E does not test the customer’s equipment, but may witness testing performed by the qualified testing firm retained by the customer.

On-site power (typically 120 V) is required for the test equipment. Every eight years, following the preparallel inspection, the customer must test the protection scheme’s circuit breakers.

Since significant equipment damage and liability can result from failures of the customer’s protective equipment, the customer must ensure that all of the facility’s protective equipment is operating properly. Please see the “Generation Operating Agreement” (Attachment 12).

3.11. Reliability and Redundancy

The customer’s design must include a protection system with enough redundancy, so that the failure of any one component will still allow the generator’s facility to be isolated from the PG&E electric system during a fault condition.

Multifunction, three-phase protective relays must have a redundant back-up relay. The circuit breakers must be trip-tested by the customer at least once a year.

3.12. Relay Grades

Two categories of relays are commonly used for interconnection protection:

3.12.1. Industrial-Grade Relays

Industrial-grade relays may be used for projects not exceeding 1,000 kW.
3.12.2. **Utility-Grade Relays**

Utility-grade relays are more costly than industrial-grade relays. For more information on utility-grade relays, please refer to Section 4, “Rule 21 Generating Facility Interconnection.”

3.13. **System-Fault Detection And Protection**

The customer’s equipment must be able to independently detect phase and ground faults on the PG&E system, as specified by CPUC Rule 21 (i.e., “sequential fault detection,” where the equipment is unable to detect the fault until after the PG&E system has been isolated, is unacceptable.) All the required fault-detection relays must coordinate with PG&E devices, as necessary.

In addition, the customer must ensure that the generator breaker’s relays are set to have overlapping zones of protection, in case a circuit breaker within any given zone fails to clear. The line-protection schemes must be able to distinguish between generation, inrush, and fault current. Multiple terminal lines are more complex to protect than single lines.

At the customer’s expense, existing relay schemes may have to be reset, replaced, or augmented with additional relays to coordinate with the customer’s facility.

The customer must place the PG&E-required relays at a location where a fault on any phase of PG&E’s interconnected line(s) can be detected.

If PG&E requires transfer-trip protection, the customer must provide and pay for all the required communication circuits. A communication circuit may be any of the following items:

- A leased line from the telephone company.
- A dedicated cable.
- A microwave.
- A fiberoptic circuit that is designed to sufficiently monitor the critical communication channels and associated equipment.

PG&E determines the appropriate communication medium on a case-by-case basis.

The leased phone line or dedicated communication network must have high-voltage protection equipment on the entrance cable so that the transfer-trip equipment will operate properly during fault conditions. (Refer to Attachment 6 for a detailed description of the protection requirements and the associated transfer-trip equipment and communication-circuit monitoring.)

The PG&E distribution network system is designed to be highly reliable. Certain load centers and customers may have multiple and/or redundant supply sources. When there are multiple sources and paths, PG&E requires more complex protection schemes to properly detect and isolate the faults.
The addition of any new generation facility to the PG&E electric system must not degrade the existing protection and control schemes or lower the levels of safety and/or reliability for existing PG&E customers. For more information on “Rule 2 – Description of Service,” please refer to: http://www.pge.com/customer_services/business/tariffs/pdf/ER2.pdf or Attachment 10.

Many parts of the PG&E electric system have provisions for an alternate feed. However, due to protection problems, there are some locations where PG&E does not allow generation to be online while being fed from an alternate source.

Whenever possible, PG&E provides the owner of the generating facility with the option of not paying for upgrades. If the owner of the generating facility pays for the upgrades, the owner’s facility may stay online while being transferred to the alternate source. However, if the owner of the generating facility does not pay for the upgrades, PG&E has the option of shutting down the facility while it is being transferred to an alternate source.

3.14. Protection and Control for Generating Facilities

The customer is responsible for providing all of the necessary protection for its own generator. Any protection requirement stated here is intended solely for the protection of the utility and its customers. (Please refer to CPUC Rule 21.)

When there are multiple units of generation, the single-phase units must be arranged and connected so that each phase of the three-phase circuit has an equal amount of generation capacity.

All generating facilities must comply with the latest, applicable regulatory standards for:

- Waveform and power quality.
- Telephone interference.
- DC and harmonic injections, etc., as specified in CPUC Rule 21 (please see Attachment 11).

Please see Table 3-2, “Generator-Protection Devices,” for the generator-protection equipment required to generate safely and reliably in parallel with PG&E’s electric system. PG&E will determine any additional generator-protection requirements on a case-by-case basis.
### Table 3-2 Generator-Protection Devices

<table>
<thead>
<tr>
<th>Generator-Protection Device</th>
<th>Device Number&lt;sup&gt;1&lt;/sup&gt;</th>
<th>40 kW or Less</th>
<th>41 kW to 400 kW</th>
<th>401 kW and Larger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Overcurrent</td>
<td>50/51</td>
<td>X&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Overvoltage</td>
<td>59</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Undervoltage</td>
<td>27</td>
<td>X&lt;sup&gt;3&lt;/sup&gt;</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Overfrequency</td>
<td>81O</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>81U</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ground-Fault-Sensing Scheme (Utility Grade)</td>
<td>51N</td>
<td></td>
<td></td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overcurrent with Voltage Restraint (51V) or Overcurrent with Voltage Control (51C)</td>
<td>51V</td>
<td></td>
<td>X&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51C</td>
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<td>Reverse-Power Relay</td>
<td>32</td>
<td>X&lt;sup&gt;6&lt;/sup&gt;</td>
<td>X&lt;sup&gt;6&lt;/sup&gt;</td>
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<td>Direct-Transfer Trip</td>
<td>TT</td>
<td></td>
<td>X&lt;sup&gt;7&lt;/sup&gt;</td>
<td>X&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Notes**

1. Please refer to Table 3-3, “Standard Device Numbers,” on Page 3-20 for device numbers, definitions, and functions.

2. When fault-detection is required, per CPUC Rule 21, the phase overcurrent protection must be able to detect all line-end phase and phase-fault conditions.

   The generator must be equipped with a phase instantaneous-overcurrent relay that can detect a line fault under subtransient conditions.

   The generator does not have to be equipped with a phase instantaneous-overcurrent relay if the generator uses a 51V or 51C relay. PG&E determines if a 51V or a 51C relay is better suited for the specific project.

3. For generators rated at 40 kW or less, installing a contactor undervoltage release may meet the undervoltage protection requirement.

4. When fault detection is required, per CPUC Rule 21, a group of generators, each of which is rated at less than 400 kW but whose aggregate capacity is 400 kW or greater, must have an overcurrent relay with voltage restraint (or voltage control, if determined by PG&E) installed on each generator greater than 100 kW.

5. Depending on PG&E’s circuit configuration and loading, PG&E will determine if a generator must be equipped with a transfer trip on the distribution-level interconnections.

6. A transfer trip must be installed if PG&E determines that there is either one of the following conditions:
   - The customer’s system cannot detect PG&E end-of-line faults and trip the generators within an acceptable time frame.
The generator is capable of keeping a PG&E line energized when the PG&E source is disconnected. (Please see Attachment 6.)

The following sections describe the protective and control devices that must be installed on generators:

3.14.1. Phase Overcurrent

Please see Table 3-3, “Standard Device Numbers,” on Page 3-20 (Device 50/51) for the definition and function of phase-overcurrent relays.

3.14.2. Over/Undervoltage Relay

The over/undervoltage relay is used to trip the generator’s circuit breaker when the voltage is above or below PG&E’s normal operating level.

In the event that the generator carries load that is isolated from PG&E’s electric system, the over/undervoltage relay is used for the generator and backup protection.

For all distribution interconnections, the undervoltage relay is set at 88 % of the nominal voltage (106 V on the 120 V base).

The overvoltage relay is set at 110 % of the nominal voltage (132 V on the 120 V base).

3.14.3. Over/Underfrequency Relay

The over/underfrequency relay is used to trip the generator’s circuit breaker when the frequency is above or below PG&E’s normal operating level. It is used for the backup protection and generator or turbine protection.

To maintain generation online during system disturbances, the customer must coordinate the generator’s underfrequency relay settings with those of other utilities in the Western Electricity Coordinating Council (WECC). For more information about the WECC, please refer to http://www.wecc.biz/main.html.

For all distribution interconnections, the underfrequency relay is set at 58 Hz with a time delay of 30 seconds. The overfrequency relay is set at 61 Hz with a time delay of 15 cycles (0.25 second).

3.14.4. Ground-Fault-Sensing Scheme

The ground-fault-sensing scheme detects PG&E’s power-system ground faults and trips the generator breaker or the generator’s main circuit breaker, preventing the generator from continuously contributing to the ground fault.

The ground-fault-sensing scheme must be able to detect faults between the PG&E system’s side of the dedicated transformer and the end of PG&E’s distribution circuit.
The following types of transformer connections, provided with the appropriate relaying equipment, are commonly used to detect system ground faults:

- System-side – grounded wye; generator-side – delta
- System-side – grounded wye; generator-side – wye; tertiary – delta

When a transformer is delta-connected on the system side to the distribution system, PG&E recommends a separate grounding transformer, in addition to the appropriate relaying equipment.

When a transformer is connected grounded-wye on the system side to a 3-wire distribution system, the generator must be equipped with a single-phase potential transformer between the neutral and ground connection, in addition to the appropriate relaying equipment. Please see Figure 3-1, “Recommended Ground-Detection Schemes 12 kV Distribution Circuits,” and Figure 3-2, “Recommended Ground-Detection Schemes 21 kV Distribution Circuits,” on Pages 3-23 and 3-24 for the typical, distribution-level interconnection schemes.

Rule 21 specifies the limitation of a single generating facility. Customers who have multiple units must contact PG&E in advance.

3.14.5. Overcurrent Relay with Voltage Restraint or Voltage Control

An overcurrent relay with voltage restraint or voltage control is used to detect multiphase faults and initiate tripping the generator’s circuit breaker.

The customer must ensure that the required relays are located on each individual generator feeder. A group of generators that have an aggregate rating over 400 kW must be equipped with an overcurrent relay with voltage restraint or voltage control located on each generator rated at more than 100 kW. Generators rated at, or greater than, 400 kW must be equipped with an overcurrent relay with voltage restraint or voltage control.

If the generator’s step-up transformer is connected wye-delta or delta-wye, a delta-wye or wye-delta auxiliary potential transformer must be installed on the potential circuits to the overcurrent relay to allow for phase-shift correction, depending on the relay’s design and operating principal.

The customer must contact the applicable PG&E representative to find out the proper phase of the auxiliary transformers connection.

4 PG&E will determine the suitability of installing a relay with a voltage restraint (Device 51V) or a voltage control (Device 51C) on a case-by-cases basis, depending on the system characteristics for the specific interconnection project.
3.14.6. Fault-Interrupting Devices

PG&E must review and approve all customer-selected fault-interrupting devices.

There are two basic types of fault-interrupting devices for distribution interconnections:

- Circuit Breakers
- Fuses

PG&E will determine the type of fault-interrupting device that a customer requires based on the following factors:

- The size and type of the generation.
- The available fault duty.
- Local circuit configuration.
- The existing PG&E protection equipment.


A three-phase circuit breaker is the required fault-interruption device at the point of interconnection due to its simultaneous three-phase operation and its ability to coordinate with PG&E line-side devices. The three-phase circuit breaker is able to automatically separate the generator from PG&E’s electric system upon detection of a circuit fault.

The customer may install additional circuit breakers and protective relays, which are not required for interconnection, in the generation facilities.

The interconnection circuit breaker must have sufficient capacity to interrupt the maximum available fault current it may experience and must be equipped with accessories to perform the following functions:

- Trip the circuit breaker with an external trip signal supplied through a battery (shunt trip).
- Telemeter the circuit breaker status, if required by PG&E.
- Lock out the circuit breaker if it is operated by protective relays.

3.14.6.2. Fuses

Fuses are single-phase, direct-acting sacrificial links that melt to interrupt fault current and protect equipment.

The customer must replace blown fuses manually after each fault before the facility may be returned to service.
Only trained personnel may replace overhead primary fuses.

Fuses cannot be used as the primary protection for three-phase generation facilities because fuses:

- Are single-phase devices.
- Do not always melt during a fault.
- Do not always automatically separate the generation facility from PG&E.
- Cannot be operated by the protective relays.

However, PG&E allows customers to use fuses as high-side protection for the dedicated transformer at generation facilities rated at less than 1,000 kW if the fuses are connected to the distribution-level system, but only if the customer’s protection can be coordinated with the existing PG&E phase and ground protection.

If fuses are used, the customer should consider installing a negative-sequence relay and/or other devices to protect the facility against single-phase conditions. If fuses are used for high-side transformer protection, the generator must have a separate generator circuit breaker to isolate it from PG&E’s electric system during a fault or abnormal system conditions.

PG&E does not allow the customer to use large primary fuses which do not coordinate with the circuit breaker ground relays in PG&E substations, because this may cause all the customers on the circuit to lose power if there is a fault inside the generating facility.

3.15 Direct Telephone Service

The customer must obtain a direct service or a dedicated line from the local telephone company so that PG&E can provide operating instructions to the designated operator of the customer’s equipment.

The customer must place a telephone communication line for the transfer trip in service at least three weeks before the facility is energized (please see Attachment 6).
<table>
<thead>
<tr>
<th>Device Number</th>
<th>Definition and Function</th>
<th>Device Number</th>
<th>Definition and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>A speed-of-frequency matching device functions to match and hold the speed or the frequency of a machine or of a system equal to, or approximately equal to, that of another machine, source, or system.</td>
<td>50</td>
<td>An instantaneous overcurrent or rate-of-rise relay indicates a fault in the apparatus or circuit that is being protected, when there is an excessive value of current, or an excessive rate of current rise.</td>
</tr>
<tr>
<td>21</td>
<td>A distance relay functions when the circuit admittance, impedance, or reactance increases or decreases beyond predetermined limits.</td>
<td>51</td>
<td>An ac time overcurrent relay has either a definite or inverse-time characteristic that functions when the current in an ac circuit exceeds a predetermined value.</td>
</tr>
<tr>
<td>25</td>
<td>Synchronizing and synchronism-check devices permit two alternating current (ac) circuits to be paralleled when they are within the desired limits of frequency, phase angle, and voltage.</td>
<td>52</td>
<td>An ac circuit breaker is used to close or interrupt an ac power circuit under normal conditions or to interrupt a circuit under fault or emergency conditions.</td>
</tr>
<tr>
<td>27</td>
<td>An undervoltage relay functions on a given value of undervoltage.</td>
<td>59</td>
<td>An overvoltage relay functions on a given value of overvoltage.</td>
</tr>
<tr>
<td>32</td>
<td>A reverse-power relay functions on a reverse-power flow at a given set point.</td>
<td>60</td>
<td>A voltage-balance relay operates on a given difference in voltage between two circuits.</td>
</tr>
<tr>
<td>46</td>
<td>A reverse-phase or phase-balance current relay functions when the polyphase currents are of reverse-phase sequence, or when the polyphase currents are unbalanced or contain negative phase-sequence components exceeding a given amount.</td>
<td>61</td>
<td>A current-balance relay operates on a given difference in the current input or output of two circuits.</td>
</tr>
<tr>
<td>47</td>
<td>A phase-sequence voltage relay functions on a predetermined value of polyphase voltage in the desired phase sequence.</td>
<td>62</td>
<td>A time-delay stopping, or opening, relay delays a shutdown, stopping, or opening operation in an automatic sequence initiated by another device.</td>
</tr>
</tbody>
</table>
### Table 3-3 Standard Device Numbers, continued

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Definition and Function</th>
<th>Device Number</th>
<th>Definition and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>An ac directional-overcurrent relay functions on a desired value of ac overcurrent flowing in a predetermined direction.</td>
<td>87</td>
<td>A differential-protective relay functions on a percentage of the phase angle or other quantitative difference between two currents or by other electrical quantities.</td>
</tr>
<tr>
<td>79</td>
<td>An ac reclosing relay controls the automatic reclosing and locking out of a circuit interrupter.</td>
<td>90</td>
<td>A regulating device regulates a quantity, or quantities, such as voltage, current, power, speed, temperature, frequency, and load, at a certain value or between certain limits for machines, tie lines, or other apparatus.</td>
</tr>
</tbody>
</table>
| 81            | A frequency relay functions on a predetermined value of frequency either under or over the normal system frequency or the normal rate of frequency change. | 94            | A tripping or trip-free relay functions to:  
  - Trip a circuit breaker, contactor, or the equipment.  
  - Permit immediate tripping by other devices.  
  - Prevent the immediate reclosure of a circuit interrupter if it opens automatically, even when its closing circuit is kept closed. |

### Table 3-4 Industrial-Grade Relays for Generation Application

<table>
<thead>
<tr>
<th></th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arga</td>
</tr>
<tr>
<td><strong>Synchronizing Relays</strong> (25)</td>
<td></td>
</tr>
<tr>
<td><strong>Undervoltage Relay</strong> (27)</td>
<td>6-327</td>
</tr>
<tr>
<td><strong>Nondirectional Overcurrent Relay</strong> (50/51)</td>
<td></td>
</tr>
<tr>
<td><strong>Overvoltage Relay</strong> (59)</td>
<td>6-327</td>
</tr>
<tr>
<td><strong>Frequency Relay (Under/Over)</strong> (81U/O)</td>
<td>6-328</td>
</tr>
<tr>
<td><strong>Overcurrent Relay</strong> (51N,V,C)</td>
<td></td>
</tr>
</tbody>
</table>

1 For utility-grade relays, please see Table 6-3, "Utility-Grade Relays for Generation Application," on Page 6-9.
Notes

1. Customers may install industrial-grade relays only on projects that are greater than 10 kW or less than or equal to 1 MW and are interconnected to distribution circuits.

2. Relays used in a ground fault-detection scheme must be utility grade.

3. The above table contains information regarding products, manufacturers, and representatives. This table is not all-inclusive. The inclusion or omission of a product, manufacturer, or representative is not meant to be an indication of the quality or reliability of a product or service. No endorsements or warranties are implied.

Other types of relays may be acceptable, but PG&E must review and approve the certified test results performed by an independent party acceptable to PG&E before the facility may be installed and released for commercial operation.

Contact PG&E’s System Protection department for the test specifications for each relay.
3-Wire Systems, Service Transformer Connected Wye on 12 kV Side
Connect a 12 kV-240 V distribution transformer (or a 12 kV-120 V potential transformer [PT]) between the neutral and ground; load the secondary with a 13 Ω resistor, and an overvoltage relay.

For 12 kV-240 V:
- Turns ratio, \( N = \frac{12,000}{240} = 50 \)
- Maximum secondary voltage, \( V^3 = \sqrt[3]{\frac{12,000}{3}} = 138.5 \) V
- Short time ratings for resistor and transformer:
  - \( V_2 = 138.5^2 = 1,477 \) W (or VA)
  - \( R = 13 \) kV

3-Wire Systems, Service Transformer Connected Delta on 12 kV Side
Install 3 PTs or distribution transformers, 12 kV-240 V, 1.0 kVA or larger, on 12 kV side as shown below. Connect a 13 Ω resistor across the broken delta.

For 12 kV-240 V:
- Turns ratio, \( N = \frac{12,000}{120} = 100 \)
- Normal secondary voltage, \( V_n = \frac{12,000}{\sqrt{3}} = 69.3 \) V (100)
- Maximum voltage across delta, \( V_d = 3 \times 69.3 = 208 \) V (minimum relay voltage rating)
- Short time ratings for resistor and transformer:
  - Resistor \( W = \frac{V_2}{13} = 3,328^* \)
  - Transformer VA = \( 120 \times 208 = 1920 \) (each)^*

*1,000 W continuous rated resistor and 1.0 kVA transformer will be adequate.
3.16. Metering Requirements

E-NET installations are generally designed to operate in parallel with the PG&E system.

The disconnect requirements are specified by PG&E. Please see Engineering Document 060559, “Disconnect Switches For Interconnection With Small Power Producers And Cogenerators,” located in Attachment 3.
As specified in Rule 21, the customer is required to have an accessible disconnect switch that may be locked in the open position. The disconnect switch must be located 10 feet or less from the main utility meter panel and must be observable from the panel.

Generators operating under the Standard E-NET program may deliver power to PG&E only during certain periods.

In accordance with the CPUC-approved tariff, customers that meet the following conditions may use a meter without a detent to net the usage (net kWh = kWh usage – kWh generation):

- The facility is rated at or less than 1 MW.
- The facility connects to PG&E’s secondary-service voltage.
- The facility meets PG&E’s E-NET rate schedule.

Only electromechanical or solid-state programmable revenue meters are used for E-NET interconnection.

Customers who are participating in the Expanded E-NET program are responsible for ensuring that the metering panels satisfy the necessary revenue-metering requirements.

In the event that the installation of a dual meter-socket adapter is necessary, the customer is required to have adequate meter working space. The meter working space is defined as an area in front of the meter or the meter enclosure. The purpose of the meter working space is to provide safe access to the metering equipment.

The meter working space must be:

- Clear and level.
- At least 36 inches by 30 inches in area.
- Kept clear of debris and unobstructed at all times.
- Located so that the centerline of the meter is at least 10 inches from any adjacent sidewall or other protruding obstruction.
- Located so there is no intrusion by landscaping, structures, or stored material.

Installed meters must also satisfy the height requirements specified in Table 3-5 on Page 3-26.
### Table 3-5  Meter Height Requirements

<table>
<thead>
<tr>
<th>Installed Meters</th>
<th>Height Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual, field-installed meter panels (i.e. not part of an assembly, such as a switchboard).</td>
<td>A minimum of 48 inches to a maximum of 66 inches as measured from the centerline of the meter to the standing surface.</td>
</tr>
<tr>
<td>Free-standing, manufactured, meter-panel enclosures, multimeter panels, or assemblies where a minimum of a 36-inch to a maximum of a 75-inch socket is placed in a factory-assembled structure (e.g. meter pedestal).</td>
<td>Please refer to the Electric and Gas Service Requirements manual (Greenbook)</td>
</tr>
<tr>
<td>Agricultural and other pole-mounted services.</td>
<td>The height from the ground to the top of the meter-socket enclosure must be 72 inches. However, the meter height may be reduced to 48 inches if the service-entrance conduit attached to the pole is made of galvanized, rigid steel or PVC Schedule 40, and at least 2 inches in diameter.</td>
</tr>
</tbody>
</table>

Customers wishing to export power to the grid are not permitted to participate in the E-NET program and will be placed in another appropriate rate schedule.

The inadvertent generation of excess power from an E-NET customer is typically measured and recorded by a bidirectional meter.

### 3.17. Telemetering Requirements

If the meter is read via a telephone line, the customer is responsible for installing the line and establishing service. If a land line is unavailable and cellular signals are acceptable, a cellular phone may be used.

If the meter’s telephone line cannot be dedicated to the meter, the customer, with approval from PG&E’s local metering group, may arrange to use a line sharing switch.

The telephone-line termination in switchboards, panels, pole-mounted meters, and pedestals must be located as follows:

- Within 5 circuit-feet of the centerline of the meter.
- Between a minimum of 18 inches and a maximum of 72 inches above the finished grade.

When cellular phones are used, the same location requirements apply to the power supply when measured from the load side of the meter and located outside PG&E’s sealable section.
3.18. **Ground Potential Rise**

The customer is responsible for determining the ground potential rise (GPR) for a line to ground power fault. The GPR value determines what grade of high-voltage protection equipment is required for the telephone cable, as well as the minimum, required dielectric strength of the cable-insulating jacket.

To calculate the GPR, the customer needs to have the highest calculated fault current (provided by PG&E), X/R ratio, and the ground resistance (provided by the customer).

When the customer’s generation units increase in aggregate nameplate rating, the customer must recalculate the GPR. For specific information, consult the responsible telecommunications engineer.

3.19. **Communication**

PG&E may require that communication circuits be installed to provide protection, Supervisory Control & Data Acquisition (SCADA), and voice communications between PG&E and the customer’s generation facilities.

The customer is responsible for the monthly costs and the costs associated with the installation of EMS, SCADA and protection circuits. In addition, the customer is responsible for the costs incurred by PG&E personnel while involved in assisting the telephone company personnel in making repairs to the leased circuits.

When external communication circuits are installed, the responsible party must ensure that the high-voltage protection (HVP) on these circuits and related equipment meets all the applicable standards.

3.20. **Operation Requirements**

If the unit is equipped with a disconnect switch, that switch must be accessible to PG&E’s employees. When maintenance or other work procedures are scheduled, this disconnect switch may have to be opened and locked for the protection of PG&E employees.

3.20.1. **Normal Voltage Operating Range**

PG&E may have specific operating-voltage ranges for larger generating facilities (larger than 11 kVA), and may require adjustable operating-voltage settings for these larger systems.

In the absence of such requirements, the operating window must be set up in a way that minimizes nuisance tripping and ranges between 88% and 110% of the appropriate interconnection voltage.

To minimize the adverse voltage effects experienced by other customers on PG&E’s electric system, any voltage flicker at the point of common coupling (PCC) caused by the generating facility
must not exceed the limits defined by the “Maximum Borderline of Irritation Curve” shown in the Institute of Electrical Engineers (IEEE) 519.

3.20.2. Limits Specific to Single-Phase Generating Facilities

The maximum capacity for single-phase generating facilities connected to a shared, single-phase secondary must not exceed 20 kVA.

Customers must install a 240 V service for generating facilities with a center-tap neutral so that no more than 6 kVA of imbalance capacity exists between the two sides of the 240 V service.
Section 4
Rule 21 Generating Facility Interconnection

4.1. Introduction

Rule 21, “Generating Facility Interconnections,” describes the interconnection, operating, and metering requirements for retail customers who want to connect their generating facilities to PG&E’s distribution system, which is under the jurisdiction of the California Public Utilities Commission (CPUC).

PG&E allows interconnection of generating facilities with its distribution system if the customer meets all the requirements of Rule 21.

“Rule 21-Generating Facility Interconnections,” which can be found at: http://www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf or in Attachment 11, defines the interconnection process for customers who install generators, including solar, wind, or conventional gas-fired generators, on their premises to offset their loads.

Rule 21-type generators operate in parallel with PG&E’s electric distribution grid system.

The cost of interconnecting a generating facility with PG&E’s system can be affected by variables such as the circuit loading, the location, and the size and type of the generating facility.


4.2. Application and Agreements

4.2.1. Application Form/Fees

Customers who want to interconnect under the provisions of Rule 21 must fill out a “Generating Facility Interconnection Application” (Form No. 79-974 in Attachment 12), and follow the process set forth in the form.

The application must include the following.

- A check for $800.
- Any supporting documents.
- A completed application form.

The application package must be sent to PG&E by registered U.S. mail to the following address:
4.2.2. Application Completeness

PG&E has 10 days, from the day of the receipt of the application, to check if the applicant has provided complete information.

A completed application includes the following:

- An initial review fee of $800.
- The project name and location.
- A single-line drawing of the project.
- The generator type, size, and data.
- A listing of protective devices.
- The type and mode of the disconnect switch.

Please note that an electronic application is not complete until PG&E receives a check for $800, made payable to Pacific Gas and Electric Company.

4.2.3. Initial Review

If PG&E deems that the application is complete, PG&E has 10 business days to perform the initial review.

At any time that PG&E deems the application incomplete, the 10-day clock for the initial review phase stops. However, as soon as the applicant provides the missing information and PG&E deems the application complete, a new 10-day clock starts.

If PG&E determines that the application qualifies for a simplified interconnection, PG&E will provide a written description of the requirements, as well as the agreements described in Section 4.3. (“Rule 21 Agreement” on Page 4-4).

4.2.4. Supplemental Review

During the initial review, if PG&E determines that the application does not qualify for a simplified interconnection, PG&E will perform a supplemental review.

PG&E will provide one of the following items after the supplemental review:

- The interconnection requirements beyond those for simplified interconnection.
- A cost estimate and schedule for an interconnection study.
The applicant must submit to PG&E a supplemental review fee of $600 within 10 calendar days after the completion of the supplemental review.

If a supplemental review is required, PG&E must complete the review within 20 business days of the receipt of a completed application.

For more details, please see Rule 21 (Attachment 11).

4.2.5. **Interconnection Study**

After the initial or supplemental review, if PG&E determines that a detailed interconnection study is necessary, PG&E will offer an agreement that sets forth the following:

- The nature and scope of the studies.
- The facility design and engineering work to be performed.

This agreement will provide cost estimates for the fixed price or actual cost billing options.

4.2.6. **Single-Line Diagram and Project Details**

A single-line diagram must accompany the application. Some drawings with complex designs may require a Professional Engineering Stamp or C10 license.

For an example of a single-line diagram, please refer to Attachment 3.

In the interest of assisting PG&E in its goal to deliver safe, uniform service, use the following guidelines for transmitting electronic drawing files for architectural, mechanical, and civil site plans:

- The PG&E electronic drawing tool is AutoCAD R14, .DWG format. All submitted electronic drawings must be completely readable and compatible with AutoCAD release 12 or above.
- Drawings should be sent on 3.5-inch diskettes, CDs, or as attached email files.
- The “Pack & Go” feature of AutoCAD should be used, if available.
- Drawings for large projects should be sent in a zipped format.
- The use of layering is encouraged and should be preserved when transferring files to PG&E.
- All drawings should be saved in model space instead of paper space.
Generation

Rule 21 Generating Facility Interconnection

- Drawing plans should be two dimensional, with the “Z” elevation at zero.
- Any External Reference Files (Xref) or drawing updates should maintain a consistent insertion point.
- All related drawing files should be included.

For more information, please contact the local PG&E representative.

4.3. Rule 21 Agreement

Generator interconnection projects under the provisions of Rule 21 generally require one or more of the following agreements. Copies of these forms can be found in Attachment 12.

4.3.1. Generating Facility Interconnection Agreement (GFIA) (Form 79-973)

The GFIA is a CPUC-approved standard agreement that provides for the customer to interconnect and operate its generating facility in parallel with PG&E’s distribution system and establishes an ongoing business relationship between the customer and PG&E, including operating and communication protocols.

4.3.2. Customer Generation Agreement (CGA) (Third-Party Generator On Premises) (Non-Exporting) (Form 79-992)

The CGA is a CPUC-approved standard agreement that allows the customer to have a third party install, operate, and maintain an ownership interest in a generating facility on the customer’s premises.

This agreement provides for the interconnection and operation of the generating facility in parallel with PG&E’s distribution system and establishes an ongoing business relationship between the customer and PG&E, including operating and communication protocols.

The customer must complete the CGA along with the “Generating Facility Interconnection Agreement (Third Party Non-Exporting)” (Form 79-988), which is between the third-party generator and PG&E.

4.3.3. Generating Facility Interconnection Agreement (GFIA) (Third Party Non-Exporting) (Form 79-988)

The GFIA (Third Party Non-Exporting) is a CPUC-approved standard agreement that allows the customer to have a third-party install, operate, and maintain an ownership interest in a generating facility on the customer’s premises.
This agreement provides for the interconnection and operation of the generating facility in parallel with PG&E’s distribution system and establishes an ongoing business relationship between the third party and PG&E, including operating and communication protocols.

The customer must complete the GFIA along with the “Customer Generation Agreement (Third-Party Generator On Premises) (Non-Exporting)” (Form 79-992), which is between the customer and PG&E.

4.3.4. **Special Facilities Agreement (SFA) (Form 79-280)**

The SFA is a CPUC-approved standard agreement between PG&E and the customer. It specifies the cost of the interconnection facilities that PG&E will construct, own, and maintain.

4.3.5. **Standby Service Agreement (SSA) (Form 79-285)**

The SSA is a CPUC-approved standard agreement to provide standby service to a customer who requires PG&E to reserve the capacity to deliver electricity on an irregular or noncontinuous basis.

4.3.6. **Natural Gas Service Agreement (NGSA) (Form 79-756)**

The NGSA is a standard agreement for electric generation customers who qualify for schedule G-EG (“Gas Transportation Service to Electric Generation and Cogeneration Facilities”) and for service under schedule G-COG (“Gas Transportation Service to Cogeneration Facilities”).

4.3.7. **Other Agreements**

The following are other agreements that may be applicable:

- “Agreement to Perform Tariff Schedule Related Work” (Form 62-4527)
  This is a standard agreement to perform work at the request of others.
- Electric Rule 15/16 Agreements (in various forms)
  These are standard agreements to install new facilities or upgrade existing facilities to accommodate new electric-service requirements.
- Gas Rule 15/16 Agreements (in various forms)
  These are standard agreements to install new facilities or upgrade existing facilities to accommodate new gas-service requirements.
Before interconnection, all applicants must sign the “Generating Facility Interconnection Agreement” (Form 79-973).

Additionally, customers who have transmission-level generators (60 kV and above) must sign the “Generation Operating Agreement” (GOA).

All additional charges and the accompanying agreement(s) are due to PG&E before work begins on the distribution system.

All customers who are operating generators connected in parallel to the grid must execute a standby agreement, except for the following three groups of customers:

1. Agricultural customers.
2. E-NET and other customers who are operating generators connected in an open transition scheme (“break-before-make”).
3. E-NET and other customers who are operating generators connected in a closed transition scheme (“make-before-break”) under 60 cycles. For more information, please see Section 5, “Portable, Emergency, Standby Generators Interconnection.”

To receive a printed copy of the materials listed above, please contact the PG&E Generation Interconnection Hotline at (415) 972-5676 or send an email to gen@pge.com.

4.3.8. Proof of Insurance Coverage

As applicable, please refer to Section 8 of Form 79-973 or 79-988 in Attachment 12.

4.4. Approved Building Permit

PG&E requires proof from the applicant that the installation has passed a building inspection conducted by local authorities.

4.5. Preparallel Inspection

PG&E will perform a final inspection of the system before operation. This allows PG&E to ensure that the system has been installed in accordance with the originally submitted specifications.

After the inspection, the customer will receive written approval from PG&E to operate the system in parallel with PG&E’s grid.

**Note:** The system **must not be operated** until the customer has received a **written approval** from PG&E.
4.6. Timeline

Table 4-1 below outlines the time frames of the review and approval process:

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 days</td>
<td><strong>Application Completeness</strong>&lt;br&gt;PG&amp;E must verify that the following items are received before conducting the initial review:&lt;br&gt;• $800 initial review fee&lt;br&gt;• The following information is provided with sufficient detail:&lt;br&gt;  – The project name and location.&lt;br&gt;  – A single-line drawing.&lt;br&gt;  – The generator type, size, and data.&lt;br&gt;  – A list of protective devices.&lt;br&gt;  – The type and mode of a disconnect switch.</td>
</tr>
<tr>
<td>10 days</td>
<td><strong>Initial Review</strong>&lt;br&gt;Engineering review using the “Initial Review Process.” Please see “Sample of the Initial Review Process,” in Attachment 5.</td>
</tr>
<tr>
<td>10 additional days, total of 20 days from receipt of completed application</td>
<td><strong>Supplemental Review Process</strong>&lt;br&gt;After the supplemental review, if PG&amp;E determines that the application is not qualified for simplified interconnection, PG&amp;E will determine a time schedule and the cost for an interconnection study.</td>
</tr>
<tr>
<td>To be determined, as required based on supplemental review.</td>
<td><strong>Interconnection Study</strong>&lt;br&gt;PG&amp;E will determine the timeline and the cost for an interconnection study on a case-by-case basis.</td>
</tr>
</tbody>
</table>

4.7. Fees/Charges

The following fees are charged for reviews:

- Initial Review – $800
- Supplemental Review (if required) – $600
- Interconnection Study (if required) – PG&E determines the fee on a case-by-case basis.

Please note that up to $5,000 of the review and/or study fees will be waived for solar-generating facilities up to 1 MW that do not export power to the grid.
4.8. **Technical Requirements**

The specific requirements of this section apply on a case-by-case basis to any retail generation customers who do not meet one or more of the simplified interconnections criteria set by the California Energy Commission (CEC) Rule 21, here referred to as CPUC “Rule 21-Generating Facility Interconnections.” See Attachment 11.

4.8.1. **Interconnection Requirements**

When interconnecting facilities to the PG&E distribution system, it is important to minimize the potential hazard to life and property. A basic safety rule requires automatic detection and isolation of abnormal system troubles within a reasonable time.

Important system troubles are fault conditions, such as a short circuit.

4.8.2. **Protection and Control Requirements**

Interconnection of a new facility to the PG&E distribution system must not degrade any of the existing PG&E protection and control schemes nor lower the existing levels of safety and reliability to other customers.

Also, as a general rule, neither PG&E nor the customer should depend on the other for the protection of their respective equipment. PG&E’s protection requirements are designed and intended to protect the PG&E electric system only.

In view of these objectives, PG&E requires that the protective equipment be able to automatically detect and rapidly isolate faulty equipment. Therefore, the application and implementation of interconnection protection must limit interruptions only to the faulty equipment or section, so that a minimum number of customers are affected by any outage.

The customer may need to install high-speed protective equipment to rapidly isolate trouble and to minimize equipment damage and the potential impact to system stability.

PG&E will determine, on a case-by-case basis, if the customer needs high-speed fault clearing.

Some of the interconnection protection requirements are discussed in Section 3.9. “Machine-Based Generation,” on Page 3-11. PG&E performs system studies to determine, on a case-by-case basis, if the system configurations or types of generating facilities need additional protection requirements.

The specific requirements for interconnection depend on the following factors:

- The generator size and type.

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1 Please refer to CPUC Rule 21 for additional information.
• The number of generators.

• Feeder characteristics (i.e., voltage, impedance, and ampacity).

• The ability of the existing protective equipment at the local PG&E distribution system to function adequately with the proposed interconnection facility (i.e., identical generator projects connected at different locations in the PG&E system can have widely varying protection requirements and associated costs. These differences are caused by different feeder configurations, fault duties, and existing protection schemes).

The customer must install, at a minimum, a disconnecting device or switch with load- and/or fault-interrupting capability, as needed, at the point of interconnection.

Typically, the customer needs additional protective relays to adequately protect the generating facility. Customers are responsible for protecting their own systems and equipment from faults or interruptions originating on either PG&E’s side or the customer’s side of the interconnection.

The system protection facilities are at the customer’s expense, and must be installed, operated, and maintained in accordance with all the applicable regulatory requirements and in accordance with the design and application requirements of this handbook.

The protective relays used in isolating the generator from the PG&E electric system at the point of interconnection must meet the following requirements:

• The devices must be approved by PG&E.

• The devices must be set to coordinate with the protective relays at PG&E’s line circuit breaker terminals for the line to which the generator is connected.

Based on the proposed station configuration or the type of interrupting device closest to the point of common coupling (PCC) to PG&E’s facilities, PG&E may impose additional requirements (i.e., the exact type and style of the protective devices) on the customer.

Note: PG&E will coordinate with the generator or its representatives on the installation of any additional protective equipment that may be required. The generator is responsible for the costs of the additional protective equipment.

To ensure that the customer’s facility is adequately protected, PG&E recommends that the customer acquire the services of a qualified electrical engineer to review the electrical design of the proposed generation facility.
4.9. Manual Disconnect Switch

4.9.1. General

A generator must be equipped with a manual disconnect switch.

As a means of electrically isolating PG&E’s electric system from the customer’s systems, the customer must provide a PG&E-operated disconnect device. To establish a visually open working clearance, in accordance with PG&E’s safety rules and practices, the manual disconnect must be opened during all maintenance and repair work.

For interconnections of 2.4 kV and above, the disconnect switch must be located at the point of interconnection with PG&E. The disconnect switch must be gang-operated, three-pole, and lockable.

If the disconnect switch will be located on PG&E’s side of the interconnection point, PG&E must install it at the customer’s expense.

If the disconnect switch will be located on the customer’s side, it must be furnished and installed by the customer. If the disconnect device is in the customer’s substation, it must be located on the substation’s dead-end structure and have a PG&E-approved operating platform. The customer must use only PG&E-approved devices.

PG&E must inspect and approve the installation before parallel operation is allowed.

The disconnect switch must not be used to make or break parallels between PG&E’s electric system and the customer’s power system. The device’s enclosure and operating handle (when present) must be locked at all times, using PG&E’s padlocks.

The disconnect switch must be visible and easily accessible to PG&E employees. When installed on the customer’s side of the interconnection, the switch must be installed close to the metering. It must be identified with a PG&E-designated switch-number plate.

4.9.2. Specifications

The manual disconnect switch must meet the following requirements:

- Be rated for the voltage and current requirements of the particular installation.
- Be gang-operated.
- Be weatherproofed or designed to withstand exposure to weather.
• Be lockable in both the opened and closed positions with a standard PG&E lock, except for the low-voltage (0 to 600 V), fused disconnect switches with interlocks listed in the PG&E Engineering Document 060559, “Disconnect Switches for Interconnection with Small Power Producers and Cogenerators.” (See Attachment 3)

The interlock feature allows the customer to open a locked, fused disconnect switch, but not to close it, so that the customer’s system can be isolated for maintenance without PG&E’s assistance. A fused disconnect switch with an interlock must be unlocked by PG&E before it can be closed.

4.9.3. Low-Voltage Disconnects (0 to 600 Volts)

Low-voltage disconnect switches are rated as “general duty” (240 V) and “heavy duty” (600 V).

PG&E-approved, low-voltage disconnects are identified in Engineering Document 060559. (See Attachment 3)

4.9.4. Medium-Voltage Disconnects (600 Volts to 25 kV)

PG&E’s requirements for medium voltage disconnect switches rated up to 25 kV are specified in Engineering Document 066195 “25 kV Underarm Sidebreak Switch.” (See Attachment 3).

4.10. Review and Study Requirements

The customer must provide PG&E with electrical drawings for review before procuring the equipment.

The customer must provide the following drawings:

• Single-line meter and relay diagrams listing the major protective equipment.

• Schematic drawings, such as 3-line alternating current (ac), and tripping schemes (direct current [dc]) for all PG&E-required relays.

PG&E will review both the inverter-based and machine-based generators for simplified interconnection and, if needed, PG&E will perform an additional interconnection study.

4.11. Inverter-Based Generating System

In addition to having an Underwriters Laboratories Standard UL 1741 certification, an inverter-based generating facility must meet the “non-islanding” criteria specified in the CPUC’s “Rule 21- Generating Facility Interconnections,” which can be found at: http://www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf or in Attachment 11.
A PG&E-approved single inverter must meet the following criteria:

- Have an Underwriters Laboratories Standard UL 1741 certification.
- Be on the California Energy Commission (CEC)-eligible list. Please refer to the following website for the CEC-eligible list: http://www.consumerenergycenter.org/buydown/eligible_inverters.html.
  Or
- Have met all the criteria set by the CEC Rule 21, Section “J,” as tested by a nationally recognized testing laboratory (NRTL) acceptable to PG&E and the test reports must have been approved by PG&E.

PG&E requires additional testing for multiple units unless the generator has received an earlier approval.

Separate single-unit or multiple-unit inverters that do not meet Underwriters Laboratories Standard UL1741 or have not been adequately tested will not be granted commercial operation status and the customer is not permitted to interconnect to the system.

PG&E reserves the right to disconnect previously certified interconnected units when Underwriters Laboratories (UL) decertifies the units. PG&E may implement an acceptable mitigation procedure for recertification at the customer’s expense.

Therefore, it is critical that the interconnecting applicant understands all of PG&E’s technical requirements before the applicant does an engineering design or procures material.

At PG&E’s discretion, noncertified inverters may be interconnected if the applicant meets the additional requirements. The additional requirements may include, but are not limited to, those listed in Table 3-3, “Standard Device Numbers,” on Page 3-20.

4.12. Machine-Based Generation

In addition to the standard generator protection (such as voltage and frequency relays), the following equipment may be required for machine-based generating facilities:

- Phase and ground fault-detection schemes to detect faults on the PG&E system (less likely to be required for induction units). (See Notes 1 and 2 on Page 4-13.)
- An anti-islanding scheme (less likely to be required for induction units).
- A reclose-blocking scheme (less likely to be required for induction units).
- A transfer-trip scheme (less likely to be required for induction units).

The power quality requirement (see Attachment 10, “Rule 2”) may also apply to machine-based generating facilities.
Notes

1. A “reverse-power” function is unacceptable as a substitute for fault detection. An “under-power” function may be a viable substitute for some fault-detection schemes. A utility-grade device with three, independent, current-measuring elements may be required for the generator.

2. An “under-power” function cannot be applied when “inadvertent export” is a possibility.

4.13. Testing and Maintenance Requirements

The customer must provide PG&E with test reports (Form G2-2, “Relay Test Report,” in Attachment 12) for the particular types of protective devices applied as outlined in Table 4-2, “Generator-Protection Devices,” on Page 4-18, before PG&E will allow the facility to parallel.

When the customer uses tele-protection (protection provided via telephone), the customer must ensure that the communication circuits are tested. The customer must also verify that the scheme’s operation is operating properly before a generating facility may be released for commercial operation. Testing for communication-assisted protection includes end-to-end satellite testing and verifying the communication between the interconnected terminals. Please see Attachment 6, “Telemetering and Transfer Trip,” for more information.

Generation customers should refer to Section 4.5., “Preparallel Inspection,” on Page 4-6, for information regarding preparallel inspections, and to Attachment 6 for information about communication-assisted line protection.

Every four years, after the initial testing, the customer must submit written test reports from a qualified testing firm to PG&E, documenting that the relays are operable and within calibration. PG&E does not test the customer’s equipment, but may witness testing performed by the qualified testing firm retained by the customer.

On-site power (typically 120 V) is required for the test equipment. Every eight years, following the preparallel inspection, the customer must test the protection scheme’s circuit breakers.

Since significant equipment damage and liability can result from failures of the customer’s protective equipment, the customer must ensure that all of the facility’s protective equipment is operating properly. Please see the “Generation Operating Agreement” (Attachment 12).

4.14. Reliability and Redundancy

The customer’s design must include a protection system with enough redundancy, so that the failure of any one component will still permit the customer’s facility to be isolated from the PG&E electric system during a fault condition.
Multifunction, three-phase protective relays must have a redundant back-up relay(s). The circuit breakers must be trip-tested by the customer at least once a year.

4.15. Relay Grades

Two categories of relays commonly used for interconnection protection are:

- Industrial-grade relays.
- Utility-grade relays.

4.15.1. Industrial-Grade Relays

Industrial-grade relays are less reliable than utility-grade relays and may be installed only in projects up to 1,000 kW (aggregate nameplate) that are interconnected to distribution circuits. (Please see Table 4-4, “Industrial-Grade Relays for Generation Application,” on Page 4-30.)

Please refer to the following sections for the protection requirements for units with an individual output capacity of 100 kW and a total aggregate generation of 400 kW or larger:

- Table 4-2, “Generator-Protection Devices,” on Page 4-18
- Section 4.15.2., “Utility-Grade Relays”
- Section 4.17.5., “Overcurrent Relay With Voltage Restraint or Voltage Control,” on Page 4-21

4.15.2. Utility-Grade Relays

Utility-grade relays, used by electric utilities, have much higher reliability and accuracy than industrial-grade relays (please see Table 6-3 “Utility-Grade Relays for Generation Application,” on Page 6-9).

These devices typically have draw-out cases and indicating targets. In addition, to facilitate testing and troubleshooting, these devices are equipped with better recording capability than industrial-grade relays.

Utility-grade relays must be installed in the following circumstances:

- In all generation facilities rated in excess of 1,000 kW (aggregate nameplate) installed on PG&E distribution circuits.
- On all relay-based generating systems that do not meet Rule 21 requirements.
- When the relays are used for a line-side, ground-fault-detection scheme.
• When overcurrent with voltage-restraint or voltage-controlled relays are used for generators 400 kW or larger, or for generators larger than 100 kW, where the aggregate generation is greater than 400 kW.

• When auxiliary relays and timers are used in the tripping circuits of PG&E-required protection schemes.

4.15.3. Relays Approved by PG&E

All utility-grade relays must include relay targets that can be reset manually.

All utility-grade relay power supplies must be powered by station-battery dc voltage, and must include a dc-undervoltage detection device and alarm.

The customer must submit all proposed relay specifications to PG&E for approval before ordering the relays. The line-protection relays must be listed on PG&E’s approved list (please see Table 6-3, “Utility-Grade Relays for Generation Application,” on Page 6-9).

Generation-protection relays must meet one of the following requirements:

• Be on the PG&E-approved list. (Please see Table 6-3 on Page 6-9).

• Be tested according to Attachment 9 - “Generator Protective Relay Requirements.”

The customer is responsible for the costs of any required, qualified tests performed on the relays. These tests must be done before PG&E’s approval of the relay for interconnection use.

PG&E approval does not indicate the quality or reliability of a product or service, and endorsements or warranties must not be implied. If the customer wants to use a relay not on the PG&E-approved list, the customer must allow additional time for testing and PG&E’s review and approval.

Please see the following sections for a list of PG&E-approved relays:

• Table 4-4, “Industrial-Grade Relays for Generation Application,” on Page 4-30

• Table 6-3 “Utility-Grade Relays for Generation Application” on Page 6-9
4.16 System Fault Detection and Protection

The customer’s equipment must be able to independently detect phase and ground faults on the PG&E system, as specified by CPUC Rule 21 (i.e., “sequential fault detection,” where the equipment is unable to detect the fault until after the PG&E system has been isolated, is unacceptable). All required fault-detection relays must coordinate with PG&E’s devices, as necessary.

In addition, the interconnection relays must be set to provide overlapping or coordinated protection to prevent extensive damage should an interrupting device fail to clear when required. The line-protection schemes must be able to distinguish between generation, inrush, and fault current. Multiple terminal lines are more complex to protect than single lines.

At the customer’s expense, the existing relay schemes may have to be reset, replaced, or augmented with additional relays to coordinate with the customer’s new facility.

The customer must place the PG&E-required relays at a location where a fault on any phase of PG&E’s interconnected line(s) can be detected.

If PG&E requires transfer-trip protection, the customer must provide and pay for all the required communication circuits and equipment based on the protection studies.

The following are examples of a communication circuit:

- A leased line from the telephone company.
- A dedicated cable.
- A circuit on a microwave system.
- A fiberoptic circuit that is designed to sufficiently monitor critical communication channels and associated equipment.

PG&E determines the appropriate communication medium to use on a case-by-case basis.

The leased telephone line or dedicated communication network must have high-voltage protection equipment on the entrance cable so the transfer-trip equipment can operate properly during fault conditions. (Please refer to Attachment 6 for a detailed description of the protection requirements and the associated transfer-trip equipment and communications circuit monitoring.)

The PG&E distribution network system is designed to be highly reliable. Certain load centers and customers may have multiple and/or redundant supply sources. When there are multiple sources and paths, PG&E may require more complex protection schemes to properly detect and isolate faults.
The addition of any new generation facility to the PG&E electric system must not degrade the existing protection and control schemes or lower the levels of safety and/or reliability for existing PG&E customers. For more information, please refer to “Rule 2 – Description of Service” at: http://www.pge.com/customer_services/business/tariffs/pdf/ER2.pdf or Attachment 10.

Many parts of the PG&E electric system have provisions for an alternate feed. However, due to protection problems, there are some locations where PG&E does not allow generation to be online while being fed from an alternate source.

Whenever possible, PG&E provides the customer with the option of not paying for upgrades. If the customer pays for the required upgrades, the customer’s facility may stay online while being transferred to the alternate source. However, if the customer does not pay for the upgrades, PG&E has the option of shutting down the facility instead of transferring it to an alternate source.

4.17. Protection and Control for Generating Facilities

The customer is responsible for providing all of the necessary protection for its own generator. Any protection requirement listed here is intended solely for the protection of the utility and its customers. (Please see “CPUC Rule 21” in Attachment 11.)

Single-phase generators are connected in multiple units so that an equal amount of generation capacity is applied to each phase of a three-phase circuit.

All generating facilities must comply with the latest, applicable regulatory standards for:

- Waveform and power quality.
- Telephone interference.
- DC and harmonic injections, etc., as specified in CPUC Rule 21 (please see Attachment 11).

Synchronous generators, regardless of the generating capacity, must be equipped with an acceptable synchronization method, as specified in subsequent sections of this document. Synchronous generators may be subjected to “reclose blocking” schemes on one or more of PG&E’s automatic reclosing devices.

Please see Table 4-2 on Page 4-18 for the protection equipment that is required to operate a generator safely and reliably in parallel with PG&E’s electric system.

PG&E will determine any additional generator-protection requirements on a case-by-case basis.
Table 4-2 Generator-Protection Devices

<table>
<thead>
<tr>
<th>Generator-Protection Device</th>
<th>Device Number</th>
<th>40 kW or Less</th>
<th>41 kW to 400 kW</th>
<th>401 kW and Larger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Overcurrent</td>
<td>50/51</td>
<td>X²</td>
<td>X²</td>
<td></td>
</tr>
<tr>
<td>Overvoltage</td>
<td>59</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Undervoltage</td>
<td>27</td>
<td>X³</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Overfrequency</td>
<td>81O</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>81U</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ground-Fault-Sensing Scheme (Utility Grade)</td>
<td>51N</td>
<td>X⁴</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Overcurrent with Voltage Restraint (51V) or Overcurrent with Voltage Control (51C)</td>
<td>51V</td>
<td>X⁵</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse-Power Relay</td>
<td>32</td>
<td>X⁶</td>
<td>X⁶</td>
<td>X⁶</td>
</tr>
<tr>
<td>Direct-Transfer Trip</td>
<td>TT</td>
<td>X⁷</td>
<td>X⁷</td>
<td>X⁷</td>
</tr>
</tbody>
</table>

Notes

1. Please refer to Table 4-3, “Standard Device Numbers,” on Page 4-29 for device numbers, definitions, and functions.

2. When fault-detection is required, per CPUC Rule 21, the phase overcurrent protection must be able to detect all line-end phase and phase-fault conditions.

The generator must be equipped with a phase instantaneous-overcurrent relay that can detect a line fault under subtransient conditions.

The generator does not have to be equipped with a phase instantaneous-overcurrent relay if the generator uses a 51V or 51C relay. PG&E determines if a 51V or a 51C relay is better suited for the specific project.

3. For generators rated at 40 kW or less, installing a contactor undervoltage release may meet the undervoltage protection requirement.

4. If CPUC Rule 21 requires fault protection, the ground-fault detection is required for any noncertified inverter-based, induction, or synchronous generating facility.

Synchronous generators with an aggregate generation over 40 kW and induction generators with an aggregate generation over 100 kW require ground-fault detection.

5. When CPUC Rule 21 requires fault protection, a group of generators, each less than 400 kW but whose aggregate capacity is 400 kW or greater, must have an overcurrent-relay with voltage restraint (or voltage control, if determined by PG&E) installed on each generator rated greater than 100 kW.
For nonexport generating facilities operating under the proper system conditions, and having a finite “minimum import” (excluding any possibility of an “incidental” or an “inadvertent” export), a set of three single-phase, very sensitive reverse-power relays, along with the dedicated transformer, may be used in lieu of ground-fault protection.

PG&E prefers that the relay be set as an “under-power” element. As specified by CPUC Rule 21, the relay can be set at 5% of the customer’s minimum import power (despite the generator’s maximum output) for each phase, to trip the main circuit breaker at a maximum time delay of 2 seconds.

As a “reverse-power” element, the relay must be set for 0.1% of the transformer rating with a time delay of 2 seconds, as specified by the CPUC Rule 21.

PG&E determines, based on PG&E’s circuit configuration and loading, if the distribution-level interconnections require transfer-trip protection.

A transfer-trip relay is required if PG&E determines that a generation facility cannot detect and trip on PG&E’s end-of-line faults within an acceptable time frame, or if PG&E determines that the generation facility is capable of keeping a PG&E line energized with the PG&E source disconnected (please see Attachment 6).

The sections below describe the required protective and control devices for generators.

4.17.1. Phase Overcurrent

Please see Table 4-3, “Standard Device Numbers,” on Page 4-29 (Device 50/51) for the definition and function of the phase-overcurrent relays.

4.17.2. Over/Undervoltage Relay

The over/undervoltage relay is used to trip the interrupting device when the voltage is above or below PG&E’s normal operating level.

In the event that the generator carries load that is isolated from PG&E’s electric system, the over/undervoltage relay is used for generator and backup protection.

For all distribution interconnections, the undervoltage relay is set for 88% of the nominal voltage (106 V on the 120 V base) unless system conditions require otherwise.

The overvoltage relay is set for 110% of the nominal voltage (132 V on the 120 V base).

4.17.3. Over/Underfrequency Relay

The over/underfrequency relay is used to trip the interrupting device when the frequency is above or below PG&E’s normal
operating level. It is used for generator or turbine protection and backup protection.

To maintain generation online during system disturbances, the customer must coordinate the generator’s underfrequency relay settings with those of other utilities in the Western Electric Coordinating Council (WECC). For more information about the WECC, please refer to http://www.wecc.biz/main.html.

For all distribution interconnections, the underfrequency relay is set at 58 Hz with a time delay of 30 seconds. The overfrequency relay is set at 61 Hz with a time delay of 15 cycles (0.25 second).

4.17.4. Ground-Fault-Sensing Scheme

4.17.4.1. General

The ground-fault-sensing scheme detects PG&E’s power-system ground faults and trips the generator’s circuit breaker or the main circuit breaker, preventing the generator from continuously contributing to a ground fault.

The ground-fault-sensing scheme is able to detect faults between the PG&E system’s side of the dedicated transformer and the end of PG&E’s distribution circuit.

The following types of transformer connections, provided with the appropriate relaying equipment, are commonly used to detect system ground faults:

- System-side – grounded wye; generator-side – delta
- System-side – grounded wye; generator-side – wye; tertiary – delta

4.17.4.2. Distribution Interconnections

For a transformer connected in a delta configuration to the distribution system with a delta connection on the system side, PG&E recommends a separate grounding transformer, in addition to the appropriate relaying equipment.

For a transformer connected in a grounded-wye configuration to the 3-wire distribution system with a grounded wye on the system side, the generator must have a single-phase potential transformer between the neutral and ground connection, in addition to the appropriate relaying equipment.

For the typical, distribution-level interconnection schemes, please see the following drawings:

- Figure 4-1, “Recommended Ground Detection Schemes 12 kV Distribution Circuits,” on Page 4-32
Figure 4-2, “Recommend Ground Detection Schemes 21 kV Distribution Circuits,” on Page 4-33

A single generator or a set of generators with an aggregate rating of more than 4 kW must not be connected to a single-phase line without providing for ground-fault tripping. The customer must discuss these situations with PG&E in advance.

For any substation or generation facility built by other entities but subsequently owned, maintained, and/or operated by PG&E, the customer must ensure that the substation or generation facility’s ground grid meets the minimum design and safety requirements used in PG&E’s substations. The ground-grid design must be analyzed according to the “Grounding Design Criteria,” and documented according to the “PG&E Analysis Specification” (please see Attachment 7).

The ground grid must meet the minimum design and safety requirements used in PG&E substations (please see Attachment 7) when the customer connects the generating facilities (operated by the customer) to the ground grid of an existing or new PG&E substation when one of the following situations occur:

- The generator is located inside or immediately adjacent to PG&E’s substations or switching stations.
- The system protection requires a solid ground connection for relay operation.

When the customer’s facilities are not connected to PG&E’s ground grid or neutral system, the customer is solely responsible for establishing design and safety limits for the grounding system.

4.17.5. **Overcurrent Relay with Voltage Restraint or Voltage Control**

An overcurrent relay with voltage restraint or voltage control is used to detect multiphase faults and initiate tripping the generator circuit breaker.

The customer must ensure that the required relays are located on each individual generator feeder. A group of generators that have an aggregate rating over 400 kW must be equipped with an overcurrent relay with voltage restraint or voltage control\(^2\) installed on each generator rated at more than 100 kW. Generators rated at, or greater than, 400 kW must be equipped with an overcurrent relay with voltage restraint or voltage control.

To allow for phase-shift correction, the potential circuits to an overcurrent relay with voltage restraint or voltage control must

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\(^2\) PG&E will determine the suitability of a voltage restraint (device 51V) or a voltage control (device 51C) relay on a case-by-cases basis and depending on the system characteristics for the specific interconnecting project.
have a delta-wye or wye-delta auxiliary potential transformer, depending on the relay design and operating principle if the generator’s step-up transformer is connected wye-delta or delta-wye.

Please contact the applicable PG&E representative to find out the proper phase of the auxiliary transformers connection.

4.17.6. Reverse-Power Relay

Please see Table 4-2, “Generator-Protection Devices,” on Page 4-18 (Device #32) for the definition and function of a reverse-power relay.

4.17.7. Fault-Interrupting Devices

PG&E must review and approve all customer-selected fault-interrupting devices.

There are two basic types of fault-interrupting devices for distribution interconnections:

- Circuit Breakers
- Fuses

PG&E will determine the type of fault-interrupting device that a customer needs based on the following conditions:

- The size and type of generator.
- The available fault duty.
- The local circuit configuration.
- The existing PG&E protection equipment.

4.17.7.1. Circuit Breakers

A three-phase circuit breaker is the required fault-interrupting device at the point of interconnection, due to its simultaneous three-phase operation and its ability to coordinate with PG&E line-side devices. The three-phase circuit breaker is able to automatically separate the generator from PG&E’s electric system upon detection of a circuit fault.

The customer may install additional circuit breakers and protective relays, which are not required for interconnection, in the generation facilities.

The interconnection circuit breaker must have sufficient capacity to interrupt the maximum fault current it may experience and must be equipped with accessories to perform the following functions:

- Trip the circuit breaker with an external trip signal supplied through a battery (shunt trip).
• Telemeter the circuit breaker status, if required by PG&E.

• Lock out the circuit breaker, if it is operated by protective relays.

### 4.17.7.2. Fuses

Fuses are single-phase, direct-acting sacrificial links that melt to interrupt fault current and protect the equipment.

The customer must replace blown fuses manually after each fault before the facility may be returned to service. Only trained personnel may replace overhead primary fuses.

Fuses cannot be used as the primary protection for three-phase generation facilities because fuses:

• Are single-phase devices.

• May not all melt during a fault.

• May not automatically separate the generation facility from PG&E’s electric system.

• Cannot be operated by the protective relays.

However, PG&E allows customers to use fuses as high-side protection for the dedicated transformer at generation facilities rated at less than 1,000 kW if the fuses are connected to the distribution-level system, but only if the customer’s protection can be coordinated with the existing PG&E phase and ground protection.

If fuses are used, the customer should consider installing a negative-sequence relay and/or other devices to protect the facility against single-phase conditions. If fuses are used for high-side transformer protection, the generator must have a separate generator circuit breaker to isolate the facility from PG&E electric system during a fault or abnormal system conditions.

PG&E does not allow the customer to use large primary fuses that do not coordinate with the circuit breaker ground relays in PG&E’s substations, because this may cause all the customers on the circuit to lose power if there is a fault inside the generating facility.

### 4.17.8. Synchronous Generators

The customer must ensure that the generating unit meets all the applicable standards of the:

• American National Standards Institute (ANSI) (please refer to: www.ansi.org)
Institute of Electrical and Electronic Engineers (IEEE)
(please refer to: www.standards.ieee.org)

The prime mover and the generator must be able to operate within
the full range of voltage and frequency excursions that may exist
on PG&E’s electric system without damaging the generator.

4.17.9. Synchronizing Relays

The purpose of synchronizing devices is to ensure that a
synchronous generator parallels with PG&E’s electric system
without causing disturbance to other customers and facilities
(present and in the future) that are connected to the same system.

Synchronizing devices also ensure that the generator will not be
damaged due to an improper parallel action. Please refer to
Attachment 8, “Generator Automatic Synchronizers for Generation
Entities,” for additional information and requirements.

Synchronous generators and other generators with stand-alone
capability must use one of the methods in the following sections to
synchronize with PG&E’s electric system.

4.17.9.1. PG&E-Approved Automatic Synchronizers

The PG&E-approved automatic synchronizer (Device
15/25) must have all of the following characteristics:

- A slip-frequency matching window of 0.1 Hz or less.
- A voltage-matching window of \( \pm 10\% \) or less.
- A phase-angle acceptance window of \( \pm 10^\circ \) or less.
- Breaker-closure time compensation.

For an automatic synchronizer that does not have the
“breaker-closure time compensation” feature, the
generator must use a tighter phase-angle window
(\( \pm 5^\circ \)) with a 1-second time-acceptance window to
achieve synchronization within a \( \pm 10^\circ \) phase angle.

**Note:** In addition to the above characteristics, the
automatic synchronizer must also be able to
automatically adjust the generator voltage and
frequency to match the system voltage and
frequency.

4.17.9.2. Automatic Synchronizers Not Approved by PG&E but
Supervised by a PG&E-Approved Synchronizing Relay

An automatic synchronizing device that is not
PG&E-approved but is supervised by a PG&E-approved
synchronizing relay (Device 25) must have all of the
following characteristics:

- A slip-frequency matching window of 0.1 Hz or less.
4.17.10. Frequency/Speed Control

Unless otherwise specified by PG&E, a governor is required on the prime mover to enhance the system stability.

The generator must set the governor characteristics to provide a 5% droop (i.e., a 0.15-Hz change in the generator speed must cause a 5% change in the generator load).
To help regulate PG&E’s system frequency, the governors on the prime mover must be able to operate freely.

4.17.11. **Excitation System Requirements**

The excitation system must be capable of regulating the generator-output voltage and power factor for the full range of the limits specified by the CPUC Rule 21.

4.17.12. **Voltage Regulation/Power Factor**

According to the California Independent System Operator (CAISO) requirements, the voltage regulator must be able to maintain the generator voltage under steady-state conditions without hunting and within ± 0.5% of any voltage level between 95% and 105% of the generator’s rated voltage. Voltage-sensing must be set at the same point as PG&E’s revenue metering.

The designated electric control center determines the voltage schedules, in coordination with the transmission operations center.

CPUC Rule 21 requires that the power-factor control maintain a power factor between 90% lagging and 90% leading (within a PG&E-acceptable tolerance).

Distribution-level generator interconnections typically require power-factor control (i.e., the generator is put on a power-factor schedule, rather than on a voltage schedule).

4.17.13. **Event Recorder**

An event recorder is required for all unattended generation facilities with a capacity greater than 400 kW and/or with automatic or remotely initiated paralleling capability.

The event recorder must provide PG&E with sufficient information to determine the status of the generation facility during system disturbances.

In addition, the event recorder for a generation facility with a nameplate rating equal to or greater than 10,000 kW must provide a record of deliveries to PG&E of the following items:

- Real power in kW.
- Reactive power in kvars.
- Output voltage in kV.

4.18. **Induction Generators**

Induction generators and other generators with no inherent var (reactive power) control capability must be able to provide an amount of reactive power equivalent to that required for a synchronous generator.
Induction machines can be self-excited by nearby distribution capacitors or as a result of the capacitive voltage on the distribution grid.

4.19. **Parallel-only (No Sale) Generator Requirement**

Parallel-only generators have the same requirements as that of any other standard synchronous-generator interconnection. The only exception is that PG&E may, at its discretion, allow the installation of three very sensitive, single-phase, reverse-power relays, such as the Basler BE1-32R, along with a dedicated transformer, as an alternative to the normally required ground relays.

The reverse-power relays must be set to pick up on transformer-magnetizing current with a time delay not to exceed 2 seconds. This option may not be feasible on generating systems with a slow load-rejection response, as these generating systems may be tripped off-line frequently for in-plant disturbances.

Owners of parallel-only generators must execute a parallel-only operating agreement with PG&E before operating the parallel-only generators.

4.20. **PG&E Protection and Control-System Changes That May Be Required to Accommodate the Generator’s Interconnection**

At the generation customer’s expense, PG&E performs a detailed interconnection study to identify the cost of any required modifications to PG&E’s protection and control systems before interconnecting the new generator. These modifications are in addition to any distribution-system upgrades that PG&E identifies in the system-impact or facilities studies.

To recover the costs to PG&E for any protection and control-system modifications that are directly assigned to the generator, retail generation customers will execute a “Generation Special Facilities Agreement” (please see Attachment 12), as indicated in Electric Rule 21. For more information on “Rule 21 – Generating Facility Interconnections”, please see www.pge.com/customer_services/business/tariffs/pdf/ER21.pdf or Attachment 11.

The following are some of the protection-system modifications that PG&E may require:

- PG&E’s automatic restoration equipment may need to be modified so that the equipment will not restore the generator until it is below 25% of the nominal voltage, as measured by the restoration equipment. (See Engineering Document 053826, “Requirements For Distribution Feeder with Synchronous Generating Equipment,” in Attachment 3.)

  The restoration of power by automatically re-energizing PG&E’s facilities may cause generator damage and system disturbances.
PG&E requires this modification when it determines that the generator(s) has the capability of energizing a line even when the PG&E electric system is disconnected.

PG&E will not allow the generator(s) to automatically re-energize PG&E’s facilities.

- For generation facilities with a greater than 1,000 kW aggregate nameplate rating, the customer must replace all the existing, single-phase, fault-interrupting devices (fuses) located in series between the generator and PG&E’s substation with a three-phase interrupting device. This replacement is to prevent possible single-phasing of other customers.

- When the generator is on a distribution circuit fed from a fused PG&E substation transformer bank, and the bank’s minimum load is equal to or less than 200% of the generator’s nameplate rating, the customer must replace the PG&E substation transformer’s high-side fuses with a three-phase interrupting device.

- If PG&E determines that it is necessary, the customer must install a transfer trip to the generator from the following devices:
  - High-side circuit breaker/circuit switcher.
  - Distribution circuit breaker.
  - Any line reclosers.

An associated Energy Management System (EMS) or Supervisory Control and Data Acquisition (SCADA) telemetering circuit is required between the generator’s site and the designated PG&E electric control center.

4.21. Direct Telephone Service

The customer must obtain direct service from the local telephone company so that PG&E can provide operating instructions to the designated operator of the customer’s equipment.

The customer must have a telephone communication line in service for the transfer trip at least three weeks before the facility is energized (please see Attachment 6).
<table>
<thead>
<tr>
<th>Device Number</th>
<th>Definition and Function</th>
<th>Device Number</th>
<th>Definition and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>A speed-of-frequency matching device functions to match and hold the speed or the frequency of a machine or of a system equal to, or approximately equal to, that of another machine, source, or system.</td>
<td>50</td>
<td>An instantaneous overcurrent or rate-of-rise relay indicates a fault in the apparatus or circuit that is being protected, when there is an excessive value of current, or an excessive rate of current rise.</td>
</tr>
<tr>
<td>21</td>
<td>A distance relay functions when the circuit admittance, impedance, or reactance increases or decreases beyond predetermined limits.</td>
<td>51</td>
<td>An ac time overcurrent relay has either a definite or inverse-time characteristic that functions when the current in an ac circuit exceeds a predetermined value.</td>
</tr>
<tr>
<td>25</td>
<td>Synchronizing and synchronism-check devices permit two alternating current (ac) circuits to be paralleled when they are within the desired limits of frequency, phase angle, and voltage.</td>
<td>52</td>
<td>An ac circuit breaker is used to close or interrupt an ac power circuit under normal conditions or to interrupt a circuit under fault or emergency conditions.</td>
</tr>
<tr>
<td>27</td>
<td>An undervoltage relay functions on a given value of undervoltage.</td>
<td>59</td>
<td>An overvoltage relay functions on a given value of overvoltage.</td>
</tr>
<tr>
<td>32</td>
<td>A reverse-power relay functions on a reverse-power flow at a given set point.</td>
<td>60</td>
<td>A voltage-balance relay operates on a given difference in voltage between two circuits.</td>
</tr>
<tr>
<td>46</td>
<td>A reverse-phase or phase-balance current relay functions when the polyphase currents are of reverse-phase sequence, or when the polyphase currents are unbalanced or contain negative phase-sequence components exceeding a given amount.</td>
<td>61</td>
<td>A current-balance relay operates on a given difference in the current input or output of two circuits.</td>
</tr>
<tr>
<td>47</td>
<td>A phase-sequence voltage relay functions on a predetermined value of polyphase voltage in the desired phase sequence.</td>
<td>62</td>
<td>A time-delay stopping, or opening, relay delays a shutdown, stopping, or opening operation in an automatic sequence initiated by another device.</td>
</tr>
</tbody>
</table>
Table 4-3  Standard Device Numbers, continued

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Definition and Function</th>
<th>Device Number</th>
<th>Definition and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>An ac directional-overcurrent relay functions on a desired value of ac overcurrent flowing in a predetermined direction.</td>
<td>87</td>
<td>A differential-protective relay functions on a percentage of the phase angle or other quantitative difference between two currents or by other electrical quantities.</td>
</tr>
<tr>
<td>79</td>
<td>An ac reclosing relay controls the automatic reclosing and locking out of a circuit interrupter.</td>
<td>90</td>
<td>A regulating device regulates a quantity, or quantities, such as voltage, current, power, speed, temperature, frequency, and load, at a certain value or between certain limits for machines, tie lines, or other apparatus.</td>
</tr>
</tbody>
</table>
| 81            | A frequency relay functions on a predetermined value of frequency either under or over the normal system frequency or the normal rate of frequency change. | 94            | A tripping or trip-free relay functions to:  
• Trip a circuit breaker, contactor, or the equipment.  
• Permit immediate tripping by other devices.  
• Prevent the immediate reclosure of a circuit interrupter if it opens automatically, even when its closing circuit is kept closed. |

Table 4-4  Industrial-Grade Relays for Generation Application

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Arga</th>
<th>Basler Electric</th>
<th>Square D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronizing Relays (25)</td>
<td>PRS 250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undervoltage Relay (27)</td>
<td>6-327</td>
<td>BE4-27</td>
<td>PR-201-UV</td>
</tr>
<tr>
<td>Nondirectional Overcurrent Relay (50/51)</td>
<td></td>
<td>BE4-51</td>
<td></td>
</tr>
<tr>
<td>Overvoltage Relay (59)</td>
<td>6-327</td>
<td>BE4-59</td>
<td>PR-101-OV</td>
</tr>
<tr>
<td>Frequency Relay (Under/Over) (81U/O)</td>
<td>6-328</td>
<td>BE4-81-O/U</td>
<td>R-101-OUF</td>
</tr>
<tr>
<td>Overcurrent Relay (51N,V,C)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ For utility-grade relays, please see Table 6-3, "Utility-Grade Relays for Generation Application," on Page 6-9.
Notes

1. Customers may install industrial-grade relays only on projects that are greater than 10 kW or less than or equal to 1 MW and are interconnected to distribution circuits.

2. Relays used in a ground fault-detection scheme must be utility grade.

3. The above table contains information regarding products, manufacturers, and representatives. This table is not all-inclusive. The inclusion or omission of a product, manufacturer, or representative is not meant to be an indication of the quality or reliability of a product or service. No endorsements or warranties are implied.

Other types of relays may be acceptable, but PG&E must review and approve the certified test results performed by an independent party acceptable to PG&E before the facility may be installed and released for commercial operation.

Contact PG&E’s System Protection department for the test specifications for each relay.
3-Wire Systems, Service Transformer Connected Wye on 12 kV Side
Connect a 12 kV-240 V distribution transformer (or a 12 kV-120 V PT) between the neutral and ground; load the secondary with a 13 Ω resistor, and an overvoltage relay.

For 12 kV-240 V:
Turns ratio, \( N = \frac{12,000}{240} = 50 \)
Maximum secondary voltage, \( V^3 = \frac{12,000}{\sqrt{3}} = 138.5 \text{ V} \)

Short time ratings for resistor and transformer:
\[ R = \frac{V^2}{13} = \frac{138.5^2}{13} = 1,477 \text{ W (or VA)} \]

3-Wire Systems, Service Transformer Connected Delta on 12 kV Side
Install 3 PTs or distribution transformers, 12 kV-240 V 1.0 kVA or larger, on 12 kV side as shown below. Connect a 13 Ω resistor across the broken delta.

For 12 kV-240 V:
Turns ratio, \( N = \frac{12,000}{120} = 100 \)
Normal secondary voltage, \( V_n = \frac{12,000}{\sqrt{3}} = 69.3 \text{ V} \)
Maximum voltage across delta, \( V_d = 3 \times 69.3 = 208 \text{ V} \) (minimum relay voltage rating)
Short time ratings for resistor and transformer:
Resistor \( W = \frac{V^2}{13} = \frac{208^2}{13} = 3,328^* \)
Transformer VA = \( 120 \times 208 = 1920 \text{ (each)*} \)

*1,000 W continuous rated resistor and 1.0 kVA transformer will be adequate.

Figure 4-1
Recommended Ground Detection Schemes
12 kV Distribution Circuits
4.22. Metering Requirements

Rule 21 installations are generally designed to operate in parallel with the PG&E system.

The disconnect requirements are specified by PG&E and listed in the Engineering Document 060559, “Disconnect Switches for Interconnection with Small Power Producers and Cogenerators.” (See Attachment 3)
As specified in Rule 21, the customer is required to have an accessible disconnect switch that may be locked in the open position and located within approximately 10 feet of the meter at a PG&E-approved location.

Revenue meters used for Rule 21 are either electromechanical or solid-state programmable meters.

The customer is responsible for ensuring that the metering panels satisfy the necessary revenue-metering requirements.

In the event that the installation of a dual-meter adapter is necessary, the customer is required to have adequate meter working space. The required meter working space is defined as an area in front of the meter or the meter enclosure. The purpose of the meter working space is to provide safe access to the metering equipment.

The meter working space must be:

- Clear and level.
- At least 36 inches by 30 inches in area.
- Kept clear of debris and unobstructed at all times.
- Located so that the centerline of the meter must be at least 10 inches from any adjacent sidewall or other protruding obstruction.
- Located so there is no intrusion by landscaping, structures, or stored material.

Installed meters must also satisfy the following height requirements:

<table>
<thead>
<tr>
<th>Installed Meters</th>
<th>Height Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual, field-installed meter panels (i.e. not part of an assembly, such as a switchboard).</td>
<td>A minimum of 48 inches to a maximum of 66 inches as measured from the centerline of the meter to the standing surface.</td>
</tr>
<tr>
<td>Free-standing, manufactured, meter-panel enclosures, multimeter panels, or assemblies where a minimum of a 36-inch to a maximum of a 75-inch socket is placed in a factory-assembled structure (e.g. meter pedestal).</td>
<td>Please refer to the Electric and Gas Service Requirements manual (Greenbook)</td>
</tr>
<tr>
<td>Agricultural and other pole-mounted services.</td>
<td>The height from the ground to the top of the meter-socket enclosure must be 72 inches. However, the meter height may be reduced to 48 inches if the service-entrance conduit attached to the pole is made of galvanized, rigid steel or PVC Schedule 40, and is at least 2 inches in diameter.</td>
</tr>
</tbody>
</table>

4.23. Telemetering Requirements

If the meter is read via a telephone line, the customer is responsible for installing the line and establishing service. If a land line is unavailable, and cellular signals are acceptable, a cellular phone may be used.
If the meter’s telephone line cannot be dedicated to the meter, the customer, with the approval from PG&E’s local metering group, may arrange to use a line sharing switch.

The telephone-line termination in switchboards, panels, pole-mounted meters, and pedestals must be installed to meet the following requirements:

- Be located within 5 circuit-feet from the centerline of the meter.
- Have a height between a minimum of 18 inches and a maximum of 72 inches above the finished grade.

When cellular telephones are used, the same location requirements apply to the power supply when measured from the load side of the meter and located outside PG&E’s sealable section.

### 4.24. Communication

PG&E may require that communication circuits be installed to provide protection, Supervisory Control & Data Acquisition (SCADA), and voice communication between PG&E and the customer’s generation facilities.

The customer is responsible for the monthly costs and the costs associated with the installation of EMS, SCADA and protection circuits. In addition, the customer is responsible for the costs incurred by PG&E personnel while involved in assisting the telephone company personnel in making repairs to the leased circuits.

When external communication circuits are installed, the responsible party must ensure that the high-voltage protection (HVP) on these circuits and related equipment meets all the applicable standards.

### 4.25. Operation Requirements

If the unit is equipped with a disconnect switch, the switch must be accessible to PG&E employees. When maintenance or other work procedures are scheduled, this disconnect switch may have to be opened and locked for the protection of PG&E employees.

#### 4.25.1. Normal Voltage Operating Range

PG&E may have specific operating-voltage ranges for larger generating facilities (larger than 11 kVA), and may require adjustable operating-voltage settings for these larger systems.

In the absence of such requirements, the operating window must be set in a way that minimizes nuisance tripping and ranges between 88% and 110% of the appropriate interconnection voltage.

To minimize the adverse voltage effects experienced by other customers on PG&E’s electric system, any voltage flicker at the point of common coupling (PCC) caused by the generating facility
must not exceed the limits defined by the “Maximum Borderline of Irritation Curve” shown in the Institute of Electrical Engineers (IEEE) 519.

4.25.2. Other Requirements

The maximum capacity for single-phase generating facilities connected to a shared, single-phase secondary must not exceed 20 kVA.

Customers must install a 240 V service for generating facilities with a center-tap neutral so that no more than 6 kVA of imbalance capacity exists between the two sides of the 240 V service.

4.25.3. System Upgrades

After PG&E’s engineering department’s review, PG&E may require system upgrades so that the system is able to accommodate the interconnection of the distribution generation (DG) system.
Section 5
Portable, Emergency, Standby Generators Interconnection

5.1. Introduction

During a power outage, customers can use an electric generator as a standby system to keep lights and appliances running until service is restored.

A generator can power the refrigerators, freezers and other essential equipment during a prolonged outage. However, generators are expensive and noisy, and can pose serious safety hazards. Therefore, customers must follow all the manufacturer’s safety instructions.

According to the law, customers are not allowed to connect a permanently-installed or portable generator to another power source, such as PG&E’s power lines.

Owners and operators of generators are responsible for ensuring that the generators are used correctly, and that the electricity from the unit does not “backfeed,” i.e., flow into PG&E’s power lines. If the generator is not used correctly, it may endanger lives and damage property.

5.2. Portable Generators

Customers must follow the safety requirements listed below:

• Connect portable generators only to selected appliances or lamps.
• Do not connect portable generators directly to a building’s wiring system.
• Read and follow all of the manufacturer’s instructions carefully, before starting the generator.
• Ensure that the total electric load on the generator does not exceed the manufacturer’s rating.
• Install the generator at a location where the exhaust vents safely.
• Prioritize electrical needs by doing the following:
  – Use the lowest wattage of light bulbs that can still provide a safe level of light.
  – Reserve power for additional lighting elsewhere or for small appliances.

Remember that the greater the load on the generator, the more fuel it will use.

• Keep cords out of the way so that they will not be a tripping hazard, especially in dimly lit doorways or halls. Customers must never run cords under rugs or carpets where heat may build up or damage to a cord may not be noticed.
• Extension cords must be properly sized to carry the electric load. Overloaded cords can overheat and cause fires or damage to equipment.

5.3. Standby Generators

Only a qualified professional, such as a licensed electric contractor, may install a permanent standby generator.

When a generator is permanently connected to a customer’s electric system, it energizes the building’s wiring. This type of installation requires a device that prevents the generator from being connected to PG&E’s power lines.

PG&E recommends using a double-pole, double-throw transfer switch to keep the generator from backfeeding into PG&E’s system.

(To see a diagram of a transfer switch, please refer to Figure 5-1 below or http://www.pge.com/004_safety/images/transfer_large.gif)

Figure 5-1
Transfer Switch

• Keeps PG&E’s power from re-energizing the building’s wiring while the generator is running.
• Protects the generator, wiring, and appliances from damage when the service is restored.
5.3.1. Safety Requirements

- The city or county building department must inspect all additions to the building’s wiring.
- When the customer completes the installation, the customer must inform PG&E of the back-up system, so that, when there is an outage, PG&E’s workers will be aware of the generators in the area. In some cases, PG&E line workers may ask to check the electric generator’s transfer switch for safety purposes.
- Customers should call the local building inspector or a licensed contractor for help determining if a permanently-installed standby generator is installed properly.
- Customers who have installed or operated the generators improperly are responsible for any injuries and damages to the property of the customer, neighbors, or PG&E.

5.4. Emergency Generators

There are two methods of transferring an electric power supply between the PG&E source and the emergency generator system:

- Open transition (“break before make”).
- Closed transition (“make before break”).

5.4.1. “Break Before Make”

Customers may transfer loads using the “break-before-make” method via a double-throw transfer switch or an interlock scheme that prevents the two systems from operating in parallel.

The circuit breaker that supplies power from PG&E to the customer must open before the customer’s generator closes. This open-transition method does not require any additional protective equipment; however, it does cause the customer to experience a short outage while transferring back to PG&E. The length of this outage depends on the transfer equipment.

5.4.2. “Make Before Break”

The “make-before-break” method is used when the customer wants to minimize any loss of power or disturbance to its electric load during a system outage.

With the “make-before-break” method, the customer’s generator and PG&E’s electric system are in parallel for the very short interval during which the customer’s load is being transferred between the PG&E source and the emergency generator.
The transfer of load from PG&E to the emergency source and back to PG&E can be done without causing the customer to experience an outage.

5.4.3. **Interconnection Requirements**

The list below gives the requirements for interconnecting emergency generators that use open or closed transfer schemes.

5.4.3.1. **Interconnection Study**

A study is not required if the applicant meets the requirements outlined in this section and submits the required reports and drawings for review and approval.

5.4.3.2. **Transfer Switch**

The transfer switch must be rated for the maximum possible load current.

5.4.3.3. **Notification and Documentation**

The customer must notify PG&E in writing regarding all emergency generator installations, regardless of the method of interconnection or transfer.

The customer must submit completed documentation that includes, but is not limited to, the following information:

- A description of the generator and control-system operation.
- Single-line diagrams of the customer’s system.
- Identification of all interlocks.
- A description of the sequence of events for transfer operation and the specifications for any PG&E-required protective devices.

PG&E must conduct relay tests and approve all documentation before the customer’s system is installed.

PG&E must review and approve the relay test reports at least 15 days before scheduling the preparallel inspection.

5.4.3.4. **Operation/Clearance**

For the purposes of any clearance or line work, the customer must consider the emergency generator as a power source.

Before a customer may perform any load transfers by the “make-before-break” transfer method, the customer must notify the responsible operation center of the intent to transfer load to the emergency generator and back to the
PG&E power source. This notification is not required for “break-before-make” operation.

5.4.3.5. “Break-Before-Make” Transfer Switch: Specific Requirements

The customer must ensure that the transfer switch has an interlock or other means to prevent it from closing and connecting the customer’s system to PG&E’s, while the emergency generator is still connected to the customer’s load.

5.4.3.6. “Make-Before-Break” Requirements

5.4.3.6.1. Transfer Switch

In the event that the transfer switch closes into a fault condition, the transfer switch must be rated for the level of fault possible in the system.

In the event that the transfer switch fails, the customer must ensure that there is an interlock that will trip either the main or the generator’s circuit breaker, so that the unit will not remain paralleled to PG&E’s electric system.

The controls for the transfer switch must prevent parallel operation of the customer’s generator and PG&E’s electric system for an extended period of time.

Customers who have systems that allow parallel conditions to exist for more than 0.5 seconds (30 cycles) on the transmission system and more than 1 second (60 cycles) on the distribution system must meet an additional set of requirements outlined in Section 4, “Rule 21 Generating Facility Interconnection,” of this manual.

5.4.3.6.2. Manual Disconnect

The customer must provide a manual disconnect, located at the point of interconnection, that may be used to establish a visually open safety clearance to protect PG&E’s employees working on PG&E’s electric system.

The manual disconnect must be:

- Operated by PG&E.
- Lockable in either the opened or closed transition.
• Easily accessible (preferably located adjacent to the electric meter).

• Have a full load-break capability.

5.4.3.6.3. Synchronizing Function

The customer must do the following to ensure that the load is transferred safely and smoothly:

• Ensure that the transfer scheme has adequate controls and protective devices.

• Use an auto synchronizer or a synchronizing relay to ensure that the customer’s electric system synchronizes with PG&E’s system before the two systems are paralleled.

The auto synchronizer or synchronizing relay must have:

• Slip frequency matching of 0.1 Hz or less.

• Voltage matching of ± 10 % or less.

• A phase-angle acceptance of ± 10 º or less.

• A circuit breaker closure-time compensation.

5.4.3.6.4. Protection

The emergency generators are paralleled with PG&E’s electric system. Therefore, in the event of a fault on the system during a load transition, the customer must have protective devices to prevent the customer’s generator from remaining connected to PG&E’s electric system.

It is important to prevent damages on the customer’s equipment, PG&E’s electric system, and other PG&E customers’ equipment caused by possible back-feeding of the customer’s power to the PG&E system.

In most installations, the customer installs a reverse-power relay to meet this protection requirement.

The customer must install this relay on the customer’s side of the service transformer that is connected to PG&E’s electric system.

To ensure that reverse power flow is detected before it actually enters PG&E’s electric system.
and other customers’ equipment, the relay must meet the following requirements:

- Be able to trip the customer’s main circuit breaker.
- Be able to detect the transformer core’s magnetizing power.

To ensure that the relay meets the requirements, the customer must set the current-level pickup to be equivalent to 60% of the transformer bank’s magnetizing current. Because this current value will be small, the current transformers associated with the relay must be capable of carrying small currents.

When transferring the customer’s load back to PG&E’s electric system, incidental power may flow back to PG&E’s system. Properly setting the synchronizing and/or generator control will avoid this reverse flow.

To prevent the reverse-power relay from unnecessarily tripping the generator each time there is a transfer, a short delay may be required. However, this delay must not exceed 1 second.

5.4.3.6.5. Dedicated Transformer

Due to the fact that the emergency generator may be connected in parallel with PG&E’s electric system, all transfer schemes of the “make-before-break” type must have a dedicated transformer.

The use of dedicated transformers makes it less likely that other PG&E customers will be affected by transfer activities. In addition, customers need a dedicated transformer to install the reverse-power relay scheme.
Section 6
Technical Requirements for Load Entities

6.1. Purpose

This section specifies the technical requirements for electric load customers interconnecting to the Pacific Gas and Electric Company’s (PG&E) primary distribution system. It applies to all existing, as well as all new, primary service (PS) customers.

If the interconnection involves load and generation, the information in the following generation sections applies:

- Section 3, “Expanded E-NET Interconnection”
- Section 4, “Rule 21 Generating Facility Interconnection”

6.2. Applicability

The applicable protection standards of this section apply to all PS customers interconnecting to any part of PG&E’s primary distribution system.

To ensure consistency with the applicable reliability criteria, PG&E has developed protection standards to govern the design, inspection, and testing of the protective devices.

6.3. Requirements For Load Interconnection

It is important to minimize the potential hazard to life and property when interconnecting facilities to the PG&E distribution system. Safety requires the automatic detection of abnormal conditions and trouble related to a PS customer’s equipment and the isolation of that equipment within a reasonable time.

The most important system troubles are faulty equipment conditions such as short-circuit problems.


Moreover, interconnection of a new facility to the PG&E distribution system must not degrade any of the existing PG&E protection and control schemes or lower the existing levels of safety and reliability to other customers.

As a general rule, neither party must depend on the other for the protection of its respective equipment. As such, PG&E’s minimum protection requirements are designed and intended to protect the PG&E power system only. Refer to CPUC Rule 21 of additional information. (See Attachment 11.)
In view of these objectives, PG&E requires that the protective equipment automatically be able to detect and rapidly isolate only the faulty equipment or section, so that only the faulty equipment or section is interrupted and the fewest number of customers are affected by any outage.

The PS customer is responsible for protecting its own system and equipment from faults or interruptions originating from both PG&E’s and the PS customer’s side of the interconnection.

The PS customer’s facilities must be designed to isolate any fault or abnormality that could affect adversely the PG&E electric system or the electric systems of other entities connected to the PG&E electric system.

The PS customer must ensure that any protective function(s), required for interconnection to PG&E meet either of the following two criteria:

- The protective device(s) is listed on Table 6-3, “Utility-Grade Relays for Generation Application,” on Page 6-9, or
- The protective device(s) has been tested for PG&E-specified functions by a test facility acceptable to PG&E.

PG&E’s typical minimum requirement consists of installing three, single-phase overcurrent relays, designed and set to trip the interrupting device nearest to the point of interconnection with PG&E.

The PS customer must provide, install, own, and maintain such protective relays, interrupting devices, or circuit breakers and all other devices necessary to remove promptly any fault condition caused by the PS customer’s facilities that contributes to any short circuit occurring on the electric system not otherwise isolated by PG&E’s equipment.

Please refer to Table 6-3, “Utility-Grade Relays for Generation Application,” for a list of the approved types of overcurrent relays and for additional information.

Notes

1. The PS customer must set the required relays to coordinate with the appropriate PG&E devices.

2. The PS customer is responsible for the cost of installing additional protective equipment requirement. PG&E will communicate and coordinate the installation of additional protective equipment with the PS customer.

PG&E assumes no liability for damage to the PS-customer-owned facilities resulting from a lack of adequate coordination between the PS customer’s protective device(s) and PG&E’s protective devices, or negligence due to the PS customer’s failure to maintain protective and/or isolation equipment.

These facilities, in addition to other protection facilities, are termed “system protection facilities.”
PG&E recommends that the PS customer acquire the services of a qualified and licensed electrical engineer to review its plans. The PS customer must, at its expense, install, operate, and maintain system protection facilities in accordance with all applicable regulatory rules and requirements, and in accordance with this handbook.

The customer’s primary protective device must be installed at a PG&E-designated service delivery point. The service delivery point must be at or near the customer’s property line. The drawings in Figures A3-1 through Figures A3-5 provide a uniform approach to what is acceptable to PG&E for the location of the PS customer’s protective device.

The relays must be tested before energizing and a test report submitted to PG&E (see Attachment 12, Form G2-2, “Relay Test Report”). The relays must be tested every 4 years after the initial energization and the report sent to the PS customer’s local PG&E account representative. The PG&E account representative will coordinate all communication between the PS customer and the local PG&E electric planning department.

The following are the test requirements that the PS customer must perform on-site (generic test reports are not allowed) before energizing:

- At least 10 working days before energizing, the PS customer must provide on-site test reports to PG&E from a qualified testing firm. Please refer to Section 6.10., “Preparallel Inspection,” on Page 6-14 for information regarding parallel inspections.
- On-site power (typically 120 volts alternating current [Vac]) is required for the test equipment.
- Circuit breakers must be tested every 8 years after the preparallel inspection.

Facilities that fail to meet the above testing requirements are subject to either a delay in service or disconnection from the PG&E power system.

### 6.3.1. Data Provided by the Applicant

The customer’s load interconnection must not impact adversely the service reliability of other PG&E customers that are served via the same distribution system as the PS customer.

The following are the responsibilities of PS customers:

- To install, set, and operate their primary protective devices to isolate the PS customer from PG&E, when problems occur on the PS customer’s system.
- To coordinate their protective devices with the appropriate, PG&E, source-side protective equipment.

A PS customer must ensure that the coordination of the PS customer protective equipment meets the criteria outlined in the PG&E protection standards that are provided to the customer or its representative.
The PS customer is responsible for owning, operating, and maintaining all the required protective equipment.

The PS customer is responsible for providing the information necessary for PG&E to determine the interconnection requirements before PG&E approves the specific PS installation. This information includes, but is not limited, to the following:

- Single-line diagrams.
- Meter and relay diagrams.
- Control diagrams.

The following is a list of the protective-relay information required (if applicable) for interconnection and coordination with PG&E’s protective devices:

- Manufacturer
- Style
- Types
- Ranges
- Settings

In addition, the PS customer must provide the following information:

- A copy of the relay instruction manual for devices that are not commonly used by PG&E.
- The projected electrical demand (kW), including the following information:
  - Power factor.
  - Load factor.
  - Large motor sizes.
  - Starting currents.
  - Customer’s transformer size.
  - Breakdown of the electric energy use by month.

Before energizing the new PS facility, the PS customer must complete the following activities:

- Submit to PG&E the on-site test reports for the switches, devices, and relays at least 10 working days prior to the scheduled energization date, in order to allow sufficient time for review, modification, and PG&E’s approval. Qualified personnel must perform these on-site test reports.
- Complete a fault study and coordination studies with full-size phase and ground coordination curves showing full coordination with PG&E’s system.
The PS customer, or its representative, must provide the results of the coordination studies to the PG&E’s electric distribution engineering department to validate the relay coordination times and relay settings.

A registered electrical engineer must prepare and stamp the fault-study results.

- Provide a documented maintenance program for the switches, interrupting devices, and protective equipment.
- Ensure that PG&E employees do a preinterconnection or preparallel inspection to verify the proper operation of the customer’s equipment.

### 6.3.2. Data that PG&E Provides to the Applicant

PG&E provides the following engineering data to the PS customer:

- System fault duty at the property line.
- Settings for PG&E source-side protective devices and the required clearance time to comply with PG&E protection standards.
- Relay curves for PG&E source-side protective devices, if requested by the PS customer.

### 6.4. Reliability and Redundancy Specifications for Relays

The applicant’s protection system must be designed with enough redundancy that the failure of any one component still allows the facility to be isolated from the PG&E system under a fault condition.

All load facilities interconnected to PG&E’s distribution system must use utility-grade relays, which are much more accurate and reliable than industrial-grade relays.

Utility-grade auxiliary relays must be used in the tripping circuits of utility-grade protective relays. All such relays must include relay targets that can be reset manually. The relays’ power supplies must be powered by a station battery supplying direct current (dc) voltage and must include a dc-undervoltage detection device and alarm.

The PS customer must submit all proposed relay specifications and settings to PG&E for approval before ordering, if the relays impact PG&E’s reliability and/or safety. (Please refer to Table 6-3, “Utility-Grade Relays for Generation Application” on Page 6-9.)

PS customers who fail to submit relay specifications for approval risk the possibility of not being able to interconnect with PG&E (please refer to “Rule 2 - Description of Service” at http://www.pge.com/customer_services/business/tariffs/pdf/ER2.pdf on in Attachment 10).
If PG&E is unfamiliar with a specific proposed relay, PG&E may do one of the following:

- Test the relays that the PS customer provided.
- Request that the PS customer supply test and supporting data from the manufacturer. Such tests must be performed at the PS customer’s expense and before PG&E’s approval of the relay for interconnection use\(^2\).

**Note:** PG&E’s approval of the relays does not indicate the quality or reliability of a product or service. No endorsements or warranties are implied.

The PG&E-required relays must be able to detect all phase and ground faults and coordinate with the appropriate PG&E line equipment.

**Table 6-1  Basic Protective Devices**

<table>
<thead>
<tr>
<th>Protection Device</th>
<th>Device Number</th>
<th>34.5 kV or less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Overcurrent (Radial systems)</td>
<td>50/51</td>
<td>X</td>
</tr>
<tr>
<td>Ground Overcurrent (Radial systems)</td>
<td>50/51N</td>
<td>X</td>
</tr>
</tbody>
</table>

Please refer to Table 6-2 for device-number definitions and functions.

**Table 6-2 Standard Device Numbers**

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Definition and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td><strong>Instantaneous overcurrent, or rate-of-rise relay</strong> is a device that functions</td>
</tr>
<tr>
<td></td>
<td>instantaneously on an excessive value of current, or on an excessive rate of current</td>
</tr>
<tr>
<td></td>
<td>rise, indicating that a fault in the apparatus or circuit is being protected.</td>
</tr>
<tr>
<td>51</td>
<td><strong>AC time overcurrent relay</strong> is a device with either a definite or inverse time</td>
</tr>
<tr>
<td></td>
<td>characteristic that functions when the current in an ac circuit exceeds a predetermined</td>
</tr>
<tr>
<td></td>
<td>value.</td>
</tr>
</tbody>
</table>

**6.4.1. Fault-Interrupting Devices**

For each particular application, PG&E must review and approve the fault-interrupting devices that the PS customer selects.

There are two basic types of fault-interrupting devices available for distribution systems:

- Circuit breakers
- Fuses

PG&E determines the type of fault-interrupting device a load facility needs based on the following criteria:

- Availability of fault duty at the interconnection point.
- Size of the load.

---

\(^2\) There are additional system tests associated with communication-assisted protection. These tests (also referred to as end-to-end satellite tests) require all terminals of a transmission line be tested as a system and include the protection, communication equipment and medium between the interconnected terminals. Please refer to Attachment 6 for more information.
• Configuration of the local circuit.
• Coordination with the existing PG&E protection equipment.

6.4.1.1. Circuit Breakers

When a circuit fault is detected, a three-phase circuit breaker at the point of interconnection automatically separates the PS customer’s equipment from PG&E’s system.

The PS customer may install additional circuit breakers for operating and protecting the facility. However, PG&E does not require that the PS customer install these additional circuit breakers.

The interconnection circuit breaker must have sufficient capacity to interrupt the maximum available fault current at its location. It must be equipped with accessories to perform the following functions:

• Trip the breaker with a trip signal supplied through a battery external to the circuit breaker (shunt trip).
• Lock out, if operated by protective relays required for interconnection.

Generally, a three-phase circuit breaker is the recommended fault-interruption device at the point of interconnection because it has a three-phase operation and the ability to coordinate with PG&E’s line-side devices.

6.4.1.2. Fuses

PG&E may approve the use of fuses for load-only facilities, if the fuses coordinate with the PG&E line-side devices for both phase and ground faults. If PG&E approves the fuses, the PS customer should consider installing a negative-sequence relay and/or other devices to protect its facility against single-phase conditions.

Fuses are single-phase, direct-acting, sacrificial links that melt to interrupt fault current and protect the equipment.

The PS customer must replace the blown fuses manually after each fault before the facility can return to service. Only trained, qualified personnel can replace the overhead primary fuses.

Since fuses are single-phase devices, they may not all melt during a fault and may not separate the PS customer’s system automatically from PG&E.

Large primary fuses that do not coordinate with PG&E’s source-side protective phase and ground relays are not allowed. These fuses may cause all the customers on the
6.5. Standby/Backup Source

6.5.1. Standby Source

When the PS customer’s load requires a high level of reliability, the PS customer may request to have either a transmission source installed or a backup distribution and transmission source installed at the PS customer’s expense.

When the PS customer’s load is transferred from the primary source to the standby source or vice versa, a momentary outage (“drop-and-pickup” operation) occurs.

When the PS customer’s equipment is being fed from the backup source and the PS customer wants to transfer the load back to the primary source with a parallel operation (“make-before-break” method), the PS customer must ensure that the following requirements are met:

- The ratios and electrical connections of the transformers on both sources must be well matched to minimize circulating currents.
- The impedance of the transformers and the relative phase angles of the sources must be such that any “through load” (i.e., flowing of power through the PS customer’s electrical system to other customers) does not cause overloads.
- The parallel transfer operation must not degrade protection or overstress PG&E’s or the customer’s equipment.
- The transfer switches, one on each side of the PS load, must be controlled by an automatic-interlock scheme to minimize the time the two systems are paralleled. The transfer switches must be circuit breakers or other suitably rated, automatically controlled switches.

Note: The parallel period must be less than one second because the presence of two parallel circuits will increase the fault duty and may overstress the PS customer’s equipment.

- Each parallel transfer operation can only proceed after PG&E’s specific approval.

In some cases, additional protective devices and special operating procedures may be required to avoid endangering the customer’s and/or PG&E’s facilities.

The PS customer must obtain PG&E’s approval before performing the parallel transfer operation. PG&E may
withhold approval if, in its sole judgment, the above requirements have not been met, or if a previously unforeseen factor or change in conditions is deemed to jeopardize the operator, public safety, or reliability to customers.

- The PS customer must assume all liability for any problems or damage resulting from any parallel transfer operation.

### Table 6-3 Utility-Grade Relays For Generation Application

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Nondirectional Overcurrent Relay 50/51</th>
<th>Nondirectional Overcurrent Relay Ground 51N</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB (ASEA) (Westinghouse)</td>
<td>RXIDF</td>
<td>Microshield (MSOC)</td>
</tr>
<tr>
<td></td>
<td>CO</td>
<td>RXIDF</td>
</tr>
<tr>
<td></td>
<td>DPU-2000R</td>
<td>DPU-2000R</td>
</tr>
<tr>
<td>ALSTOM</td>
<td>MCGG</td>
<td>MCGG</td>
</tr>
<tr>
<td>Basler Electric</td>
<td>BE1-51</td>
<td>BE1-51</td>
</tr>
<tr>
<td>Beckwith Electric</td>
<td>M-0420</td>
<td>M-0420</td>
</tr>
<tr>
<td></td>
<td>M-3410</td>
<td>M-3410</td>
</tr>
<tr>
<td></td>
<td>M-3420</td>
<td>M-3425</td>
</tr>
<tr>
<td></td>
<td>M-3430</td>
<td>M-3520</td>
</tr>
<tr>
<td>Brush Electric</td>
<td>IFC</td>
<td>IFC</td>
</tr>
<tr>
<td>General Electric</td>
<td>SR-489</td>
<td>SR-489</td>
</tr>
<tr>
<td></td>
<td>SR-745</td>
<td>SR-745</td>
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<tr>
<td></td>
<td>L-90, T-60</td>
<td>L-90, T-60</td>
</tr>
<tr>
<td></td>
<td>SR-735</td>
<td>SR-735</td>
</tr>
<tr>
<td></td>
<td>SR-737</td>
<td>SR-737</td>
</tr>
<tr>
<td>Schweitzer</td>
<td>SEL-251</td>
<td>SEL-251</td>
</tr>
<tr>
<td></td>
<td>SEL-311C</td>
<td>SEL-311C</td>
</tr>
<tr>
<td></td>
<td>SEL-321</td>
<td>SEL-321</td>
</tr>
<tr>
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<td>SEL-351</td>
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<td>SEL-501</td>
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</tr>
<tr>
<td></td>
<td>SEL-387</td>
<td>SEL-387</td>
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<tr>
<td></td>
<td>SEL-387E</td>
<td>SEL-387E</td>
</tr>
<tr>
<td></td>
<td>SEL-587</td>
<td>SEL-587</td>
</tr>
<tr>
<td>Woodward</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 All the relays specified in this table imply three single-phase relays.
2 All microprocessor-based relays that are used as a multifunctional protective device must have backup relays.
6.6. Metering Requirements

This section addresses direct access (DA) and bundled-service PS customers, who are connected at distribution voltages (34.5 kV and below), as described in Rule 2, Section 13, “Service Delivery Voltages.” (See Attachment 10.)

Customers connected at the available service voltages must satisfy PG&E’s revenue-metering requirements and those of other applicable governing authorities (i.e., California Public Utilities Commission [CPUC], California Independent System Operator [CAISO], etc.).

For customers exporting power, loads connected at distribution voltages must satisfy the metering protocols established by PG&E and CAISO. Exceptions will be handled on a case-by-case basis with approval from PG&E’s Customer Metering Services in close coordination with Field Metering Services.

Other arrangements that affect the required metering installation may also require a “Generation Special Facilities Agreement.” (See Attachment 12.)

6.7. Types of Distribution Services

The two types of distribution services are:

- Wholesale
- Retail (i.e., end-users)

6.7.1. Wholesale Service

For wholesale-service interconnections, the PS customers must provide, install, own, and maintain all revenue-metering-related equipment, including all the items provided and maintained by PG&E or a Meter Service Provider (MSP) listed under “Retail Service” below.

PS customers who are interested in wholesale service must meet the following criteria:

- CAISO metering standards.
- CPUC-approved metering standards.
- PG&E’s requirements.
- Enter into a Meter Service Agreement (MSA) with the CAISO and, in certain cases, with PG&E. The MSA specifies requirements regarding the retrieval of load data and accessibility by CAISO.

The wholesale PS customer is responsible for ensuring that the meters comply with CAISO’s meter standards and accuracy requirements.
All PS customers must contact PG&E’s local account services representative for PG&E’s revenue-metering requirements.

6.7.2. Retail Service (End Users)

“Rule 22 Direct Access Service” governs the interconnection and operating requirements for DA customers.


According to Rule 22, customers have the opportunity to acquire their electric power needs under the following two options:

- Bundled Utility Services - traditional service from PG&E.
- DA – customers purchase energy from various suppliers and related services from Energy Service Providers (ESPs).

6.7.2.1. Bundled Services

For bundled (full-service) utility services, PG&E, in most cases, continues to provide the following services:

- Own, provide, and maintain metering equipment, including the meter.
- Read the meter.

Customers returning to bundled service may own the meter, if the meter is supported by PG&E. In the event that the customer’s meter becomes nonfunctional, PG&E will replace the meter with an equivalent meter and return the former meter to the customer (end-user).

6.7.2.2. Customer Meter Options

Customers may obtain meters in the following ways:

- DA customers, PG&E, or the ESP may own the hourly meter.
- The ESP can be its own MSP or hire an MSP to maintain metering equipment compliance.
- The ESP may also act as its own Meter Data Management Agent (MDMA) or hire an MDMA to read the meter and maintain the meter data.
- PG&E can perform metering services or meter-data management, if contracted to do so.
- PG&E retains the right to physically access any hourly or monthly meter data.
- PG&E continues to read, test, and inspect the meters on PG&E’s system.
6.7.2.3. PG&E Is the MSP

PG&E, as the MSP, continues to provide, install, maintain, and test the following:

- Revenue-metering instrument transformers (voltage transformers and current transformers), which are considered part of the distribution system per CPUC decision D.97-10-087, dated October 30, 1997.

The use of combination revenue-metering units is preferred for customers being served at 34.5 kV. The Engineering Document 058779, “Pole Top Primary Metering Installation, Cluster Mounted (12 or 21 kV Line),” in Attachment 3, shows typical, distribution pole-type metering.

- Secondary wiring from the base of the metering transformers to the revenue meter in a customer-supplier dedicated raceway (conduits) used solely for revenue metering.

- Meters and associated metering devices such as isolation relays, test switches, etc.

6.7.2.4. PG&E Is the MDMA

PG&E, as the MDMA, continues to provide the following services:

- To read raw meter data from the interval meter.
- To validate, edit, and estimate the data of a settlement-quality form.
- Place the settlement-quality data on the MDMA server and, if necessary, perform usage adjustment.

6.7.2.5. Customer Responsibilities

The customer (end-user) maintains the following:

6.7.2.5.1. The Meter Enclosure

To maintain the required metering accuracy, the distance between the meter enclosure and the revenue-metering transformers must not exceed 50 feet.

PG&E must approve any variance from this general rule to avoid any metering inaccuracy. The enclosure must be grounded and located within the substation ground grid. Access must be readily available for PG&E employees to read and maintain the metering equipment.
The enclosure must be equipped with the following items:

- An auxiliary 120 V duplex plug.
- An overhead light.
- A light switch adjacent to the door.
- A ground bus connected to the ground and mounted near the bottom of the wall where the meters are located.

Please refer to PG&E’s *Electric and Gas Services Requirements*, Section 9, and Engineering Document 058779, “Pole Top Primary Metering Installation, Cluster Mounted (12 or 21 kV Line).” (See Attachment 3.)

### 6.7.2.5.2. PG&E-Approved Meter Panels

Please refer to PG&E’s *Electric and Gas Services Requirements*. (http://www.pge.com/002_biz_svc/002b4b_green_bk.shtml)

### 6.7.2.5.3. The Pull Line

The customer must install a pull line in the conduit between the metering enclosure and the junction box at the base of the metering-unit support structure to facilitate the MSP’s installation of the metering-unit secondary wires.

The customer must install only the MSP’s revenue-metering wire in the conduit between the metering enclosure and the current transformer/potential transfer (CT/PT) units. Conduits may be metallic or nonmetallic.

### 6.7.2.5.4. Telephone Lines Into the Metering Enclosure

If a telephone line is required to read the meter, the customer is responsible for installing the line into the metering enclosure and establishing telephone service. If a land line is unavailable and cellular signals are acceptable, the use of a cellular telephone is acceptable.

If the meter’s telephone line cannot be dedicated to the meter, the customer, with prior approval from PG&E’s local metering group, may arrange to use a line sharing switch.

The customer must ensure that the telephone line terminations in switchboards, panels,
pole-mounted meters, and pedestals meet the following requirements:

- Located within 5 circuit-feet of the centerline of the meter.
- Located between a minimum of 18 inches and a maximum of 72 inches above the finished grade.

When cellular telephones are used, the same location requirements apply to the power supply, as measured from the load side of the meter. The power supply must be located outside PG&E’s sealable section.

6.8. Revenue Metering Interconnection Point

Customers who are served at distribution voltage must have the revenue meter installed at the point of service or when there is a change in ownership.

High-side metering is PG&E’s preferred metering configuration. However, PG&E will grant exceptions if the customer can demonstrate that high-side metering will impose extraordinary costs or cause significant safety issues.

If low-side metering is justifiable, a 2% adjustment factor must be applied at each stage of the transformation. Line losses are calculated as a function of the maximum load current through, and the electrical characteristics of, the line between the point of service and the point of metering.

6.9. Communications Circuits

PG&E may require communications circuits between PG&E and the customer’s generation facilities for the following purposes:

- Protection
- Energy Management System (EMS)
- Supervisory Control and Data Acquisition (SCADA)
- Voice communications

When external communication circuits are installed, the responsible party must ensure that the high-voltage protection (HVP) equipment on these circuits meets all applicable standards.

6.10. Preparallel Inspection

In order for PG&E to provide the PS customer with a timely pre-energization service, it is important to meet all the deadlines stated in this section.
It is the PS customer’s responsibility to ensure that any inspections required by local governmental and regulatory agencies are complete and any applicable permits are obtained before the energization date.

6.11. Required Tests for the PS Customer’s Equipment Before Energizing

The tests referred to in the sections below apply only to the equipment at the interconnection point, up to and including the main transformer, and the relays, along with the PG&E-required connected circuits.

The items below that are marked ∇ are the common requirements for both fused transformers and transformers protected by circuit breakers. However, fused transformers need to meet only the requirements that are marked ∇.

The customer has to meet the following requirements:

- Ensure that the equipment completes and passes all the tests outlined in the sections below.
- Submit two copies of the test reports to a PG&E representative a minimum of 10 working days before the requested energization date.
- Ensure that all the test reports identify the equipment in their header information and that the identification matches the single-line or three-line diagrams.
- Submit single-line and three-line diagrams of the facility along with the test reports.

The customer must meet all the above requirements and ensure that the test reports are approved at least 3 working days before the requested energization date.

6.11.1. Proving Insulation

A 2,500 volt (V) dc megger or a 1,000 V high-pot test is preferred for any of the insulation tests below, but a 1,000 V megger test is acceptable.

- ∇ The main transformer(s) must be meggered winding-to-winding and each winding-to-ground.
- The circuit breaker(s) at the interconnection point that are operated by PG&E-required relays must be meggered according to Table 6-4 on Page 6-16.
Table 6-4  Circuit Breaker Positions and Connections

<table>
<thead>
<tr>
<th>Circuit Breaker Position</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit breaker open</td>
<td>Each pole to ground, pole 1 to 2, pole 3 to 4, pole 5 to 6</td>
</tr>
<tr>
<td>Circuit breaker closed</td>
<td>Pole 1-ground, pole 3-ground, pole 5-ground</td>
</tr>
<tr>
<td>If the poles are in a common tank or cell</td>
<td>Pole 1 to 3, pole 3 to 5, pole 5 to 1</td>
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</table>

- ∇ All buses from the interconnection point to the main transformer must be meggered phase-to-phase and phase-to-ground.
- ∇ The main transformer(s) and main circuit breaker(s) must have a dielectric test performed on the insulating medium (gas or oil). This test is not required for factory-sealed, circuit-switcher interrupters.
- ∇ If the main transformer is fused, all fuses must be checked for continuity before energizing.

6.11.2. Proving Ratios

∇ The main transformer(s) ratio(s) must be proven by one of the following methods:
- Using a turns-ratio tester.
- Using a voltage-ratio test on the final operating tap. This tap position must be recommended by PG&E to best match the present distribution-system voltages.

6.11.3. Circuit Breakers

The following are the requirements for circuit breakers:
- A minimum-to-trip test at 70% or less of the nominal control voltage must be performed on all circuit breakers or circuit switchers operated by PG&E-required relays.
- The customer must perform a micro-ohm test on the main circuit breaker(s) at the interconnection point.
- The customer must perform a timing test showing the time from the trip initiation to the opening at the main poles.

6.11.4. Current Transformers and Current Circuits

Customers must perform the following tasks for current transformers (CTs) and current circuits:
- Check the saturation on all CTs associated with the required PG&E relays. If this is not possible, a manufacturer’s curve is acceptable.
• Prove the ratio of all CTs by using current (primary to secondary) or voltage (secondary to primary).

• Check the CTs for the proper polarity whenever they feed PG&E equipment.

• Check the CT circuits for the proper connections.

• Check the continuity of the CTs by performing the following tasks:
  – Apply primary current or secondary current at the CT block.
  – Verify that the proper current exists in each phase relay and the ground relay.

Customers must perform each test (primary or secondary) in all combinations to prove that all phase relays and ground relays have proper connections.

In addition, customers must ensure that no loose wiring or parallel current paths exist, by applying or injecting the current to achieve a secondary reading of 5 amperes (A) in each relay.

• Check the single phase on each phase of each current circuit feeding PG&E-required relays.

• Megger the total circuit with the ground wire lifted, to prove that only one ground exists.

6.11.5. Relays/Fuses

The following are the requirements for relays/fuses:

• Customers must ensure that all the relays are utility-grade and PG&E-approved. If multifunctional relaying is used, some form of redundancy is required.

• Customers must keep a full set of replacement fuses (PG&E must approve the size and type) on-site.

• Customers must ensure that all relays are field-tested to specified settings to verify the following items:
  – The minimum operating point at which the relay picks up (minimum pickup).
  – Time delays at three, different, current-test points, in integral multiples of the minimum pickup, that closely characterize the relay time-current curve.
6.12. Energizing

Customers must meet the following requirements before PG&E can begin the energizing process:

- If possible, the customer must use a proven PG&E circuit breaker for the initial energizing of all equipment. A PG&E representative must write a test program outlining all the steps to energize the equipment.
- A PG&E technical representative must witness trip checks of all the required relays. This may require injecting a signal to trigger the relay. This is to prove that the relay will handle the trip current of the circuit breaker and to provide relay targeting. jumpering the studs on the back of the relay is not acceptable.
- After load is placed on the feeder, a PG&E technical representative must witness the reading of the load current in each phase relay and the absence of load current in the ground relay. The PG&E technical representative must then seal the relays. A PG&E technical representative must witness these tests.

The following are the PS customer’s responsibilities:

- To perform all the tests with the PG&E representative as an observer.
- To provide all the test equipment and the qualified personnel to perform the required tests.

6.13. General Notes

- The PG&E system has an A-C-B counterclockwise rotation.
- Before the customer can make any changes to the PG&E-required protection equipment or major substation equipment (transformer, breaker, etc.), the customer must submit the proposed changes to the PG&E representative for review and to the appropriate PG&E engineer for approval.
- Routine maintenance on PG&E-required protective relays and on circuit breaker(s) must meet PG&E’s maintenance and test practices.

After completion of these tests, the customer must submit the test reports to the PG&E representative for review and to the appropriate PG&E engineer for approval.
A PG&E technical representative must reseal the PG&E-required relays at the customer's facilities.

- All questions must be directed to the local PG&E representative.
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Attachment 1
Glossary

This glossary can also be found online at
### Attachment 2
Website Addresses

<table>
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Attachment 3
Drawings

Figure A3-1  Underground Primary Service from Underground Distribution Preferred Service Arrangement Customer’s Termination Facility \( \leq 500 \) Feet From PG&E Splice Box

Figure A3-2  Underground Primary Service from Underground Distribution Non-Preferred Service Arrangement Customer’s Termination Facility > 500 Feet From PG&E Splice Box

Figure A3-3  Underground Primary Service from Overhead Distribution Preferred Service Arrangement Customer’s Termination Facility \( \leq 500 \) Feet From PG&E Pole

Figure A3-4  Underground Primary Service from Overhead Distribution Non-Preferred Service Arrangement Customer’s Termination Facility > 500 Feet From PG&E Pole

Figure A3-5  Overhead Primary Service from Overhead Distribution Preferred Service Arrangement

Figure A3-6  Advanced Electric Systems GC-1000 (grid intertie inverter) No batteries, no transfer or bypass switching

Expanded E-NET Typical Electrical Single-Line Drawing

Rule 21 Example of Single-Line Drawing

Document 053826  Requirements for Distribution Feeder with Synchronous Generating Equipment

Document 058779  Pole-Top Primary Metering Installation, Cluster Mounted (12 or 21 kV Line)

Document 060559  Disconnect Switches for Interconnection with Small Power Producers and Cogenerators

Document 066195  25 kV Underarm Sidebreak Switch
PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.

1. PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.

2. If PG&E’s primary facilities are across the street, PG&E will own and maintain substructures in the franchise area and the customer will own and maintain substructures on private property. PG&E will still provide one continuous pull of cable to customer’s termination facility, not to exceed 500 feet.

Notes:

- Conduit owned and maintained by customer
- Conductor by PG&E
- PG&E provides one continuous pull of cable to customer’s termination facility, not to exceed 500 feet.

Figure A3-1
Underground Primary Service from Underground Distribution
Preferred Service Arrangement
Customer’s Termination Facility ≤ 500 Feet From PG&E Splice Box
**Notes:**

1. PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.

2. If PG&E’s primary facilities are across the street, PG&E will own and maintain substructures in the franchise area and the customer will own and maintain substructures on private property. PG&E will provide cable to the point of service.

---

**Figure A3-2**

Underground Primary Service from Underground Distribution
Nonpreferred Service Arrangement
Customer’s Termination Facility > 500 Feet From PG&E Splice Box
Notes:

1. PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.

2. If PG&E’s primary facilities are across the street, PG&E will own and maintain substructures in the franchise area and the customer will own and maintain substructures on private property. PG&E will still provide one continuous pull of cable to customer’s termination facility, not to exceed 500 feet.

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Figure A3-3
Underground Primary Service from Overhead Distribution
Preferred Service Arrangement
Customer’s Termination Facility ≤ 500 Feet From PG&E Pole

May 1, 2003
Notes:
1. PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.
2. If PG&E's primary facilities are across the street, PG&E will own and maintain substructures in the franchise area and the customer will own and maintain substructures on private property. PG&E will provide cable to the point of service.

Figure A3-4
Underground Primary Service from Overhead Distribution
Nonpreferred Service Arrangement
Customer’s Termination Facility > 500 Feet From PG&E Pole
• Customer provides protective device.
• PG&E approves settings.
• Protective device pole must be as close as possible to metering pole, not to exceed 50 feet.

Note:

PG&E will install a protective device under a special facilities agreement if there are extenuating circumstances that prevent the customer from installing one. This is an exception and will be handled on a case-by-case basis.

Figure A3-5
Overhead Primary Service from Overhead Distribution
Preferred Service Arrangement
Advanced Electric Systems GC-1000 (grid intertie inverter)

No batteries, no transfer or bypass switching
Attachment 4
Equipment

List of Eligible Inverters
Attachment 5
Rule 21 Process

Rule 21 Application/Interconnection Process Flowchart

Rule 21 Generating Facility Interconnections Initial Review Process for Applications to Interconnect Generating Facilities
Attachment 6
Telemetering and Transfer Trip

Telemetering and Transfer Trip
Substation Grounding Requirements
Attachment 8
Generator Automatic Synchronizers

Generator Automatic Synchronizers for Generation Entities
Attachment 9
Generator Protective Relay Requirements

Generator Protective Relay Requirements for Generation Entities
Rule 2, “Description of Service”
Rule 21, “Generating Facility Interconnections”
Attachment 12
Forms and Agreements

Authorization To: Receive Customer Information or Act on a Customer’s Behalf

Generator Interconnection Agreement

Generation Operating Agreement

Generation Special Facilities Agreement

E-9 Checklist   (All Customers Selecting the Schedule E-9 Rate Must Complete the Following Qualifying Checklist)

Form 62-4527 Agreement to Perform Tariff Schedule Related Work

Form 79-280 Agreement for Installation or Allocation of Special Facilities for Parallel Operation of Nonutility-Owned Generation and/or Electrical Standby Service (Electric Rules 2 and 21)

Form 79-285 Pacific Gas and Electric Company’s Special Agreement for Electrical Standby Service

Form 79-756 Natural Gas Service Agreement

Form 79-843 Pacific Gas and Electric Company Standby Account Data Sheet

Form 79-854 Interconnection Agreement for Net Energy Metering for Residential and Small Commercial Solar or Wind Electric Generating Facilities of 10 Kilowatts or Less

Form 79-973 PG&E Generating Facility Interconnection Agreement

Form 79-974 Generating Facility Interconnection Application

Form 79-978 Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1000 kW or Less, Other than Residential or Small Commercial Facilities of 10 kW or Less

Form 79-988 Generating Facility Interconnection Agreement (3rd Party Non-Exporting)

Form 79-992 Customer Generation Agreement (3rd Party Generator on Premises) (Non-Exporting)
### Attachments

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<td>Form 79-994</td>
<td>Application for Interconnecting Residential or Small Commercial Net Energy Metering (E-NET) Customers with Solar or Wind Electric Generating Facilities of 10 Kilowatts or Less</td>
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<td>Form G2-2</td>
<td>Relay Test Report</td>
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<td>Form G5-1</td>
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