

	<b>DISTRIBUTED GENERATION INTERCONNECTION REQUIREMENTS – LOW VOLTAGE DISTRIBUTION SECONDARY SPOT AND GRID NETWORKS</b>	<b>094673</b>
	<b>Asset Type:</b> Electric Distribution	<b>Function:</b> Design, Estimating, and Planning
<b>Issued by:</b> Thomas Cannon (TJCa) <i>Thomas Cannon</i>	<b>Date:</b> 2/10/21	
<b>Rev. #00:</b> This is a new document.		

### Purpose and Scope

This document provides the requirements for connecting Distributed Generation to the Low Voltage Distribution Secondary Spot and Grid Network on the PG&E system in San Francisco and Oakland.

### General Information

1. PG&E has developed the following criteria for the interconnection on Distributed Generation (DG) on the Low Voltage Secondary Network in San Francisco and Oakland. Because of the unique operational requirements of Network Protectors, it is essential to ensure that DGs do not negatively affect the operation of the Network.
2. Unlike radial DG connections, exporting power from the DG back into the PG&E Network system is not allowed due to function of the Network Protectors (NP). The Network Protectors will trip on reverse current as part of their basic design.
3. This document addresses the Spot connections (typically 480V feeding one customer in one building) and the Grid connections (typically 208V feeding several customers). The detailed requirements are listed in the following sections: Network Protectors, NP Operational Requirements, Protection and Fault Analysis, Minimum Load Controls and General Requirements. At the end of this document there is a separate section for the additional requirements for Grid installations.
4. Process Flow Charts for the Spot and Grid are included for better understanding and to determine what work is needed to fulfill the requirements.
5. This document is written in alignment with the proposed guidelines and industry practices as discussed in IEEE 1547.6 2011 (IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks) and the PG&E DIH (Distribution Interconnection Handbook).
6. A key initial decision point for Spot and Grid interconnection is if the DG is < 10% of the minimum load. This threshold determines if further analysis and protective devices are required.
7. For the Spot connections, the DG must be < 50% of the average daily load.
8. For the Grid connections, the aggregate DG generation must be < 10% of the Grid minimum load.
9. DGs are not allowed to be connected to a 2 spot as this creates additional operational complications.
10. PG&E requires warning placards, signs or tags in the vault on all DG projects on the Network to alert company employees of a potential alternate source of power. These signage specifications are not intended to replace any requirements in the National Electric Code (NEC).

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**Network Protectors**

1. The addition of a DG on the Spot or Grid Network should not cause any Network Protector to exceed its fault current rating. The existing Network Protectors will be evaluated for their ability to withstand the projected fault conditions.
2. The fault current of the NP with the addition of the proposed DG will be reviewed by the Network Engineer. If the NP fault current rating will be exceeded because of the DG, then the NP will be replaced, or the design of the DG design will be modified to reduce the fault current.
3. Note that the factory supplied fault current ratings are based on an assumed X/R ratio. This ratio is used to determine the three-phase asymmetrical fault current rating with respect to the symmetrical fault current rating.
4. If the proposed machine-based DG including the secondary cable has an X/R ratio of greater than 7, then fault current must be recalculated using the proposed DG and X/R ratio. Note the average X/R ratio of 7 was determined through Fault Studies on all San Francisco Network groups.
5. Existing NPs may remain, provided that the fault current rating is adequate and:
  - A. The network protector relays are MPCV relays, ETI relays or other PG&E-approved relays, capable of at least 2 set points, one with a time delay. If the existing NP does not have this type of relay, then the relays must be upgraded at the customer's expense.
6. Older style NPs (CM-22, CMD and MG-8) will receive a more detailed review due to their age/capabilities and the possibility of lower fault current ratings.

**Network Protectors Operational Requirements**

The DG Producer will meet the minimum number of NPs closed requirements below:

The DG may not operate in parallel with PG&E unless a minimum number of network protectors are closed. The DG must trip instantaneously when the number of closed network protectors falls below the following the values:

**Table 1 Minimum number of NPs**

Number of Network Protectors in the Spot	Minimum Number of Network Protectors Required in Order for the DG to Operate
3	2
4	2
5	3

**Notes**

1. A GE C-30 relay/controller or other PG&E approved controller is required to monitor the NP minimum number closed. If the minimum number of NPs closed criteria is not met, the relay will trip the DG offline to prevent operational issues on the Network. (GE C-30 Material Code, M590788, 24/48V DC).
2. The cost for controller along with the installation and operating and maintenance costs of the relay/controller will be borne by the DG Producer. The DG Producer shall install and terminate a rigid 2-inch conduit and a pair of wires from the trip device to inside the transformer vault. The location of the conduit core shall be reviewed and approved by PG&E.
3. The DG Producer will provide a 24VDC source from their battery with a charging system for the GE C-30 controller or PG&E approved controller.
4. The DG Producer shall install and terminate a rigid steel 2-inch conduit and two pairs of wires to the inside of the vault. One pair or wires will be from the trip device and one pair from the 24 VDC source.
5. PG&E or contractors approved by PG&E will do the installation of the GE C-30 relay/controller or approved controller in the property owner's transformer vault. See Figure 3 on Page 7.
6. Note that the minimum number of network protectors closed criteria applies only to the Spot connections and does not apply the Grid.

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### Protection and Fault Analysis

1. The presence and operation of a DG on the Spot Network will initiate a detailed Protection Review to be completed by the Division Network Engineer. This work can be subdivided into 3 groups as shown below (Primary, PG&E Secondary and Customer Secondary).

#### 2. Primary Faults

Under fault conditions on the PG&E primary system, the customer's under power relay shall be coordinated with the sensitive time trip of the NP relay such that only the NP on the faulted feeder opens and the Under power relay does not trip the DGs.

A. Under fault conditions on the PG&E primary system on an adjacent primary feeder, a coordination review shall be completed. If coordination is inadequate, either the settings must be changed or the old relays will be replaced with approved microprocessor relays.

#### 3. PG&E Secondary side faults

Under fault conditions on the secondary within PG&E jurisdiction, the Network protectors will remain closed.

#### 4. Customer side Secondary faults

A. Under fault conditions on customer's side of the point of common coupling, the Network Protectors will remain closed.

B. Under fault conditions on the customer's side – Breakers separating all generation must open immediately without any intentional time delay.

### Minimum Load Controls

1. The DG Producer will meet the minimum import requirements below:

A. A redundant PG&E-approved under power (Device 37) relay is required. This device should be either a three-phase relay set for single phase operation or three single phase relays. All three phases need to be monitored such that if any one phase does not meet the minimum import requirement the under-power relay will trip the DG.

B. The device will have the settings of ten percent (10%) of the nameplate rating of the largest single network transformer serving the PG&E secondary spot network bus where the DG is installed.

C. If the minimum import flow is not met, the DG must trip with no intentional time delay to ensure that the DGs trip prior to the network protectors. Redundant protection of the net import minimum power must be provided. Previous project Network DG experience has shown that a DG trip setting of 15 cycles or less is adequate.

D. A meter with kVA summation of multiple services from the spot network bus is allowed on the common spot network bus through one or more DGs. If PG&E's meters do not support summation and protection requirements, the DG Producer shall be responsible for the cost of providing meters capable of supporting summation. This refers to the scenario where there are multiple DGs on multiple main switches. For example, consider the scenario where there are three main switches and a DG on each switch. In that case there should be meters on all main switches and a summation showing net load to the NPs. Another option would be to install six 3-phase under-power relays or eighteen 1 phase under power relays, which would be normal and backup to all three mains. Also, the customer cannot export power from one main switch to another main switch through PG&E secondary cables.

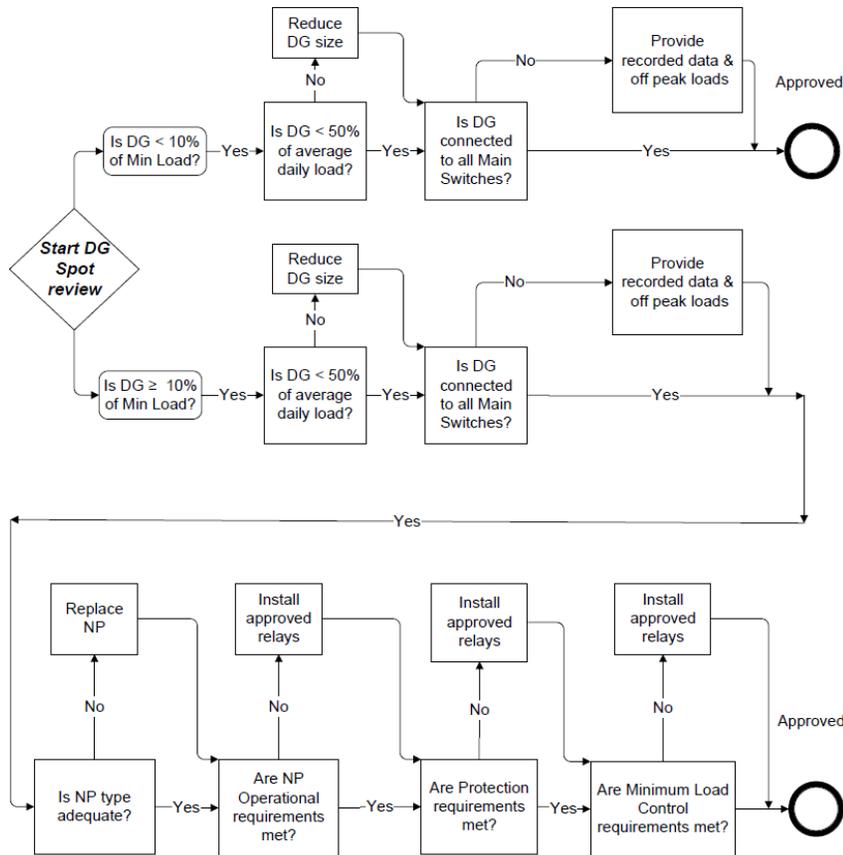
E. As an example of the 10% import setting, consider a 3 spot with 750kva transformers. In this scenario, 10% of 750kVA is 75kva which results in the minimum import setting of 75kva three phase or 25kva per phase.

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**General Requirements**

1. For the Spot connections, the DG must be < 50% of the average daily load. The Network Engineer will evaluate an appropriate period of loading data to ensure that the DG will not produce more energy than the spot consumes at any time.
2. Connections to 4 spots will be given extra analysis due to the concern of the DG causing the NPs to operate or stay open more often than before the DG was connected.
3. Examples of common Network Transformer connections to a 480V Spot are shown below:
  - A. 12kV system: Delta (12kV) / Wye-Grd (480V)
  - B. 34.5kV system: Wye-Grd (34.5kV) / Wye-Grd (480V)
4. The DG Producer will provide all necessary technical requirements as specified in Rule 21, including the protective device settings and frequency/voltage settings.
5. Battery Stem technology typically involving daytime peak shaving strategies is already approved and in operation in the Network on both Spot and Grid applications. For this type of DG, 10% of the daytime peak load should be used since it is programmed to only reduce peak loads which are typically in the daytime hours.
6. For PV installations, 10% of the daytime peak load should be used since the nighttime minimum load is not applicable for PVs. See the minimum load definition on Page 1.
7. PG&E will reserve the right to suspend, change, modify or add to the above conditions based on the results from future test reports or guidelines as they become available.
8. For an overview of the process and better understanding of the requirements, flowcharts for Spot and Grid are included in Figure 1 and Figure 2. The flowchart details for the Spot are written out step by step in Notes 9, 10 and 11 below:

Flow Chart 1 - Distributed Generation Requirements for Spot Networks



**Figure 1**  
**Flow Chart for Distributed Generation Requirements for Spot Networks**

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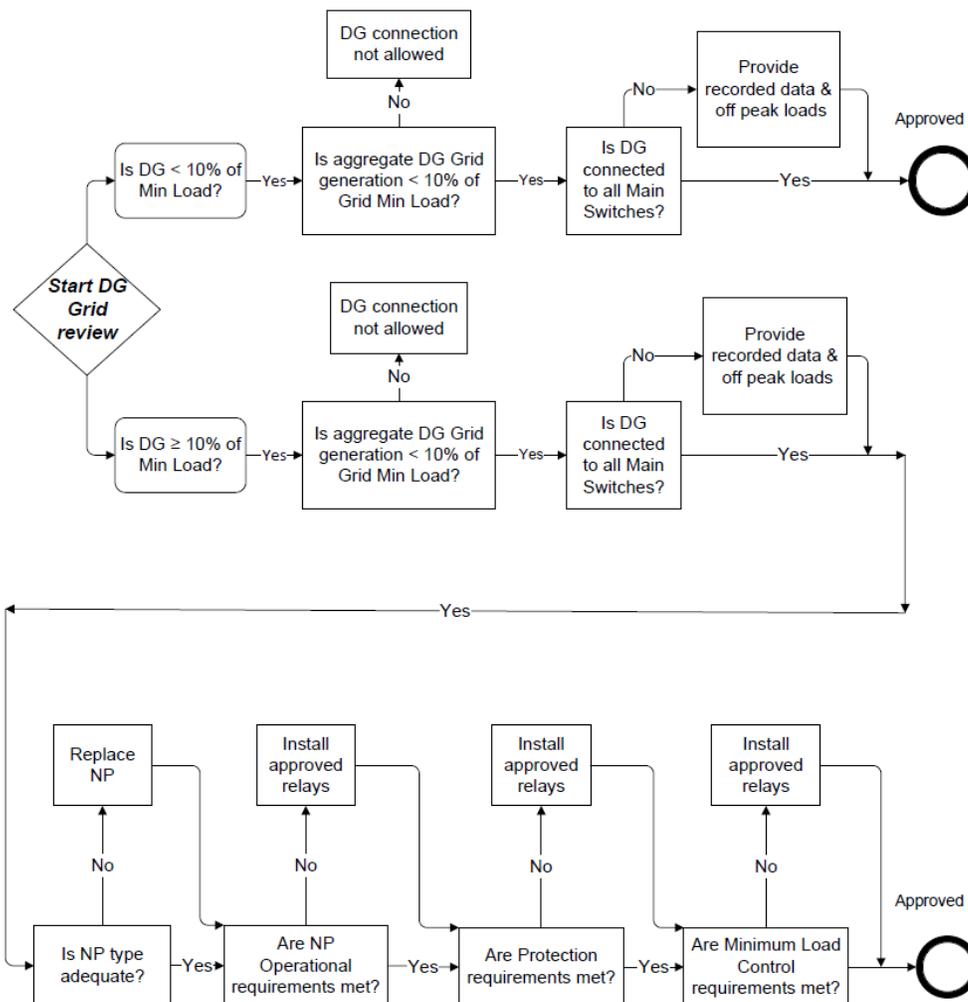
9. Start DG Spot Review (includes Machine based and Certified Inverters for PV and Battery Storage)
10. DG is < 10% minimum load
  - A. If the DG is < 50% of the average daily load of the Spot, then proceed to the next box.
  - B. If the DG is  $\geq$  50% of the average daily load of the Spot, then the DG size must be reduced to be able to be considered for approval.
  - C. If the DG is connected to all of the customer's main switches, then the DG can proceed through the Simplified Interconnection path. In this case the customer's minimum load can be obtained from SCADA.
  - D. If the DG is not connected to all of the customer's main switches, then further information about the customer's load must be obtained.
  - E. It is then required to record the minimum load data for main switch loads involved in the study including off peak loading such as weekends and holidays. This data is not available on SCADA and will need to be recorded on meters set at the customer's building.
  - F. If all of the above requirements are met, the DG will be considered for approval.
11. DG is  $\geq$  10% minimum load, then a more comprehensive review and additional protection requirements are needed as follows:
  - A. If the DG is < 50% of the average daily load of the Spot, then proceed to the next box.
  - B. If the DG is  $\geq$  50% of the average daily load of the Spot, then the DG size must be reduced to be able to be considered for approval.
  - C. If the DG is connected to all of the customer's main switches, then proceed to NP Type.
  - D. If the DG is not connected to all of the customer's main switches, then further information about the customer's load must be obtained.
  - E. It is then required to record the minimum load data for main switch loads involved in the study including off peak loading such as weekends and holidays. This data is not available on SCADA and will need to be recorded on meters set at the customer's building.
  - F. If NP Type check is adequate, then proceed to NP Operational Check.
  - G. If NP Type check is not adequate, then the NP will be replaced as recommended by the Network Engineer.
  - H. If the NP Operational requirements are met, then proceed to Protection.
    - I. If the NP Operational requirements are not met, then install approved relays.
    - J. If the Protection requirements are met, then proceed to Minimum Load Controls review.
    - K. If the Protection requirements are not met, then install approved relays as needed.
    - L. If the Minimum Load Control requirements are met, then the project can be approved.
    - M. If the Minimum Load Control requirements are not met, then install approved relays.
    - N. If all of the above requirements are met, the DG will be considered for approval.

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**Grid Network Interconnection Requirements**

1. The minimum number of NPs closed criteria and the DG is < 50% of the average daily load requirements apply only to the Spot and does not apply to the Grid.
2. The requirements discussed above for the Spot Interconnection (with the exception of the two discussed above in 11.A and 11.B On Page 5) also apply to a DG interconnection to the Grid.
3. There are several additional requirements for connections to the Grid as stated below.
4. Only PVs and Battery Storage Systems will be allowed to be connected to the secondary grid. No rotating machines can be connected to the Secondary Grid.
5. All units must be “Certified” Inverter-based as described by CPUC Rule 21.
6. If the aggregate generation level of all the DGs connected to the Grid in a Network Group is 10% or higher than the verifiable minimum Grid load of the Network Group, then the PV will not be allowed to be connected to the secondary grid regardless of the additional protection proposed.
7. The aggregate generation level sets an upper bound on the total capacity of generation that may be received for a particular Secondary Grid. Once, this capacity has been exhausted, further interconnection applications to that grid will be denied until appropriate guidelines are added to IEEE 1547 or CPUC Rule 2.

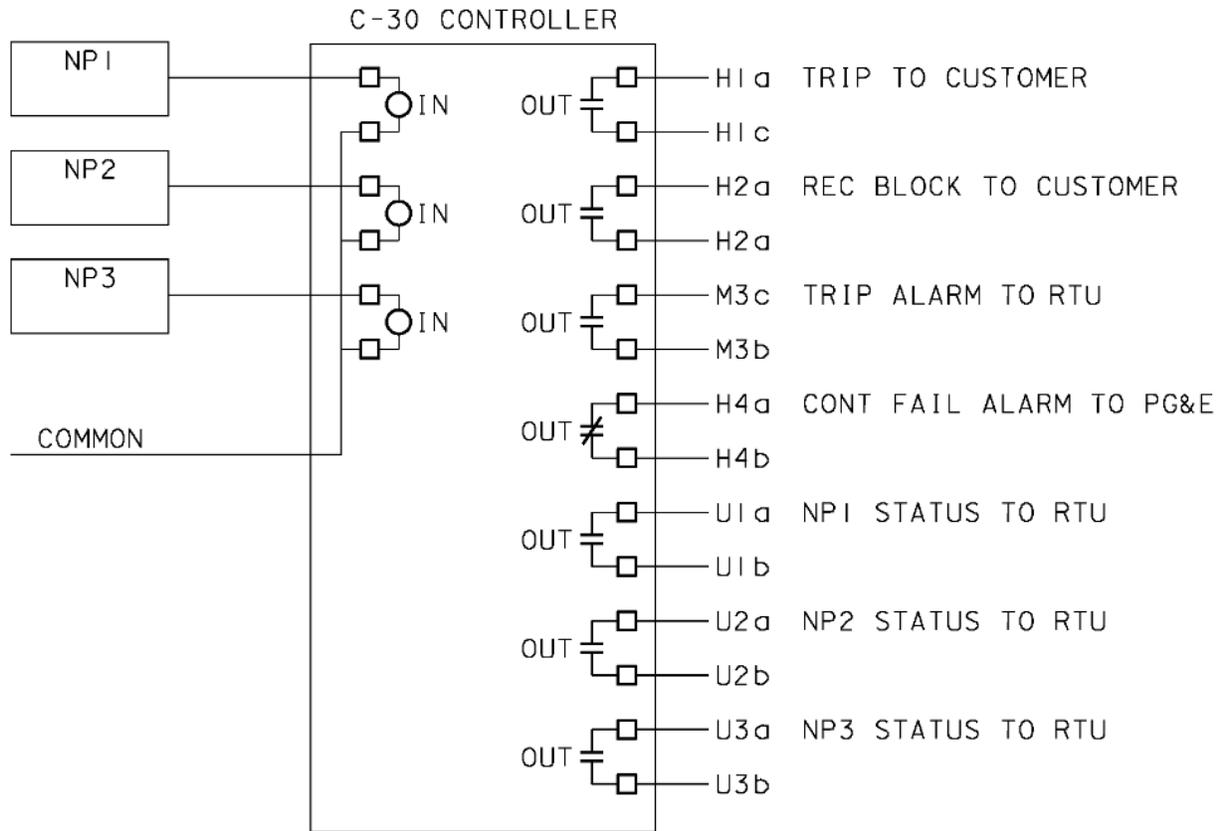
Flow Chart 2 - Distributed Generation Requirements for Grid Networks



**Figure 2**  
**Flow Chart for Distributed Generation Requirements for Grid Networks**



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**Figure 4**  
**Typical Connection Diagram using a GE C-30 relay**

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### **Definitions**

**Certified Inverter** – For the purposes of this document it is an inverter that has been “Certified” per UL 1741 or UL 1741A to trip in 2 seconds or less after the formation of an unintended island.

**DG; Distributed Generation (DG)** – Electric power producing devices or equipment, not directly connected to the bulk electric system, includes both generators and electric storage devices.

**Grid** – A low voltage distribution network, consisting of two or more primary feeders with Network Protectors. The grid typically feeds numerous customers at 208 volts with the customers separated geographically.

**Minimum load** – The absolute minimum load that is based on a years’ worth of load data. For solar generating facilities with no battery storage daytime load will be used (10 am to 4pm for fixed panel installations and 8 am to 6 pm for solar generating facilities with tracking systems).

**Network Protector (NP)** – A specialized air insulated circuit breaker operated by one or more self-contained relays which continually monitors the voltage across the open breaker contacts and current through the closed breaker contacts.

**Spot** – A low voltage distribution network, consisting of two or more primary feeders with Network Protectors and typically feeding one customer at 480 volts.

### **Revision Notes**

Revision 00 has the following changes:

1. This is a new document.