

Section G3: OPERATING REQUIREMENTS FOR TRANSMISSION GENERATING ENTITIES

PURPOSE

The purpose of this section is to help all generators satisfy applicable PG&E operating requirements. In addition to the operating requirements in this handbook, a more detailed description may be found in the [CAISO Tariff](#) and Protocols, which may be obtained from the ISO. See [Appendix A](#) for the ISO's address or visit the ISO website.

Applicability

The operating requirements of this section apply to all generators interconnecting with the Transmission System. All generators must meet applicable Western Electric Coordinating Council ([WECC](#)) standards.

Participating Generators shall operate, or cause their facilities to be operated, in accordance with the CAISO Tariff and Protocols, and are required to have signed applicable Agreements with the ISO. Participating Generators, connected to the ISO Controlled Grid, are required to schedule energy or Ancillary Services through a designated Scheduling Coordinator. Furthermore, Participating Generators greater than 10 MW (and their active Scheduling Coordinator) electing to provide Ancillary Services must possess and maintain a valid ISO certification to provide such Ancillary Services.

In the absence of specific ISO Protocols, the Participating Generator shall abide by the CAISO Tariff and operating requirements established by PG&E. If conflicts arise between the PG&E's operating requirements and the CAISO Tariff or Protocols, the CAISO Tariff and Protocols shall take precedent subject to resolution through the TAC or ADR processes.

G3.1. REACTIVE AND VOLTAGE CONTROL REQUIREMENTS FOR GENERATORS

Reactive power (Var) and voltage control are vital components of safe and reliable system operation. It is essential that PG&E receive both real and reactive power from interconnected generators. Where a Generator is unable to furnish reactive power support, due to interconnection limitations, type of generator, the generator loading or other reasons, the Generation Entity shall install equivalent reactive support or power factor correction at the Generation Entity's expense or make other arrangements with PG&E.

How a generator meets PG&E's reactive requirements depends on its type and size. Synchronous generators have an inherent reactive flexibility that allows them to operate within a range to either produce or absorb Vars. Induction generators operate at a power factor absorbing Vars and require power factor corrective equipment such as capacitors. Inverters, such as those used to connect Photo-voltaic (PV) generating facilities to AC systems, are also subject to reactive and voltage control requirements.

G3.1.1. Synchronous Generator Control

G3.1.1.1. Frequency/Speed Control

To enhance system stability, a governor is required on the prime mover, set to provide a 5 percent droop characteristic. Exceptions must be approved in writing by PG&E. Governors shall be operated unrestrained to regulate system frequency.

G3.1.1.2. Voltage Control

Voltage regulators are required for all synchronous generators larger than 100 kW. All synchronous generators connected to PG&E's transmission system shall operate the units using the voltage regulators for voltage control. The PG&E Grid Control Center will specify the required voltage schedule that will be used to determine the set point of the automatic voltage regulator. Generators connected to the distribution system in most cases will also require a power factor controller. Generators connected to the transmission system that have both voltage and power factor modes available on the controller system, shall be set on voltage control mode. In rare exceptions the PG&E Grid Control Center may direct a specific generator(s) to operate on power factor control mode.

Voltage regulators must be capable of maintaining the generator voltage under steady-state conditions without hunting and within ± 0.5 percent of any voltage level between 95 percent and 105 percent of the rated generator voltage. The generator must be capable of operating at 90 percent lagging power factor and at 95 percent leading power factor at rated output measured at the generator terminals.

G3.1.1.3. Power System Stabilizer Operating Requirements for Generators

Synchronous generators larger than 30 MVA or part of a complex that has an aggregate capacity larger than 75 MVA are required to have power system stabilizers (PSS). Generators with properly tuned and calibrated PSS provide damping to electric power oscillations. Such damping improves stability in the electrical system and may also prevent an individual generator from unnecessary tripping.

The PSS must be calibrated and operated in accordance with the latest standard procedures for calibration, testing and operation of such equipment. See Appendix H for WECC tuning guidelines.

G3.1.1.4. Power Factor Control

Power factor control is not allowed.

G3.1.2. Non-synchronous Generator Control

As of June 16, 2016, approval of FERC Order 827 changed the power factor requirements for non-synchronous generators.

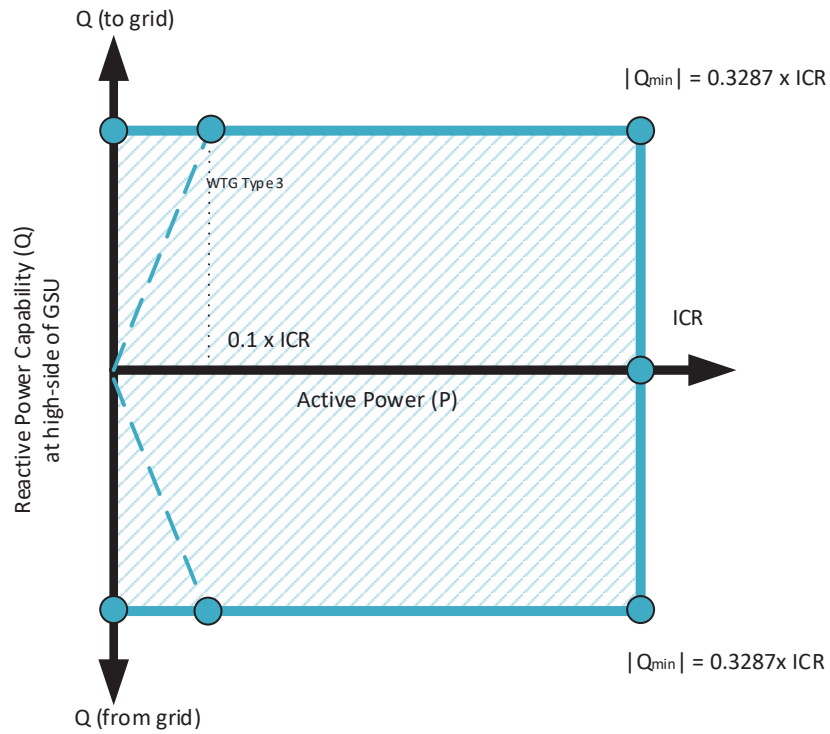
Before: Non-synchronous generating projects with Interconnection Agreements prior to June 16th, 2016 must follow power factor requirements as identified for safety and/or reliability reasons in the Phase II study.

After: Non-synchronous generators with Facilities Study Agreement executed after June, 16, 2016 must provide dynamic reactive power within the range of 0.95 leading to 0.95 lagging at the high-side of the generator substation while operating at full nameplate output. The power factor range must be dynamic and can be met using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two. All non-synchronous generating facilities will operate the plant in voltage control mode according to the voltage schedule as directed by the PG&E Grid Control Center.

Minimum reactive power capability of IBR plants must meet the requirements at the high-side of the GSU transformer as referenced in IEEE Standard 2800-2022.

For resources with active power injection only (solar, wind, etc.), refer to figure G3-1 for minimum reactive power requirements. Plants consisting of Type III WTGs will have reduced minimum reactive power requirements with lower outputs due to limitations.

For energy storage resources, minimum reactive requirements must be met in all modes of operation (charging and discharging). Refer to figure G3-2 for reference.



ICR = IBR continuous rating (MW)

Q_{min} = Minimum reactive power capability (MVAR)

Fig. G3-1 Minimum Reactive Capability Curve for Non-Synchronous Facilities with Active Power Injection Only

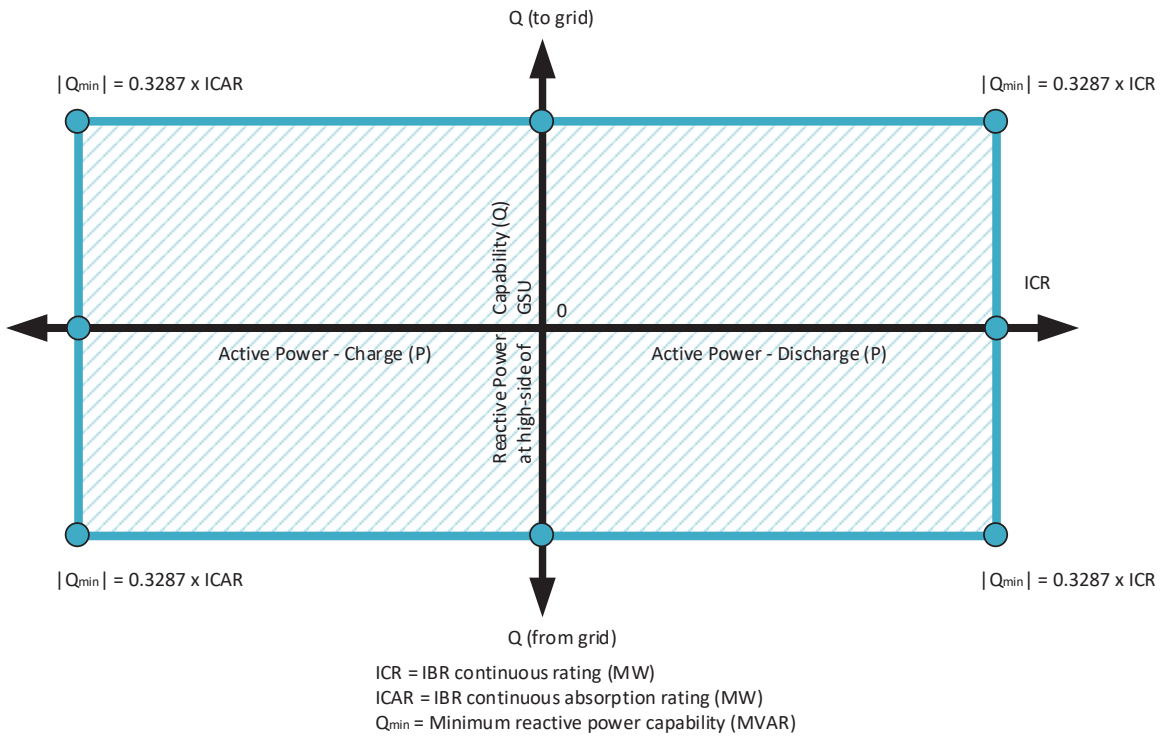
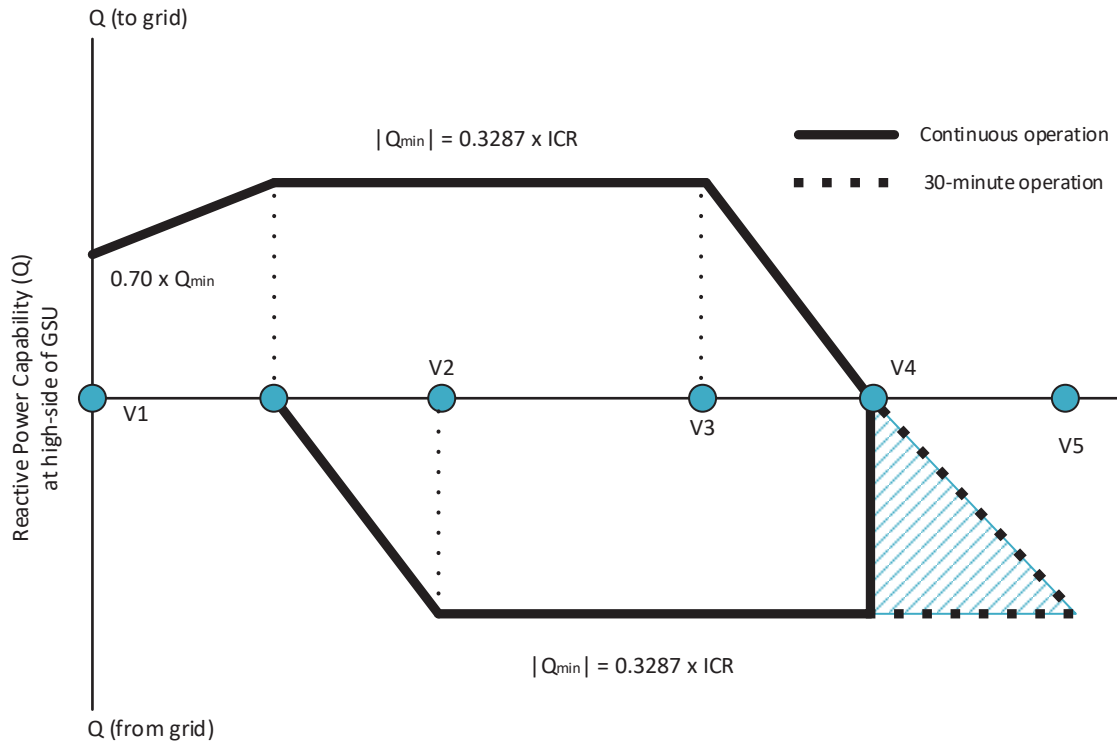


Fig. G3-2 Minimum Reactive Capability Curve for Energy Storage Facilities**Fig. G3-3 Minimum Reactive Capability Curve vs. System Voltage**

The minimum reactive power capability for continuous and up to 30-minute operation shall be met at the following voltage ranges specified below.

Nominal voltage	V1	V2	V3	V4	V5
60 kV	54 kV	60 kV	62 kV	66 kV	68 kV
70 kV	63 kV	70 kV	72 kV	77 kV	79 kV
115 kV	109 kV	115 kV	121 kV	126 kV	128 kV
230 kV	219 kV	230 kV	237 kV	242 kV	253 kV
500 kV (525 kV nominal)	499 kV	525 kV	541 kV	550 kV	577 kV

G3.1.3 Voltage Schedule Guidance

PG&E will issue a voltage schedule to all transmission connected generators¹ in accordance with VAR-001 upon completion of final commissioning.

For general design purposes the following general schedules can be referenced. They are subject to change based local area voltages and final engineering review.

North/South Schedule:

Time	Interconnection Voltage Level			
	230 kV	115 kV	70 kV	60 kV
0001 to 0700 (Off Peak)	234 kV	116 kV	71 kV	61 kV
0700 to 2100 (On Peak)	236 kV	119 kV	71 kV	61 kV
2100 to 2400 (Off Peak)	234 kV	116 kV	71 kV	61 kV

Central Schedule:

Time	Interconnection Voltage Level			
	230 kV	115 kV	70 kV	60 kV
0001 to 0700 (Off Peak)	232 kV	116 kV	71 kV	61 kV
0700 to 2100 (On Peak)	234 kV	119 kV	71 kV	61 kV
2100 to 2400 (Off Peak)	232 kV	116 kV	71 kV	61 kV

Central Area:

Fulton, Fresno, Los Banos, Metcalf, Moss Landing, Newark, Pittsburg, San Mateo, Tesla and Vaca Dixon.

North Area:

Round Mountain and Table Mountain

South Area:

Diablo Canyon and Midway

G3.1.4 500kV Interconnection

Note: The “500kV class system” is operated at 525kV with a typical operating range of 525 – 540 kV.

- For a 500kV breaker to remain in service, the breaker failure relay and protection system must be operational and cut in.

¹ Specifically, facilities connecting under G3.1.1 & G3.1.2

- For a 500kV line to remain in service, one communication aided protection scheme in service and cut in (high speed protection and DTT) and at least one additional non-communication aided relay in service and cut in.
- At least one 500kV bus differential protection must be in service and cut in for the bus to remain in service.
- At least one high speed protection must be in service and cut in for any 500kV element connected to the 500kV system to remain in service (such as a transformer).

G3.2. GENERATOR STEP-UP TRANSFORMER

The available voltage taps of a Generation Entity's step-up transformer must be reviewed by PG&E for their suitability with PG&E's system. The Generation Entity is expected to request this review before acquiring the transformer.

PG&E shall determine which voltage taps would be suitable for a step-up transformer for the Generation Entity's proposed project. Suitable taps are required to give the transformer the essential capacity for the generator to:

- Deliver maximum reactive power to PG&E's system at the point of interconnection (per generators lagging power factor requirements) and,
- Absorb maximum reactive power from PG&E's system at the point of interconnection (per generators leading power factor requirements).

The Generation Entity's transformer, with correct voltage taps, helps maintain a specified voltage profile on PG&E's system for varying operating conditions. Actual voltage tap settings can be different for transformers connected at the same voltage level, depending upon their electric connection point to the grid.

G3.3. POWER QUALITY REQUIREMENTS

G3.3.1. Voltage Fluctuation Limits

A generator connected to the PG&E system must not cause harmful voltage fluctuations or interference with service and communication facilities. Any generation facility that does so is subject to being disconnected from the PG&E system until the condition has been corrected. Refer to [Electric Rule 21](#), Section D.9.

G3.3.2. Harmonic Limits

All generators shall comply with the voltage and current harmonic limits specified in IEEE Standard 519-2014, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems".

The harmonic content of the voltage and current waveforms in the PG&E system must be restricted to levels which do not cause interference or equipment operating problems for PG&E or its customers.

Any harmonic problems shall be handled on a case-by-case basis. A generation facility causing harmonic interference is considered by PG&E as a serious interference with service and is subject to being disconnected from the PG&E system until the condition has been corrected. (Refer to Electric Rule 21, Section D.9). If the cause of the problem is traceable to the Generation Entity's facilities, all costs associated with determining and correcting problems shall be at the customer's expense.

Many methods may be used to restrict harmonics. The preferred method is to install a transformer with at least one delta connection between the generator and the PG&E system. This method significantly limits the amount of voltage and current harmonics entering the PG&E system. Generation system configuration with a star-grounded generator and a two-winding (both star-grounded) transformer shall not be allowed.

G3.4. VOLTAGE & FREQUENCY RIDE-THROUGH REQUIREMENTS

All generating facilities interconnecting must ride through abnormal frequency and voltage events and not disconnect during such events per FERC Order 828, issued July 21, 2016.

PG&E currently follows the Voltage and Frequency Ride-Through Criteria that WECC has adopted to ensure continued reliable service.

The interconnection customer must ensure all generator protection is compliant with those set forth in NERC standard PRC-024.

More information on voltage ride-through issues associated with alternative technologies can be found on the FERC website:

<http://www.ferc.gov/industries/electric/indus-act/gi/wind.asp>

G3.5. TRANSMISSION INTERCONNECTIONS FOLLOWING RULE 21² TARIFF

According to Rule 21 Tariff Section B.1., All Generating Facilities seeking Interconnection with Distribution Provider's Transmission System shall apply to California Independent System Operator (CAISO) for Interconnection and be subject to CAISO Tariff except for i) Net Energy Metering (NEM) Generating Facilities less than or equal to one MW and ii) Generating Facilities that do not export to the grid or sell any exports sent to the grid.

Net Energy Metering Generating Facilities with Permission to Operate letters received as of May 6, 2022, or proposed Net Energy Metering Generating Facilities with materially complete interconnection applications submitted as of May 6, 2022, need not apply to CAISO.

The study process, technical requirements and power factor requirement for each type of Rule 21 Generating Facilities are summarized as:

² [ELEC RULES 21.pdf \(pge.com\)](#)

Rule 21 on Transmission³	Study Process	Technical Requirements	0.97 lag to 0.99 lead Power Factor Requirement	Additional Application Documents
NEM >1 MW on CAISO controlled grid	CAISO Tariff	CAISO Tariff ⁴	Only for the load	Follow CAISO process
NEM >1 MW on non-CAISO controlled grid	Rule 21 Tariff	CAISO Tariff	Only for the load	(1) datasheet 1.Project Configuration and datasheet 1-a.Short Circuit Data Table of CAISO Attachment A . (2) epc and dyd models if total size ≥ 10 MVA
NEM or non-export ≤1 MW	Rule 21 Tariff	Rule 21 Tariff	At the POI	none
Non-export >1 MW	Rule 21 Tariff	CAISO Tariff per good utility practice	Only for the load	(1) datasheet 1.Project Configuration and datasheet 1-a.Short Circuit Data Table of CAISO Attachment A . (2) epc and dyd models if total size ≥ 10 MVA

G3.5.1. Transmission NEM Generating Facilities > 1 MW on CAISO Controlled Grid

Transmission NEM Generating Facilities on CAISO controlled grid, greater than 1 MW, seeking Interconnection shall apply to CAISO for interconnection and be subject to CAISO Tariff.

Please visit CAISO's website for generation interconnection to submit an interconnection request:

[California ISO - Interconnection Request \(caiso.com\)](https://www.caiso.com/interconnection)

Here are some of the critical requirements that the Generating Facilities must comply if they are required to follow technical requirements from CAISO Tariff:

1. FERC Order 827, +/-0.95 dynamic reactive power capability at the high side of the main transformer for non-synchronous generating facilities. See Section 3.1.2 of this document.
2. FERC Order 842, for both synchronous and non-synchronous generating facilities, to stall, maintain, and operate equipment capable of providing primary frequency response as a condition of interconnection.

³ 1 MW size threshold is based on installed capacity.

⁴ Please refer to TIH section G3.5.1 and [CAISO Tariff](#) for CAISO technical requirements.

3. NERC PRC-024: for both synchronous and non-synchronous generating facilities to have voltage and frequency ride through capabilities.
4. Voltage control mode: both synchronous and non-synchronous generating facilities shall operate in voltage control mode. See Section 3.1 of this document.

G3.5.2. Transmission NEM Generating Facilities > 1 MW on Non-CAISO Controlled Grid

Transmission NEM Generating Facilities on non-CAISO controlled grid, greater than 1 MW, seeking Interconnection shall still apply to Rule 21 process for interconnection.

It is required that Generating Facilities of this category meet all technical requirements such as FERC 827, FERC 842, PRC-024, voltage control mode, etc that are required in CAISO Tariff.

G3.5.3. Transmission NEM or Non-Export Generating Facilities \leq 1 MW

Transmission NEM or Non-Export Generating Facilities \leq 1 MW shall apply to Rule 21 process and be subject to Rule 21 Tariff requirements.

G3.5.4. Transmission Non-Export Generating Facilities > 1 MW

Transmission Non-Export Generating Facilities > 1 MW shall apply to Rule 21 process and be subject to CAISO Tariff requirements per good utility practice.

G3.5.5. Power Factor Requirements

The CAISO Tariff, effective on March 31, 1998, specifies that all loads connected directly to the ISO grid are to maintain a power factor between 0.97 lag and 0.99 lead, as measured at the point where the retail facilities interconnect with the ISO-controlled facilities.

If a load is connected on non-CAISO controlled grid, it shall maintain a power factor range specified by PG&E, which is typically between 0.97 lag and 0.99 lead.

If the Rule 21 Generating Facilities, NEM or Non-Export, \leq 1 MW, the Project is required to meet the load power factor requirement of 0.97 lag and 0.99 lead at Point of Interconnection.

Rule 21 Generating Facilities of the other categories are required to be operated in voltage control mode therefore the 0.97 lag and 0.99 lead power factor range is only required for the load itself.

G3.5.6. Required Application Files

If Rule 21 Generating Facilities shall meet CAISO Tariff requirements, in addition to the documents required by Rule 21 Tariff, please also complete CAISO form [Generating Facility Data – Attachment A to Appendix 1](#) for PG&E to collect and review technical details of the application.

If the total capacity of the proposed and existing generating facilities behind the same customer meter is ≥ 10 MVA, PSLF power flow model *.epc and dynamic model *.dyd for the proposed project and existing generating facilities if any are also required to be submitted.

G3.5.7. Coordination with CAISO

For the Rule 21 Generating Facilities that follow Rule 21 process, as part of PG&E's obligations with NERC as the registered Transmission Owner for the PG&E transmission system, and to meet NERC Standard FAC-001 and FAC-002 requirements, the study results for generation interconnection projects may be communicated to the CAISO, PG&E's Balancing Authority, or other neighboring entities that may be impacted, for coordination and incorporation of its transmission assets. Input from the CAISO and other neighboring entities are solicited to ensure coordination of transmission systems.

G3.6. SUBMITTING MODELING DATA

After interconnecting to PG&E's transmission system, when there is an update to the Generation Facility, Generator Owner will provide modeling data in accordance with NERC Reliability Standards, the [WECC Data Preparation Manual](#)⁵, and the [WECC Generating Unit Model Validation Policy](#)⁶ to PG&E and the CAISO, to meet NERC Reliability Standards (MODs 025, 026, & 027 & PRCs 19 & 24) and [WECC Generating Unit Model Validation Policy](#). The document "[WECC Generating Facility Data, Testing, and Model Validation Requirements](#)"⁷ lists in detail the specific data that is required from the Generator Owners. This data is normally obtained during on-site testing and there are a number of firms which can be contracted to perform this testing. At this time all generators over a certain output, single unit capacity of 10 MVA or larger, or facilities with an aggregate capacity of 10 MVA or larger have to be re-tested every ten years according to NERC standards and every five years according to WECC standards. Please refer to the [WECC Generating Unit Model Validation Policy](#). Intant, or Generator Owners should submit modeling data and/or test reports must be submitted to PG&E's Electric Asset Management, Transmission Planning Department via an email to GenModel@pge.com.

⁵ [WECC Data Preparation Manual](#)

⁶ [WECC Generating Unit Model Validation Policy](#)

⁷ [WECC Generating Facility Data, Testing, and Model Validation Requirements](#)