

# Smart Inverter Implementation Workshop

January 30, 2018

*These slides are current as of **January 30, 2018**. Also, while PG&E strives to be accurate about the material presented in these slides, if there is any discrepancy between these slides and PG&E's tariffs, [PG&E's tariffs control](#).*



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# Agenda

<b>Topic</b>		<b>Presenter</b>
Safety	9:05	Justin Starks
Welcome	9:10	Karen Khamou
Grounding	9:20	Justin Starks
Smart Inverter Requirements and Benefits	9:30	Chase Sun
Break	10:45	
Interconnection Best Practices	11:00	Rob Chan
Rule 21 Financial Securities Requirements	11:30	Harold Hirsch
Closing	11:55	Justin Starks

- Contact Emergency Services
  - CPR Certified
  - Retrieve AED
  - Meet Security
  - Sweep
  - Lead Evacuation
  - Emergency Exits
  - Assembly Point
- 
- Earthquake: Duck, Cover, and Hold
  - Active Shooter: Get out, hide out, take out, call out





# Welcome

**Karen Khamou**

Director, Electric Grid Interconnection



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# Questions during this session only?

[NEMUpdates@pge.com](mailto:NEMUpdates@pge.com)

Important Note: [NEMUpdates@pge.com](mailto:NEMUpdates@pge.com) is a special mailbox used primarily for notices. Outside of the Smart Inverter Workshop, [NEMUpdates@pge.com](mailto:NEMUpdates@pge.com) is **not monitored**. Questions submitted to this mailbox after the Smart Inverter Workshop will not be responded to.

For questions related to interconnection, please respond to the appropriate interconnection mailbox.



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# Electrically Bonding and Grounding Gas Pipe

**Justin Starks**

Senior Program Manager - NEM



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# Compliance with PG&E's Greenbook

- PG&E is governed by the rules and general orders set forth by the California Public Utilities Commission (CPUC)
  - PG&E has the right to establish requirements that meet or exceed the CPUC rules
- PG&E is not bound by state and/or federal electrical, mechanical, and building codes
- Applicants must bond and ground their electric services and metering equipment as required by applicable electrical codes, local ordinances, and PG&E requirements (Section 5.8, Grounding)
  - The building standards of each Authority Having Jurisdiction (Building Department)
  - PG&E's Greenbook
- Projects not in compliance with both create a potential safety hazard

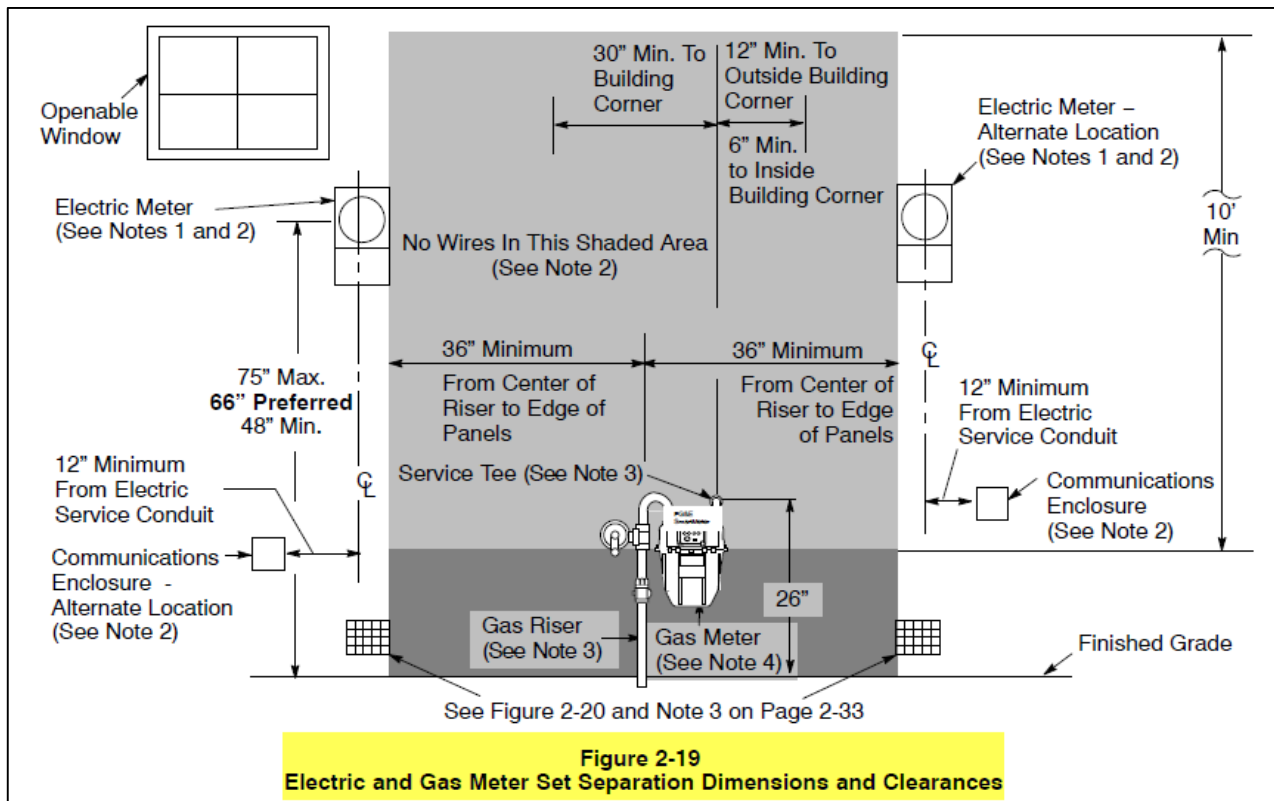
- We have identified sites that are bonding/grounding to the gas meter facilities
  - Some are grounding to the “PG&E Riser” (the pipe that runs from the gas meter into PG&E’s gas distribution lines)
- Correct Position
  - Bonding and grounding must occur a minimum of 36” away from the gas facilities, as measured from the gas riser. This no bonding/grounding 36” clearance zone may include the house line side of the meter (the pipe that runs from the meter back into the house) if within 36” of the gas riser.



## Section 2, Gas Service (2.5.3)—“Electrically Bonding and Grounding Gas Pipe” & Section 5, Electric Metering: General (5.8)—“Grounding”

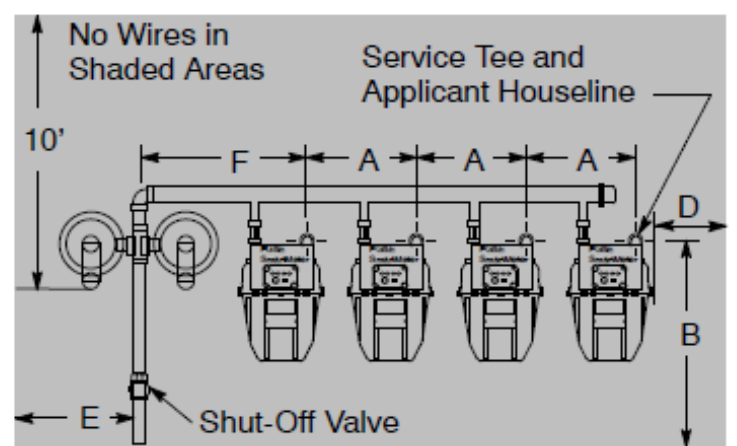
A. Applicants must not use PG&E’s gas facilities as part of the electrical grounding system.

1. Do not install electrical devices or equipment, wires, cables, bonding or grounding wires, clamps, or ground rods around the gas meter set as shown in Figure 2-19 on Page 2-32 and Figure 2-22 on Page 2-35
2. Do not use PG&E’s gas service piping, gas risers, or meter facilities for electric bonding or grounding that allows the gas meter, piping, or other gas facilities to become current-carrying conductors.
3. Do not allow gas pipe to be electrically bonded within meter enclosures, cabinets, or meter rooms



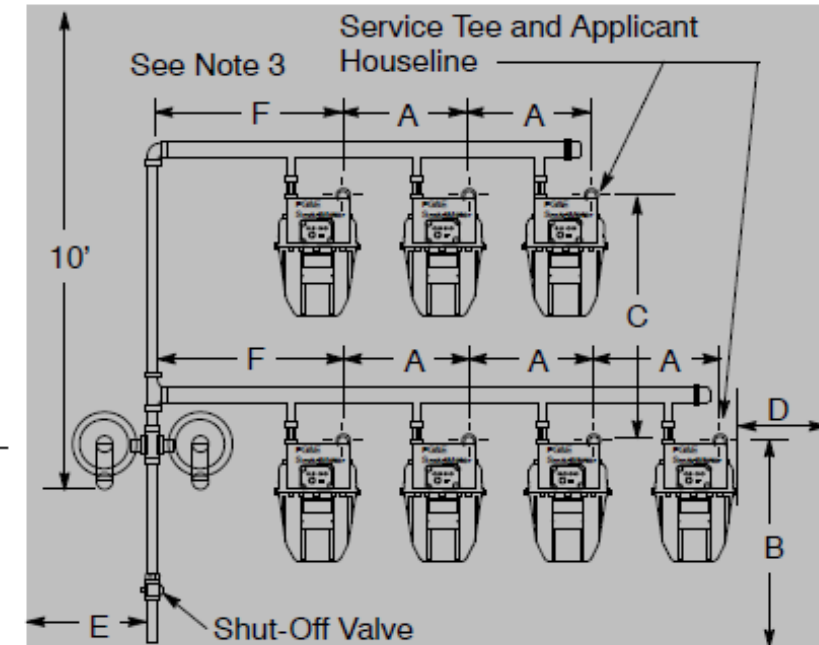
Notes in reference to Figure 2-19

- Applicants must **not** install any electrical devices or equipment, including wires, cables, metering enclosures, telecommunication enclosures, **bond wires, clamps, or ground rods** within the shaded area around the gas meter. The 36-inch distance can be reduced to 18 inches for electrical devices or equipment certified for NEC Class I, Division 2 locations.



Finished Grade

**Single Manifold**



Finished Grade

**Two-Tier Manifolds**

**Figure 2-22  
Dimensions for Typical, Residential, Multimeter Installations**

Notes in reference to Figure 2-22

- Applicants must not install any electrical devices or equipment, including wires, cables, metering enclosures, telecommunication enclosures, **bond wires, clamps, or ground rods** within 36 inches horizontally from the farthest edge of PG&E facilities and 10 feet above the regulator vent.



# Resources

- A. Greenbook website  
<https://www.pge.com/greenbook>
- B. Electronic Greenbook  
[https://www.pge.com/includes/docs/pdfs/mybusiness/customerservice/otherrequests/newconstruction/greenbook/greenbook\\_manual\\_full.pdf](https://www.pge.com/includes/docs/pdfs/mybusiness/customerservice/otherrequests/newconstruction/greenbook/greenbook_manual_full.pdf)
- C. Distribution Interconnection Handbook (DIH) Website  
<https://www.pge.com/dih>
- D. Electronic (DIH)  
<https://www.pge.com/includes/docs/pdfs/shared/customerservice/nonpgeutility/electrictransmission/handbook/distribution-interconnection-handbook.pdf>
- E. Building and Renovation Services Center  
1-877-743-7782



# Smart Inverter Requirements and Benefits

**Chase Sun**

Principal – Integrated Grid Planning



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## Old IEEE-1547 and Rule 21 requirements outdated

- Developed >15 years ago when penetration was 1% and DER impacts were insignificant
- Focused on safety and simplified interconnection
- Resulted in relatively tight voltage and frequency trip settings as back-up to newly developed anti-islanding certification
- Approach was to use grid operating margin to carry DERs at the low penetration levels to simplify interconnection
- Tight settings turned out to be undesirable at higher DER penetration levels
  - Inadvertent trips that led to area wide outages were documented in high penetration areas, such as Germany and Hawaii
- CA SIWG was formed to address the high penetration issues and IEEE-1547 subsequently followed

# List of Phase 1 Smart Inverter Functions

- Maintain Anti-Islanding Protection
- Voltage Ride-Through Requirements
- Frequency Ride-Through
- Dynamic Volt/Var Control (Reactive Power Priority Pending)
- Fix Power Factor Control
  - <15KW (0.90 Lag/Lead down to 20%)
  - $\geq 15$ KW (0.85 Lag/Lead down to 20%)
- Ramp Rate/Soft Reconnect
  - Normal course of operation
  - Restarting after disconnection
- Volt/Watt (Update to Requirements Pending – [PG&E AL 5129-E.](#))
- Frequency/Watt (Update to Requirements Pending – [PG&E AL 5129-E.](#))



# Rule 21 Smart Inverter Requirements

- All smart Inverters must be certified to UL 1741-SA
  - NEM PV inverters must utilize Smart Inverters found on [CEC list](#)
  - Non-NEM PV Smart Inverters must also be certified
- Smart Inverters must meet Rule 21 Requirements:
  - The following functions must be set per Rule 21 requirements (see following slides for specific settings):
    - Dynamic Volt/Var
      - Reactive Power Priority (if not preset by manufacturer)
    - Active Power Factor
    - Ramp Rate
    - Volt/Watt
    - Frequency/Watt
  - The following functions do not need adjustment, the default certification settings conform to Rule 21 required settings:
    - Maintain Anti-Islanding Protection
    - Voltage Ride-Through
    - Frequency Ride-Through





# Rule 21 Smart Inverter Requirements (2)

- Actions Required by Applicants (Key Points)
  1. Install Smart Inverters
  2. Confirm that the Smart Inverter is compliant with Rule 21 at the time of installation
    - All the functions must be enabled
    - The default settings must be active
  
- Field Inspections
  1. Non-compliant Smart Inverters are subject to having the Permission to Operate (PTO) letter withdrawn
  2. The PTO will not be re-instated until the Applicant provides sufficient evidence that the Smart Inverter is compliant with all Rule 21 requirements

## Maintain Anti-Islanding Protection

- To verify anti-islanding performance with extended voltage and frequency ride through functions. Anti-islanding certification is the lynchpin of the simplified requirements.
- On a typical radial distribution feeder, if there is a car-pole accident with wire down on the ground, once the feeder breaker tripped, the circuit is de-energized and safe. But with hundreds of DERs on the feeder, each capable of energizing the downed conductor, it is not easy to verify that the conductor will be de-energized. Anti-islanding provided the assurance that the DERs will cease to energize within 2 seconds.

## Voltage Ride-Through

- To avoid/minimize trip during infrequent severe voltage excursions. Every time there is a local transmission or distribution fault, the distribution voltage will sag due the laws of physics.
- So, it would be desirable for the inverter to ride through the remote transmission voltage sags without tripping. However, if the voltage sag by more than 50%, there is a high probability that the fault is on a local distribution circuit and the inverter should trip after a short time delay. There should still be a short time delay since the fault may be on an adjacent feeder protected by that feeder's breaker.

## Frequency Ride-Through

- To avoid/minimize trip during rare severe frequency excursions and aggravating the disturbance
- This is not an issue at low penetration levels of a few percentage point, since there are enough existing generation resources to carry the load even if all of the DERs tripped off line. Currently, PG&E has 16% of aggregated DER penetration relative to PG&E system peak load. CAISO only has 15% reserve margin at this time. So, if 16% of DER generation tripped off line at once, there may not be sufficient generation to cover all of the loads during the disturbance and the system may go into UFLS mode (involuntary load shedding) and trip loads to maintain system stability. About 37% of the PG&E loads are set up to be shed at different frequency blocks automatically to maintain system stability. At the old setting of 59.3 Hz, the UFLS is still going through the load shedding sequence. Any DER tripped at 59.3 Hz will cause more customer load to be shed.

## Dynamic Volt / Var Control

- For mitigating excessive voltage rise during PV backfeed by absorbing reactive power at higher voltage levels.
- Can also be used to boost voltage by injecting reactive power, when voltage drop below Rule 2 limits. This may happen during fast cloud movements at higher penetration levels.
- Default settings:
  - Volt/Var On
  - Set at Reactive Power Priority (see table Hh-4 from Rule 21)

Voltage Setpoint	Voltage Value	Reactive Setpoint	Reactive Value	Operation
V1	92.0%	Q1	30%	Reactive Power Injection
V2	96.7%	Q2	0	Unity Power Factor
V3	103.3%	Q3	0	Unity Power Factor
V4	107.0%	Q4	30%	Reactive Power Absorption

## Fixed Power Factor Control

- $< 15\text{KW}$  (0.90 Lag/Lead down to 20%)
- $\geq 15\text{KW}$  (0.85 Lag/Lead down to 20%)
  - Similar to above volt/var, except by controlling power factor. PF control may also be used at locations close to the existing voltage regulating devices where a reactive power response proportional to active power output is more beneficial.
- Default setting:
  - Fix Power Factor Off, to avoid conflict with volt/var function

## Ramp Rate / Soft Reconnect

- Normal course of operation to avoid fast voltage fluctuation (flicker) during fast cloud movements at higher penetration levels.
  - Default: 100%/sec
- Restarting after disconnection- For reducing voltage rate of change during start up.
  - Default: 2%/sec

## **Volt/Watt** (Update to Requirements Pending – [PG&E AL 5129-E.](#))

- For mitigating excessive voltage excursions due to PV backfeed- used as back-up to volt/var when volt/var is not adequate
  - Default: 25%  $P_{rated}/V\%$ , starting at 106% and ending at 110% of  $V_{nom}$

## **Frequency/Watt** (Update to Requirements Pending – [PG&E AL 5129-E.](#))

- Used to automatically reduce generation output during over-frequency events and increase generation output during UF events (when the unit is capable of such operation. Most PV inverters are operated at maximum power output (MPPT) and not capable of providing additional power output and frequency support during low frequency events.
  - Default: 50%  $P_{out}/Hz$ , curtailment starting at 60.1 Hz





# Interconnection Best Practices

**Rob Chan**  
Supervisor – NEM Operations



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# Rule 21 Interconnection Process Overview

Application

Planning/Studies

Tender Contract

Implementation

Inspection/Close



# Application Phase

Application

Planning/Studies

Tender Contract

Implementation

Inspection/Close

## Common Deficiency

## Best Practice

<ul style="list-style-type: none"> <li>Discrepancies with Customer information</li> </ul>	<ul style="list-style-type: none"> <li>Use Customer information from the most recent utility bill</li> </ul>
<ul style="list-style-type: none"> <li>Make and model of AC Disconnect, Inverter(s), and/or PV modules not listed or differs from application or single-line diagram</li> </ul>	<ul style="list-style-type: none"> <li>Ensure that single-line and application information match, including make, model, and quantity of equipment</li> </ul>
<ul style="list-style-type: none"> <li>Existing system is not identified or missing complete information</li> </ul>	<ul style="list-style-type: none"> <li>Identify the make, model, and quantity of the existing system on the application and single-line diagram</li> </ul>
<ul style="list-style-type: none"> <li>Inverter is not on CEC approved Smart Inverter List</li> </ul>	<ul style="list-style-type: none"> <li>Refer to the current CEC Certified inverter List</li> </ul>
<ul style="list-style-type: none"> <li>Point of interconnection selected not shown or incorrectly labeled on single-line diagram</li> </ul>	<ul style="list-style-type: none"> <li>Clearly identify point of interconnection in relation to main breaker</li> </ul>
<ul style="list-style-type: none"> <li>Single Line Diagram depiction of Line Side Tap shown in utility section</li> </ul>	<ul style="list-style-type: none"> <li>Provide photos of customer panel with:               <ul style="list-style-type: none"> <li>Proposed Point of Interconnection (POI)</li> <li>Wire routing</li> </ul> </li> </ul> <p>NOTE: POI and wires cannot be in utility sealed section</p>
<ul style="list-style-type: none"> <li>Submit interconnection fee payment with application number</li> </ul>	<ul style="list-style-type: none"> <li>Submit required interconnection payment with invoice and application number</li> </ul>



# Planning / Studies Phase

Application

Planning/Studies

Tender Contract

Implementation

Inspection/Close

Program	Common Deficiency	Best Practice
All	<ul style="list-style-type: none"><li>Inaccurate nameplate information</li></ul>	<ul style="list-style-type: none"><li>Provide correct nameplate information</li></ul>
	<ul style="list-style-type: none"><li>Missing data required to complete supplemental review</li></ul>	<ul style="list-style-type: none"><li>Provide SLD Impedance data per F2x ii and per the study</li></ul>
	<ul style="list-style-type: none"><li>Incorrect impedance information provided</li></ul>	<ul style="list-style-type: none"><li>Provide correct impedance information</li></ul>
Non-Export and other Large Projects	<ul style="list-style-type: none"><li>Incorrect non-export option selected during application phase</li></ul>	<ul style="list-style-type: none"><li>Provide correct non-export information</li></ul>
	<ul style="list-style-type: none"><li>Customer specified inverter is not certified</li></ul>	<ul style="list-style-type: none"><li>Ensure specified inverter is UL certified</li></ul>



# Tender Contract Phase

Application

Planning/Studies

**Tender Contract**

Implementation

Inspection/Close

## Common Deficiency

- Customer information discrepancies
- Interconnection Agreement (IA) signed by someone other than the PG&E Customer of Record (i.e., IA signatory allowed must be someone whose name appears in the generating facility's electric service account)
- New Customer signature and date missing when there are changes made to a previously signed Interconnection Agreement

## Best Practice

- Use Customer information from the most recent utility bill
- Ensure Interconnection Agreement is signed by Customer of Record
- Provide a new Customer signature and date to show that the Interconnection Customer has reviewed and agreed to the changes made



# Implementation Phase

Application

Planning/Studies

Tender Contract

Implementation

Inspection/Close

## Common Deficiency

- Missing/incorrect information

## Best Practice

- Work with assigned Service Planning Representative on requested information



# Inspection / Close Phase

Application

Planning/Studies

Tender Contract

Implementation

Inspection/Close

## Common Deficiency

- Final Signed-Off Building Permit is missing information
- Equipment is different from what was originally indicated in the submitted application that was reviewed
- System is connected to meter not listed on application
- Site not ready for final inspection (i.e., site contact for did was not onsite for inspection, customer is still finalizing installation-related, etc.)
- Generating system has point of interconnection and/or wires in the utility's sealed section

## Best Practice

- Ensure that signing jurisdiction, project address, scope of work, final sign-off date and signature or initial of inspector is included
- Provide updated information if changes are made
- New application is required if inverter nameplate increases
- Ensure application and point of interconnection references the same meter
- Ensure generating facility is ready for PG&E's final inspection to minimize need for rescheduling.
- The Point of Interconnection and wires cannot be in the utility's sealed section



# Financial Security for Rule 21 Projects

**Harold Hirsch**

Senior Interconnection Manager – Retail Distribution and Rule 21 Programs



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## Section 4 of Rule 21 Tariff: Interconnection Financial Security (IFS)

### Purpose for IFS

- Ensure PG&E is covered for Customer's interconnection costs, in the event the customer fails to pay any outstanding invoices. If the customer does not pay, PG&E can leverage the IFS posted to cover costs incurred for the projects. The customer has the option to pay before PG&E draws or liquidates their IFS postings.

### Types of Acceptable Financial Security

The Interconnection Financial Security posted by an Interconnection Customer may be any combination of the following types of financial instruments, provided in favor of the Distribution Provider:

- (i) an irrevocable and unconditional letter of credit issued by a bank or financial institution that has a credit rating of A or better by Standard and Poor's or A2 or better by Moody's;
- (ii) an unconditional and irrevocable guaranty issued by a company has a credit rating of A or better by Standard and Poor's or A2 or better by Moody's;
- (iii) a cash deposit standing to the credit of the Distribution Provider and in an interest-bearing escrow account maintained at a bank or financial institution that is reasonably acceptable to the Distribution Provider;



# Financial Security for R21 Projects

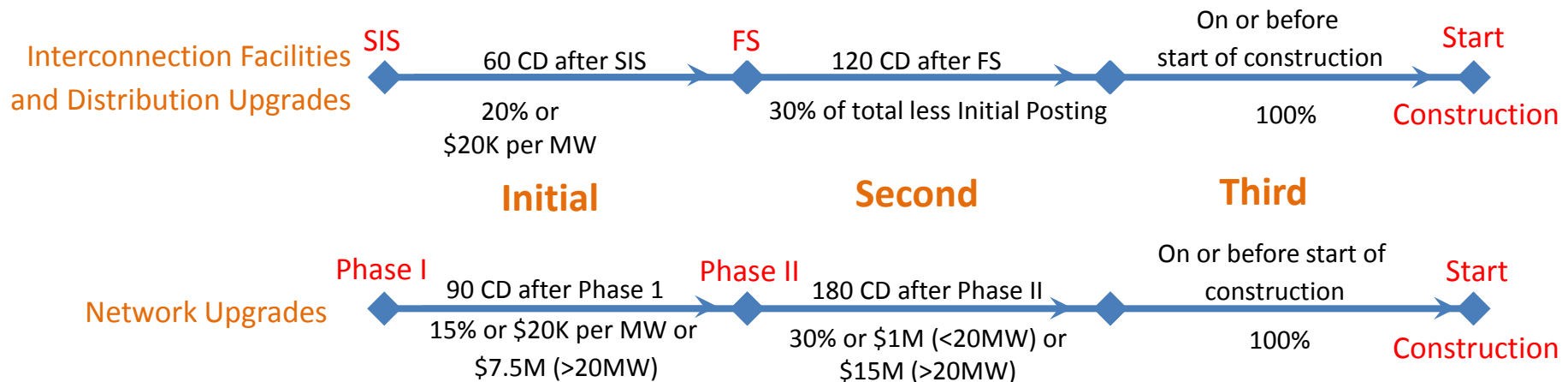
## Fast Track Process

- Minimum of 35% due within 60 calendar days of IA execution date (15% NU/20% IF)
- Remainder due 20 calendar days prior to start of construction

## R21 Projects required to post IFS

- Rule 21 Export
- NEM2 when >1MW

*\*Refer to Article 6 PG&E Filed Form 79-1144-02 Rule 21 Generator Interconnection Agreement For Net Energy Metering (Nem-2) Generating Facilities Greater Than 1,000 Kw and Article 6 Filed Form 79-1144 Rule 21 Generator Interconnection Agreement for Exporting Generating Facilities Interconnecting Under the Fast Track Process*



## Failure to post IFS

- Failure to timely post the Interconnection Financial security require by Section F.4b shall result in the Interconnection Request being deemed withdrawn subject to Section F.6.

## Release of IFS

- IFS will be released once Final Settlement is Complete (typically 6 months after COD)
- Upon internal approvals, the original Letter of Credits / Escrows will be sent back to the issuance bank

## Link to Tariff:

[https://www.pge.com/tariffs/tm2/pdf/ELEC\\_RULES\\_21.pdf](https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_21.pdf)

## Smart Inverters with Default Settings are Now Required

- In addition to having Smart Inverters installed, they must be compliant with Rule 21
- Non-compliant Smart Inverters will be subject to having the Permission to Operate (PTO) letter withdrawn until sufficient evidence is provided confirming that the Smart Inverter is compliant with Rule 21

**Thank You for Attending!**

