

February 22, 2021

Advice 6093-E

(Pacific Gas and Electric Company ID U 39 E)

Public Utilities Commission of the State of California

**Subject: Modifications to Electric Rule 21 Pursuant to Resolution E-5000
Ordering Paragraphs 6, 7, and 8 for IEEE 1547.1 Standards**

I. Purpose

Pacific Gas and Electric Company (PG&E) submits this Tier 2 Advice Letter (“AL”) proposing modifications to its Electric Rule 21 - *Generator Interconnections* – to report the consensus of the testing Procedure of the IEEE 1547.1¹, in compliance with the California Public Utilities Commission (“CPUC” or “Commission”) Resolution E-5000² Ordering Paragraph (“OP”) 6, 7, and 8.

II. Background

The Commission initiated Rulemaking (R.) 11-09-011³ on September 22, 2011, to review and, if necessary, revise the rules and regulations governing the interconnection of generation and storage facilities to the electric distribution systems of PG&E, San Diego Gas and Electric Company (SDG&E) and Southern California Edison Company (SCE), (collectively, the “Utilities”). The Utilities’ rules and regulations pertaining to the interconnection of generating facilities are set forth in each of the Utilities’ Commission-approved Electric Rule 21 Tariffs (Rule 21).

¹ IEEE 1547.1 or alternatively [IEEE 1547.1-2020](#) - *IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces* - Published Date:2020-05-21. The [Institute of Electrical and Electronics Engineers \(IEEE\)](#) is a Standards Association.

² Resolution [E-5000](#) - *Clarifies smart inverter communications requirements in response to the Petition of the California Solar & Storage Association for Modification of Resolution E-4832 and Resolutions E-4898* - Date of Issuance – July 12, 2019

³ R. 11-09-011 - *Order Instituting Rulemaking on the Commission’s Own Motion to improve distribution level interconnection rules and regulations for certain classes of electric generators and electric storage resources.* – Filing Date September 22, 2011

On June 23, 2016, the Commission adopted Decision (D.)16-06-052⁴, which effectively established the Commission's clear policy direction toward communications-capable smart inverters. The decision directed⁵ the Utilities to file proposed revisions to Rule 21 setting forth any agreed-upon technical requirements, testing and certification processes, and effective dates for the Phase 2 communications requirements and Phase 3 advanced functions. On December 20, 2016, PG&E submitted Advice Letter (AL) 4982-E⁶ establishing these requirements.

Resolution E-4832⁷ approved AL 4982-E with modifications and established a mandatory effective date for Phase 2 communications that was defined as: the later of (a) March 1, 2018, or (b) nine months after the release of the SunSpec Alliance communication protocol certification test standard or the release of another industry-recognized communication protocol certification test standard. Additionally, E-4832 in OP 2 established the compliance deadlines for the Phase 2 communication requirements and for Phase 3 Functions 1 (Monitor Key Data) and 8 (Scheduling) as nine months after the release of the SunSpec Alliance (SunSpec) communication protocol certification test standard, which set the effective deadline as: "*the later of (a) March 1, 2018 or (b) nine months after the release of the SunSpec Alliance communication protocol certification test standard or the release of another industry-recognized communication protocol certification test standard.*"⁸

On March 31, 2017, the Smart Inverter Working Group (SIWG) issued final revisions to the Phase 3 recommendations. PG&E submitted AL 5129-E⁹ to incorporate the recommendation with proposed Rule 21 tariff revisions that set forth agreed-upon technical requirements, testing and certification processes, and effective dates for the Phase 3 functions. In addition, the Phase 3 ALs proposed revisions to the smart inverters Phase 2 communications.

⁴ [D. 16-06-052](#) - *Alternate Decision Instituting Cost Certainty, Granting Joint Motions to Approve Proposed Revisions to Electric Tariff Rule 21, And Providing Smart Inverter Development a Pathway Forward for Pacific Gas And Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company* -Date of Issuance 7/1/2016

⁵ D. 16-06-052 OP 9 see p50

⁶ [AL 4982-E](#) - *Modifications to Electric Tariff Rule 21 to Incorporate Communication Requirements for Smart Inverters (Phase 2)* – submitted December 20, 2016

⁷ [E-4832](#) - *Resolution E-4832. Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E), Approval with Modification of Revisions to Electric Tariff Rule 21 to Incorporate Smart Inverter Working Group (SIWG) Phase 2 Communications Recommendations in Compliance with Decision (D.) 16-06-052* - Date of Issuance: April 7, 2017

⁸ E-4832, SEE OP 2, p5.

⁹ [AL 5129-E](#) - *Modifications to PG&E's Electric Rule 21 Tariff and Interconnection Agreements and Forms to Incorporate Smart Inverter Phase 3 Modifications* – submitted August 18, 2017.

On April 26, 2018, the Commission issued Resolution E-4898¹⁰ that approved, with modifications, the revisions to Rule 21 put forth in AL 5129-E, thereby adopting the Phase 3 recommendations.

Additionally, E-4898 revised the compliance deadlines for the Phase 2 communication requirements and for Phase 3 Functions 1 (Monitor Key Data) and 8 (Scheduling) as nine months after the release of the SunSpec Alliance (SunSpec) communication protocol certification test standard, which set February 22, 2019, as the effective deadline.

On November 19, 2018, CALSSA submitted a letter to the Executive Director requesting a six-month extension of this compliance deadline. This request was granted,¹¹ extending the compliance deadline to August 22, 2019.

Subsequently on February 11, 2019, CALSSA submitted a Petition for Modification (Petition)¹² of Resolutions E-4832 and E-4898, to request that the Commission “*include more details and not exceed areas of consensus.*” In response to the Petition, the Commission issued Resolution E-5000 that clarified the implementation details of the smart inverter Phase 2 communications requirements and of Phase 3 Functions 1 and 8. In addition, Resolution E-5000 extended the compliance deadlines to January 22, 2020, for:

- 1) Phase 2 communications requirements
- 2) Phase 3 Functions 1 and 8
- 3) Phase 3 Functions 2 (DER Disconnect and Reconnect) and 3 (Limit Maximum Active Power)

Resolution E-5000, OP 6 ordered the Utilities to submit a Tier 2 Advice Letter within 9 months of publication of IEEE 1547.1, proposing the new testing regime and reporting on the which elements thereof were supported by the consensus of the SIWG. Additionally, the Utilities were required to report the items of non-consensus. The IEEE 1547.1 test procedures were published May 21, 2020. PG&E therefore submits this Tier 2 advice letter to comply with OP 6 of Resolution E-5000.

¹⁰ [E-4898](#) - Resolution E-4898. Approval, with Modifications, of Request for Modifications to Electric Rule 21 Tariff to Incorporate Smart Inverter Phase 3 Advanced Functions in Compliance with Decision 16-06-052 - Date of Issuance: April 27, 2018

¹¹ The request was approved by the Executive Director of the Energy Division, Alice Stebbins, on January 2, 2019.

¹² *Petition of The California Solar & Storage Association for Modification Of Resolution E-4832 And Resolution E-4898* – dated February 8, 2019

DISCUSSION

Aligning IEEE 1547-2018 with Rule 21

Resolution E-5000 OP 6 required the Utilities to work with the SIWG to incorporate the new testing procedures, as appropriate, into the testing regime for Phase 2 and Phase 3 requirements.

In order to incorporate the IEEE 1547.1 testing procedures into Rule 21, it was necessary that the base standard requirements (IEEE 1547-2018¹³) also be incorporated into Rule 21. It is impractical and incomplete to only include the IEEE 1547.1 testing procedures without incorporating the base standard requirements.

In addition, as these testing procedures account for many functions within the base standard, the Utilities used this opportunity to align all the applicable technical requirements for inverter-based technology, mainly outlined in Rule 21 Section Hh, to the IEEE 1547-2018 standard.

The proposed changes in this AD and Rule 21 tariff revision align PG&E's Rule 21 tariff to the applicable section of IEEE 1547-2018 and IEEE 1547.1-2020.

Working with the Smart Inverter Working Group

Following the publication of the IEEE 1547.1 test procedures, Resolution E-5000 OP 6 required the utilities to work with the SIWG to incorporate the new procedures, as appropriate, into the testing regime for the Phase 2 and 3 requirements.

SIWG discussions commenced on July 23, 2020, and continued through January 2021. Throughout these discussions, the Utilities discussed each clause of IEEE 1547-2018 and related Rule 21 proposed modifications. In general, these discussions involved the Utilities proposing initial changes based on a specific IEEE 1547-2018 clause. Input from SIWG members was sought for each proposal and revisions were then incorporated based upon stakeholder feedback until consensus or clear non-consensus was achieved. This process continued until the last SIWG meeting held on January 21, 2021. A total of 11 SIWG meetings were held between July 23, 2020 and January 21, 2021.

The process outlined above allowed the Utilities to modify their Rule 21 proposals, which led to consensus proposals to nearly all categories including:

- Applicability of IEEE 1547 to interconnection requests at voltage < 50KV
- Inclusion of Generating Facility Rapid Voltage Changes
- Limitations of overvoltage over one fundamental frequency period

¹³ [IEEE 1547-2018](#) - *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces – Amendment 1547a-2020*
Published Date:2018-04-06

- Limitations of cumulative instantaneous overvoltage events
- Enter Service ramp controls
- Storage Inverter Normal Operation Ramp Control requirements
- Replacement of existing Frequency-Watt function with Frequency-Droop
- Requirement on measurement and calculation accuracies
- Prioritization of Smart Inverter requirements
- Ride-through of consecutive voltage disturbances
- Restore output without dynamic voltage support
- Transition between performance operating regions
- Constant reactive power mode
- Inclusion of Reference Point of Applicability (RPA) and implication to generating facility operating requirements
- Update of existing Rule 21 language related to flicker and harmonic distortion
- Replacement of existing voltage ride-through and trip tables for Section Hh with new IEEE 1547-2018 tables
- Replacement of existing frequency ride through and trip tables for Section Hh with new IEEE 1547-2018 tables
- Update of existing IEEE 1547-2003 references to IEEE 1547-2018 references
- Requirement for Rate of Change of Frequency (ROCOF) ride-through requirement
- Update of reactive power requirements for Smart Inverters and default settings
- Update to communication requirements

Non-Consensus Items

The Utilities and SIWG members worked diligently and resolved differences to achieve consensus. However, there appears to be only one item where one SIWG stakeholder did not concur with the Utilities' proposal, even with the inverter manufacturers supporting the Utilities' position. This non-consensus issue is related to the default setting for the Frequency-Droop function (the replacement of the existing Rule 21 frequency-watt function). The Utilities propose that this function continues to perform as approved by the Commission in Resolution E-4898. The stakeholder asserted that it would be more appropriate to use the IEEE 1547-2018 default settings given that rest of the industry has not yet adopted the CPUC approved default setting for the frequency-watt function.

The Utilities believe that the default settings, as currently utilized, are identical and no more restrictive than what was approved by the Commission in Resolution E-4898. In addition, the Utilities believe that going to a slower frequency-droop default value essentially reduces the capabilities that Smart Inverters can provide to the grid during

potential emergency conditions where frequency may deviate from nominal. This requirement has been in place for new Smart Inverters since September 7, 2017 and the Utilities have not received any complaints that this function may be reducing energy production. Therefore, the Utilities' position is that the Commission approved default settings should remain.

Proposing the New Testing Regime

Phase 3 Function 1 – Monitor Key Data

In accordance with OP 7 of Resolution E-5000, manufacturer attestations are accepted as sufficient evidence of compliance with Phase 3 Function 1 (Monitor Key Data) until 18 months after the publication of a nationally recognized test procedure containing Phase 3 Function 1. IEEE 1547.1 was published on May 21, 2020 and thus 18 months from such day is November 21, 2021. Therefore, **attestations for Function 1 requirements would be accepted until November 21, 2021**, as required by Resolution E-5000.

Starting on November 22, 2021, certification under IEEE 1547.1-2020 would be required to satisfy Function 1 communication requirements. However, given industry preparedness needs, **the Utilities propose that the acceptance of attestations as sufficient evidence of compliance with Function 1 be extended until December 31, 2021 and new requirements under this AL for all Rule 21 updates to IEEE 1547-2018 and IEEE 1547.1-2020 be required as of January 1, 2022**. During SIWG discussions, several SIWG members indicated the need for additional time and agreed that a January 1, 2022 compliance day for the new IEEE 1547-2018 functions is more appropriate.

Phase 3 Function 8 - Scheduling

OP 8 of Resolution E-5000 allows manufacturer attestations as sufficient evidence of compliance with Phase 3 Function 8 (Scheduling) until 12 months after the publication of a nationally recognized test procedure containing Phase 3 Function 8. Since IEEE 1547-2018 and therefore IEEE 1547.1 did not address Function 8, **attestation will continue to be used for compliance with this function as outlined in OP 8 until such time that a nationally recognized test standard is published** to address this function. At this time, the Utilities have no projections as to when this may occur.

PROPOSED TARIFF CHANGES

Note on proposed Rule 21 Changes: As the IEEE Standards (IEEE 1547-2018 and IEEE 1547.1-2020) (“Standards”) are proprietary to the IEEE and subject to the IEEE’s copyright, rather than include direct language from the Standards, the Utilities reference the relevant IEEE sections in Rule 21. If at some future date the IEEE authorizes the Utilities to use their language in Rule 21, the Utilities may choose to incorporate it to replace the references.

Schedule Rule 21:

- Modify Table of Contents to add new Sections in:
 - B.5
 - H.2
 - H3
 - Hh.2
- Modify Table of Contents to rename Sections:
 - Hh.2.i
 - Hh.2.k
 - Hh.2.l
 - Hh.2.m
 - Hh.2.n
 - Hh.2.o
 - Hh.2.p
 - Hh.2.q
 - Hh.2.r
- Modify Rule 21 to add reference to UL 1741 Supplement B
 - Table of Contents
 - Mm
 - G.i
 - L
 - L.3.b
 - Mm
- Modify the following Sections to conform with IEEE 1547-2018
 - B.3
 - New B.5
 - New definitions C
 - H
 - H.1
 - H.2
 - Hh

- Hh.1
- HH.2
- Hh.5
- Hh.7
- Hh.8
- L.1
- Table L.1
- Update IEEE 1547-2018 reference sections
 - G.2.b
 - H
 - H.1
 - H.2
 - Hh.1
 - Hh.2
 - Hh.7
 - Hh.8
 - L.2.a
 - L.3.e
 - Table L.3
 - L.3.g
 - L.7.a

No cost information is required for this advice letter.

This advice letter will not increase any rate or charge, cause the withdrawal of service, or conflict with any other schedule or rule.

III. Protests

*****Due to the COVID-19 pandemic and the shelter at home orders, PG&E is currently unable to receive protests or comments to this advice letter via U.S. mail or fax. Please submit protests or comments to this advice letter to EDTariffUnit@cpuc.ca.gov andPGETariffs@pge.com*****

Anyone wishing to protest this submittal may do so by letter sent via U.S. mail, facsimile, or E-mail, no later than March 15, 2021, which is 21 days¹⁴ after the date of this submittal. Protests must be submitted to:

¹⁴ The 20-day protest period concludes on a weekend; therefore, PG&E is moving this date to the following business day.

CPUC Energy Division
ED Tariff Unit
505 Van Ness Avenue, 4th Floor
San Francisco, California 94102

Facsimile: (415) 703-2200
E-mail: EDTariffUnit@cpuc.ca.gov

Copies of protests also should be mailed to the attention of the Director, Energy Division, Room 4004, at the address shown above.

The protest shall also be sent to PG&E either via E-mail or U.S. mail (and by facsimile, if possible) at the address shown below on the same date it is mailed or delivered to the Commission:

Erik Jacobson
Director, Regulatory Relations
c/o Megan Lawson
Pacific Gas and Electric Company
77 Beale Street, Mail Code B13U
P.O. Box 770000
San Francisco, California 94177

Facsimile: (415) 973-3582
E-mail: PGETariffs@pge.com

Any person (including individuals, groups, or organizations) may protest or respond to an advice letter (General Order 96-B, Section 7.4). The protest shall contain the following information: specification of the advice letter protested; grounds for the protest; supporting factual information or legal argument; name, telephone number, postal address, and (where appropriate) e-mail address of the protestant; and statement that the protest was sent to the utility no later than the day on which the protest was submitted to the reviewing Industry Division (General Order 96-B, Section 3.11).

IV. Effective Date

PG&E requests this Tier 2 advice letter, pursuant to Ordering Paragraph 6 of Resolution E-5000, become effective on March 24, 2021, the 30th calendar day after submission.

V. Notice

In accordance with General Order 96-B, Section IV, a copy of this Advice Letter is being sent electronically and via U.S. mail to parties shown on the attached list and the parties on the service lists GO 96-B and R.11-09-011 and R.17-07-007. Address changes to the General Order 96-B service list should be directed to PG&E at email address

PGETariffs@pge.com. For changes to any other service list, please contact the Commission's Process Office at (415) 703-2021 or at Process_Office@cpuc.ca.gov. Send all electronic approvals to PGETariffs@pge.com. Advice letter submittals can also be accessed electronically at: <http://www.pge.com/tariffs/>.

_____/S/

Erik Jacobson
Director, Regulatory Relations

cc: Service Lists GO 96-B and R.11-09-011 and R.17-07-007

Attachments:

Attachment 1: Tariffs

Attachment 2: Redline Tariff Revisions



ADVICE LETTER SUMMARY

ENERGY UTILITY



MUST BE COMPLETED BY UTILITY (Attach additional pages as needed)

Company name/CPUC Utility No.: Pacific Gas and Electric Company (ID U39E)

Utility type:

- ELC GAS WATER
 PLC HEAT

Contact Person: Kimberly Loo

Phone #: (415)973-4587

E-mail: PGETariffs@pge.com

E-mail Disposition Notice to: KELM@pge.com

EXPLANATION OF UTILITY TYPE

ELC = Electric GAS = Gas WATER = Water
 PLC = Pipeline HEAT = Heat

(Date Submitted / Received Stamp by CPUC)

Advice Letter (AL) #: 6093-E

Tier Designation: 2

Subject of AL: Modifications to Electric Rule 21 Pursuant to Resolution E-5000 Ordering Paragraphs 6, 7, and 8 for IEEE 1547.1 Standards

Keywords (choose from CPUC listing): Compliance, Rule 21

AL Type: Monthly Quarterly Annual One-Time Other:

If AL submitted in compliance with a Commission order, indicate relevant Decision/Resolution #: Res. E-5000

Does AL replace a withdrawn or rejected AL? If so, identify the prior AL: No

Summarize differences between the AL and the prior withdrawn or rejected AL:

Confidential treatment requested? Yes No

If yes, specification of confidential information:

Confidential information will be made available to appropriate parties who execute a nondisclosure agreement. Name and contact information to request nondisclosure agreement/ access to confidential information:

Resolution required? Yes No

Requested effective date: 3/24/21

No. of tariff sheets: 115

Estimated system annual revenue effect (%): N/A

Estimated system average rate effect (%): N/A

When rates are affected by AL, include attachment in AL showing average rate effects on customer classes (residential, small commercial, large C/I, agricultural, lighting).

Tariff schedules affected: See Attachment 1

Service affected and changes proposed¹: N/A

Pending advice letters that revise the same tariff sheets: 5988-E,6014-E,5915-E

¹Discuss in AL if more space is needed.

Protests and all other correspondence regarding this AL are due no later than 20 days after the date of this submittal, unless otherwise authorized by the Commission, and shall be sent to:

CPUC, Energy Division
Attention: Tariff Unit
505 Van Ness Avenue
San Francisco, CA 94102
Email: EDTariffUnit@cpuc.ca.gov

Name: Erik Jacobson, c/o Megan Lawson
Title: Director, Regulatory Relations
Utility Name: Pacific Gas and Electric Company
Address: 77 Beale Street, Mail Code B13U
City: San Francisco, CA 94177
State: California Zip: 94177
Telephone (xxx) xxx-xxxx: (415)973-2093
Facsimile (xxx) xxx-xxxx: (415)973-3582
Email: PGETariffs@pge.com

Name:
Title:
Utility Name:
Address:
City:
State: District of Columbia Zip:
Telephone (xxx) xxx-xxxx:
Facsimile (xxx) xxx-xxxx:
Email:

Cal P.U.C. Sheet No.	Title of Sheet	Cancelling Cal P.U.C. Sheet No.
48753-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 1	42298-E
48754-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 8	42305-E
48755-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 10	42307-E
48756-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 11	42308-E
48757-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 12	42309-E
48758-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 13	42310-E
48759-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 14	42311-E
48760-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 16	42313-E
48761-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 17	42314-E
48762-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 18	42315-E
48763-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 19	42316-E
48764-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 20	42317-E
48765-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 26	42323-E
48766-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 27	42324-E

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48767-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 28	42325-E
48768-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 30	42327-E
48769-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 31	42328-E
48770-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 71	42368-E
48771-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 151	42448-E
48772-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 156	42453-E
48773-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 157	42454-E
48774-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 165	42462-E
48775-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 166	42463-E
48776-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 167	42464-E
48777-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 168	42465-E
48778-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 169	42466-E
48779-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 170	42467-E
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48781-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 175	42472-E
48782-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 177	42474-E
48783-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 178	42475-E
48784-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 179	42476-E
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48789-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 186	42483-E
48790-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 187	42484-E
48791-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 188	42485-E
48792-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 189	42486-E
48793-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 190	42487-E
48794-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 191	42488-E

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48797-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 194	42491-E
48798-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 195	42492-E
48799-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 196	43700-E
48800-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 197	43701-E
48801-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 198	43702-E
48802-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 199	43703-E
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48805-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 202	43706-E
48806-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 203	42500-E
48807-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 204	46382-E
48808-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 205	42502-E

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48809-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 206	42503-E
48810-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 207	46383-E
48811-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 209	46384-E
48812-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 211	43712-E
48813-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 212	43713-E
48814-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 213	
48815-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 214	42510-E
48816-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 215	42511-E
48817-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 216	42512-E
48818-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 217	42513-E
48819-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 218	42514-E
48820-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 219	42515-E
48821-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 220	42516-E
48822-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 221	42517-E

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48828-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 227	42523-E
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48831-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 230	42525-E
48832-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 231	42526-E
48833-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 232	42527-E
48834-E	ELECTRIC RULE NO. 21 GENERATING FACILITY INTERCONNECTIONS Sheet 233	42528-E
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Sheet 17

C. DEFINITIONS (Cont'd.)

Added Facilities: See Special Facilities. (L)

Affected System: An electric system other than Distribution Provider's Distribution or Transmission System that may be affected by the proposed Interconnection. (L)

Affected System Operator: The entity that operates an Affected System.

Affiliate: With respect to a corporation, partnership or other entity, each such other corporation, partnership or other entity that directly or indirectly, through one or more intermediaries, controls, is controlled by, or is under common control with, such corporation, partnership or other entity.

Allocated Capacity: Existing aggregate generation capacity in megawatts (MW) interconnected to a substation/area bus, bank or circuit (i.e., amount of generation online).

Anti-Islanding: A control scheme installed as part of the Generating or Interconnection Facility that senses and prevents the formation of an Unintended Island.

Applicant: The entity submitting an Interconnection Request pursuant to this Rule.

Application: See Interconnection Request.

Available Capacity: Total Capacity less the sum of Allocated Capacity and Queued Capacity.

(L)

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 18

C. DEFINITIONS (Cont'd.)

Base Case: Data including, but not limited to, base power flow, short circuit and dynamic/stability data bases, underlying load, generation, and transmission facility assumptions, contingency lists, including relevant special protection systems, and transmission diagrams used to perform the Interconnection Studies. The Base Case may include Critical Energy Infrastructure Information (as that term is defined by FERC). The Base Case shall include (a) transmission facilities as approved by Distribution Provider or CAISO, as applicable, (b) planned Distribution Upgrades that may have an impact on the Interconnection Request, (c) Distribution Upgrades and Network Upgrades associated with generating facilities in (iv) below, and (d) generating facilities that (i) are directly interconnected to the Distribution System or CAISO Controlled Grid; (ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request; (iii) have a pending request to interconnect to the Distribution System or an Affected System; or (iv) are not interconnected to the Distribution System or CAISO Controlled Grid, but are subject to a fully executed Generator Interconnection Agreement (or its equivalent predecessor agreement) or for which an unexecuted Generator Interconnection Agreement (or its equivalent predecessor agreement) has been requested to be filed with FERC.

Business Day: Monday through Friday, excluding Federal and State Holidays.

CAISO Controlled Grid: The system of transmission lines and associated facilities that have been placed under the CAISO's Operational Control.

CAISO Tariff: The California Independent System Operator FERC Electric Tariff.

Calendar Day: Any day, including Saturday, Sunday or a Federal and State Holiday.

Certification Test: A test pursuant to this Rule that verifies conformance of certain equipment with Commission-approved performance standards in order to be classified as Certified Equipment. Certification Tests are performed by Nationally Recognized Test Laboratories (NRTLs).

Certification; Certified; Certificate: The documented results of a successful Certification Testing.

Certified Equipment: Equipment that has passed all required Certification Tests.

Commission: The Public Utilities Commission of the State of California.

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

C. DEFINITIONS (Cont'd.)

Commercial Operation: The status of a Generating Facility that has commenced generating electricity, excluding electricity generated during the period which Producer is engaged in on-site test operations and commissioning of the Generating Facility prior to Commercial Operation. (L)

Commercial Operation Date: The date on which a Generator at a Generating Facility commences Commercial Operation, as agreed to by the Parties. (L)

Commissioning Test: A test performed during the commissioning of all or part of a Generating Facility to achieve one or more of the following:

- Verify specific aspects of its performance;
- Calibrate its instrumentation;
- Establish instrument or Protective Function set-points.
- Confidential Information: See Section D.7.

Conservation Voltage Regulation (CVR): The CVR program that the Commission directed Distribution Provider to implement as applicable to the operation and design of distribution circuits and related service voltages.

Construction Activities: Actions by Distribution Provider that result in irrevocable financial commitments for the purchase of major electrical equipment or land for Distribution Provider's Interconnection Facilities, Distribution Upgrades, or Network Upgrades assigned to the Interconnection Customer that occur after receipt of all appropriate governmental approvals needed for Distribution Provider's Interconnection Facilities, Distribution Upgrades, or Network Upgrades.

Continuous Operation: The Smart Inverter operates indefinitely without tripping. Any functions that protect the Smart Inverter from damage may operate as needed.

Control Area: As defined in the CAISO Tariff.

Cost Envelope: A cost-certainty framework defined as plus or minus twenty-five (25) percent of the estimated cost of certain Interconnection Facilities and/or Distribution Upgrades identified in the Cost Envelope Estimate that is offered to an Applicant based on actual costs within such twenty-five (25) percent envelope. Applicant's cost responsibility for Interconnection Facilities and/or Distribution Upgrades subject to the Cost Envelope is set forth in Section F.7.b.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 20

C. DEFINITIONS (Cont'd.)

Cost Envelope Option: A five-year pilot option described in Section F.7 applicable to Interconnection Requests for Generating Facilities that are processed under the Fast Track Process or Independent Study Process.

Cost Envelope Estimate: An estimate prepared by the Distribution Provider and delivered to Applicant pursuant to the Cost Envelope Option that contains (i) the estimated cost of Distribution Provider's required Interconnection Facilities and/or Distribution Upgrades that are offered to Applicant that are subject to the Cost Envelope, and (ii) the estimated costs of related activities and facilities that are excluded from the Cost Envelope and offered on an actual cost basis, both pursuant to Section F.7.

Customer: The entity that receives or is entitled to receive Distribution Service through Distribution Provider's Distribution System or is a retail Customer of Distribution Provider connected to the Transmission System.

db_{OF} - A single-sided deadband value for high-frequency in Hz used in Section Hh.L.

(T)

db_{UF} - A single-sided deadband value for low-frequency in Hz used in Section Hh.L.

(T)

Dedicated Transformer; Dedicated Distribution Transformer: A transformer that provides electricity service to a single Customer. The Customer may or may not have a Generating Facility.

Delivery Network Upgrades: The transmission facilities at or beyond the point where Distribution Provider's Distribution System interconnects to the CAISO Controlled Grid, other than Reliability Network Upgrades, as defined in the CAISO Tariff.

Detailed Study: An Independent Study, a Distribution Group Study or a Transmission Cluster Study.

Detailed Study Agreement: The agreement entered into by the Interconnection Customer and Distribution Provider which sets forth the Parties' agreement to perform Interconnection Studies under the Independent Study Process or the Distribution Group Study Process.

Device: A mechanism or piece of equipment designed to serve a purpose or perform a function. The term may be used interchangeably with the terms "equipment" and function without intentional difference in meaning. See also Function and Protective Function.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 26

C. DEFINITIONS (Cont'd.)

Interconnection Request: An Applicant's request to interconnect a new Generating Facility, or to increase the capacity of, or make a Material Modification to the operating characteristics of, an existing Generating Facility that is interconnected with Distribution Provider's Distribution or Transmission System.

Interconnection Study: A study to establish the requirements for Interconnection of a Generating Facility with Distribution Provider's Distribution System or Transmission System, pursuant to this Rule.

Interconnection System Impact Study: An engineering study conducted by Distribution Provider for an Interconnection Customer under the Independent Study Process that evaluates the impact of the proposed interconnection on the safety and reliability of Distribution Provider's Distribution and/or Transmission System and, if applicable, an Affected System. The scope of the study is defined in Section G.3.c.i.

Island; Islanding: A condition on Distribution Provider's Distribution System in which one or more Generating Facilities deliver power to Customers using a portion of Distribution Provider's Distribution System that is electrically isolated from the remainder of Distribution Provider's Distribution System.

k_{OF}: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop) for high frequency conditions, unitless used in Section Hh.2.I.

(T)

k_{UF}: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop) for low frequency conditions, unitless used in Section Hh.2.I.

(T)

Large Generating Facility: A Generating Facility having a Generating Facility Capacity of more than 20 MW.

Line Section: That portion of Distribution Provider's Distribution or Transmission System connected to a Customer bounded by automatic sectionalizing devices or the end of the distribution line.

Local Generating Facility Communication Interface: Interface at the Generating Facility capable of communicating to support the information exchange requirements specified in this rule and as required in IEEE 1547-2018 for all applicable functions that are in Section Hh.

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(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 27

C. DEFINITIONS (Cont'd.)

Local Furnishing Bond: Tax-exempt bonds utilized to finance facilities for the local furnishing of electric energy, as described in Internal Revenue Code, 26 U.S.C. § 142(f).

(L)

Local Furnishing Distribution Provider: Any Distribution Provider that owns facilities financed by Local Furnishing Bonds.

Mandatory Operation: The Smart Inverter operates at maximum available current without tripping during Distribution Provider's Transmission or Distribution System excursions outside the region of continuous operation. Any functions that protect the Smart Inverter from damage may operate as needed.

(L)

Material Modification: Those modifications that have a material impact on cost or timing of any Interconnection Request with a later queue priority date or a change in Point of Interconnection. A Material Modification does not include a change in ownership of a Generating Facility.

Metering: The measurement of electrical power in kilowatts (kW) and/or energy in kilowatt-hours (kWh), and if necessary, reactive power in kVAR at a point, and its display to Distribution Provider, as required by this Rule.

Metering Equipment: All equipment, hardware, software including meter cabinets, conduit, etc., that are necessary for Metering.

Momentary Cessation: The Smart Inverter momentarily reduces current output to the Distribution Provider's Transmission or Distribution System to below 10% of the maximum continuous output current rating. The Smart Inverter is allowed to increase current output to the Distribution Provider's Transmission or Distribution System without any intentional reconnection delay once voltage exits the Momentary Cessation region and enters a Permissive Operation region or Continuous Operation region.

Momentary Parallel Operation: The Interconnection of a Generating Facility to the Distribution and Transmission System for one second (60 cycles) or less.

Nationally Recognized Testing Laboratory (NRTL): A laboratory accredited to perform the Certification Testing requirements under this Rule.

(L)

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 28

C. DEFINITIONS (Cont'd.)

Net Energy Metering (NEM): Metering for the receipt and delivery of electricity between Producer and Distribution Provider pursuant to California Public Utilities Code (PUC) sections 2827, 2827.1 (as currently implemented by Commission Decision (D.)16-01-044), 2827.8, or 2827.10.

(L)

NEM-1: Refers to Interconnection Requests for service pursuant to Schedules NEM, NEMV, and NEMVMASH.

NEM-2: Refers to Interconnection Requests for service pursuant to Schedules NEM2, NEM2V, NEM2VMSH, and NEM2VSOM.

(L)

Net Rating or Net Nameplate Rating: The Gross Rating minus the consumption of electrical power of the auxiliary load.

Network Upgrades: Delivery Network Upgrades and Reliability Network Upgrades.

Networked Secondary System: An AC distribution system where the secondaries of the distribution transformers are connected to a common bus for supplying electricity directly to consumers. There are two types of secondary networks: grid networks (also referred to as area networks or street networks) and Spot Networks. Synonyms: Secondary Network. Refer to IEEE 1547.6 for additional detail.

Non-Emergency: Conditions or situations that are not Emergencies, including but not limited to meter reading, inspection, testing, routine repairs, replacement, and maintenance.

Nominal: Standard frequency and voltage.

Non-Export; Non-Exporting: When the Generating Facility is sized and designed such that the Generator output is used for Host Load only and is designed to prevent the transfer of electrical energy from the Generating Facility to Distribution Provider's Distribution or Transmission System.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 30

C. DEFINITIONS (Cont'd.)

Parallel Operation: The simultaneous operation of a Generator with power delivered or received by Distribution Provider while Interconnected. For the purpose of this Rule, Parallel Operation includes only those Generating Facilities that are Interconnected with Distribution Provider's Distribution or Transmission System for more than 60 cycles (one second).

Paralleling Device: An electrical device, typically a circuit breaker, operating under the control of a synchronization relay or by a qualified operator to connect an energized generator to an energized electric power system or two energized power systems to each other.

Party, Parties: Applicant or Distribution Provider.

Periodic Test: A test performed on part or all of a Generating Facility/Interconnection Facilities at pre-determined time or operational intervals to achieve one or more of the following: 1) verify specific aspects of its performance; 2) calibrate instrumentation; and 3) verify and re-establish instrument or Protective Function set-points.

Permissive Operation: The Smart Inverter is allowed, but not required, to operate at any current level.

Point of Common Coupling (PCC): The transfer point for electricity between the electrical conductors of Distribution Provider and the electrical conductors of Producer.

Point of Distributed Energy Resources Connection (Point of Generating Resource Connection–PoC): The point where a generating resource unit is electrically connected in a generating facility and meets the requirements of this rule.

(N)
|
(N)

Point of Interconnection (POI): The point where the Interconnection Facilities connect with Distribution Provider's Distribution or Transmission System. This may or may not be coincident with the Point of Common Coupling.

(T)

Pre-Construction Activities: The actions by Distribution Provider, other than those required by an Engineering and Procurement Agreement under Section F.3.f, undertaken prior to Construction Activities in order to prepare for the construction of Distribution Provider's Interconnection Facilities, Distribution Upgrades, or Network Upgrades assigned to the Interconnection Customer, including, but not limited to, preliminary engineering, permitting activities, environmental analysis, or other activities specifically needed to obtain governmental approvals for Distribution Provider's Interconnection Facilities, Distribution Upgrades, or Network Upgrades.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 31

C. DEFINITIONS (Cont'd.)

Producer: The entity that executes a Generator Interconnection Agreement with Distribution Provider. Producer may or may not own or operate the Generating Facility, but is responsible for the rights and obligations related to the Generator Interconnection Agreement.

Production Test: A test performed on each device coming off the production line to verify certain aspects of its performance.

Protective Function(s): The equipment, hardware and/or software in a Generating Facility (whether discrete or integrated with other functions) whose purpose is to protect against Unsafe Operating Conditions.

Prudent Electrical Practices: Those practices, methods, and equipment, as changed from time to time, that are commonly used in prudent electrical engineering and operations to design and operate electric equipment lawfully and with safety, dependability, efficiency, and economy.

Queue Position: See Section E.5.C.

Queued Capacity: Aggregate queued generation capacity (in MW) for a substation/area bus, bank or circuit (i.e., amount of generation in the queue).

Reference Point of Applicability (RPA): The location where the Generating Facility interconnection and interoperability performance requirements shall be met.

(N)
|
(N)

Reasonable Efforts: With respect to an action required to be attempted or taken by a Party under this Rule, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Reliability Network Upgrades: The transmission facilities at or beyond the point where Distribution Provider's Distribution System interconnects to the CAISO Controlled Grid, necessary to interconnect one or more Generating Facility(ies) safely and reliably to the CAISO Controlled Grid, as defined in the CAISO Tariff.

Section 218 Load: Electrical power that is supplied in compliance with California PUC section 218. PUC section 218 defines an "Electric Corporation" and provides conditions under which a transaction involving a Generating Facility would not classify a Producer as an Electric Corporation. These conditions relate to "over-the-fence" sale of electricity from a Generating Facility without using Distribution Provider's Distribution or Transmission System.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 71

F. REVIEW PROCESS FOR INTERCONNECTION REQUESTS (Cont'd.)

1. OVERVIEW OF THE INTERCONNECTION REVIEW PROCESS (Cont'd.)

b. Fast Track Review

Fast Track evaluation allows for rapid review of the Interconnection of those Generating Facilities that do not require Detailed Study. Regardless of study process, all Generating Facilities shall be designed to meet the applicable requirements of Section H or Hh which identifies Generating Facility Design and Operation Requirements. (T)

Fast Track review consists of an Initial Review and, if required, a Supplemental Review. The need for Supplemental Review will be determined based on the results of Initial Review Screens A through M in Section G.1. Applicants that successfully pass Initial Review Screens A through M will be allowed to interconnect without Supplemental Review.

Non-Export AC/DC Converter installations that have a complete and valid Interconnection Request will be eligible to bypass screens B through D and F through M.

If Supplemental Review is required, Distribution Provider will notify Applicant and Applicant must pay a nonrefundable Supplemental Review fee, per Table E-1 or withdraw its Interconnection Request. Supplemental Review shall consist of the application of Screens N through P in Section G.2. Applicants that pass Screens N through P will be allowed to interconnect without additional review.

If Supplemental Review reveals that a proposed Generating Facility cannot be interconnected to Distribution Provider's Distribution System by means of Fast Track evaluation, Distribution Provider will notify Applicant that Detailed Study will be required.

Failure to pass Fast Track evaluation means only that further review and/or study are required before the Generating Facility can be interconnected with Distribution Provider's Distribution System. It does not mean that the Generating Facility cannot be interconnected.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 151

G. ENGINEERING REVIEW DETAILS (Cont'd.)

1. INITIAL REVIEW SCREENS (Cont'd.)

i. Screen I: Will power be exported across the PCC? (Cont'd.)

Option 4 (Relative Generating Facility Rating): This option, when used, requires the Net Rating of the Generating Facility to be so small in comparison to its host facility's minimum load, that the use of additional Protective Functions is not required to ensure that power will not be exported to Distribution Provider's Distribution or Transmission System. This option requires the Generating Facility capacity to be no greater than 50% of Producer's verifiable minimum Host Load over the past 12 months.

Option 5: Inadvertent Export as described in Section M.

Option 6: Inadvertent Export utilizing UL-1741 or UL-1741 SA/SB listed grid support (Non-Islanding) inverters as described in Section Mm. (T)

Significance:

1. If it can be assured that the Generating Facility will not export power, Distribution Provider's Distribution or Transmission System does not need to be studied for load-carrying capability or Generating Facility power flow effects on Distribution Provider voltage regulators.
2. This Screen permits the use of reverse-power or minimum-power relaying as a Non-Islanding Protective Function (Option 1, 2, and 3).
3. This Screen allows, under certain defined conditions, for Generating Facilities that incorporate Certified Non-Islanding protection to qualify for interconnection through the Fast Track process without implementing reverse power or minimum power Protective Functions (Option 3).

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 156

G. ENGINEERING REVIEW DETAILS (Cont'd.)

2. SUPPLEMENTAL REVIEW SCREENS (Cont'd.)

a. Screen N: Penetration Test (Cont'd.)

Note 4: Distribution Provider will not consider as part of the aggregate Generating Facility capacity for purposes of this screen Generating Facility capacity known to be already reflected in the minimum load data.

Note 5: NEM Generating Facilities with net export less than or equal to 500 kW that may flow across the Point of Common Coupling into Distribution Provider's Distribution or Transmission System will not be studied in the Transmission Cluster Study Process, but may be studied under the Independent Study Process.

Significance: Penetration of Generating Facility capacity that does not result in power flow from the circuit back toward the substation will have a minimal impact on equipment loading, operation, and protection of the Distribution System.

b. Screen O: Power Quality and Voltage Tests

In aggregate with existing Generating Facility capacity on the Line Section, distribution circuit, and/or substation.

i) Can it be determined within the Supplemental Review that the voltage regulation on the line section can be maintained in compliance with Commission Rule 2 and/or Conservation Voltage Regulation voltage requirements under all system conditions?

ii) Can it be determined within the Supplemental Review that the voltage fluctuation is within acceptable limits as defined by IEEE 1547-2018 7.2 or utility practice similar to IEEE1547-2018 7.2? (T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 157

G. ENGINEERING REVIEW DETAILS (Cont'd.)

2. SUPPLEMENTAL REVIEW SCREENS (Cont'd.)

b. Screen O: Power Quality and Voltage Tests (Cont'd.)

In aggregate with existing Generating Facility capacity on the Line Section, distribution circuit, and/or substation. (Cont'd.)

iii) Can it be determined within the Supplemental Review that the harmonic levels meet IEEE 1547-2018 7.3 limits at the Point of Common Coupling (PCC)? (T)

- If yes to all of the above (pass), continue to Screen P.
- If no to any of the above (fail), a quick review of the failure may determine the requirements to address the failure; otherwise Electrical Independence Tests and Detailed Studies are required. Continue to Screen P. (Note: If Electrical Independence tests and Detailed Studies are required, Applicants will continue to the Electrical Independence Tests and Detailed Studies after review of the remaining Supplemental Review Screens.)

Significance: Adverse voltages and undesirable interference may be experienced by other Customers on Distribution Provider's Distribution System caused by operation of the Generating Facility(ies).

c. Screen P: Safety and Reliability Tests

Does the location of the proposed Generating Facility or the aggregate generation capacity on the Line Section create impacts to safety or reliability that cannot be adequately addressed without Detailed Study?

- If yes (fail), review of the failure may determine the requirements to address the failure; otherwise Electrical Independence Tests and Detailed Studies are required. Continue to Section G.3.
- If no (pass), Supplemental Review is complete.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 165

G. ENGINEERING REVIEW DETAILS (Cont'd.)

3. DETAILED STUDY SCREENS (Cont'd.)

c. Independent Study Process and Distribution Group Study Process Interconnection Studies (Cont'd.)

ii) Interconnection Facilities Study and DGS Phase II Interconnection Study. (Cont'd.)

(1) Scope and Purpose of the Interconnection Facilities and DGS Phase II Interconnection Study. (Cont'd.)

Good Utility Practice to physically and electrically connect the Generating Facility to the Distribution or Transmission System. The Interconnection Facilities Study or DGS Phase II Interconnection Study shall also identify (i) the electrical switching configuration of the connection equipment, including, without limitation: the transformer, switchgear, meters, and other station equipment; the nature and estimated cost of any Distribution Provider's Interconnection Facilities, Distribution Upgrades, and Network Upgrades necessary to accomplish the interconnection; and an estimate of the time required to complete the construction and installation of such facilities. The analyses in the Interconnection System Impact Study (or DGS Phase I Interconnection Study in the case of the Distribution Group Study Process) will be updated as necessary in the Interconnection Facilities Study (or DGS Phase II Interconnection Study), to account for withdrawal of interconnection requests in the interconnection queue.

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS

Section H shall be used for interconnection of non-inverter based technologies.

(D)

(D)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 166

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS

This section is consistent with the requirements of IEEE 1547-2018. In the event of conflict, this Rule shall take precedent. (T)
(T)

The Protective Functions and requirements of this Rule are designed to protect Distribution Provider's Distribution and Transmission System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for its Generating Facility and Interconnection Facilities. Producer's Protective Functions shall not impact the operation of other Protective Functions on Distribution Provider's Distribution and Transmission System in a manner that would affect Distribution Provider's capability of providing reliable service to its customers.

a. Protective Functions Required

Generating Facilities operating in parallel with Distribution Provider's Distribution or Transmission System shall be equipped with the following Protective Functions to sense abnormal conditions on Distribution Provider's Distribution or Transmission System and cause the Generating Facility to be automatically disconnected from Distribution Provider's Distribution or Transmission System or to prevent the Generating Facility from being connected to Distribution Provider's Distribution or Transmission System inappropriately:

- i) Over and under voltage trip functions and over and under frequency trip functions;
- ii) A voltage and frequency sensing and time-delay function to prevent the Generating Facility from energizing a de-energized Distribution or Transmission System circuit and to prevent the Generating Facility from reconnecting with Distribution Provider's

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 167

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

a. Protective Functions Required (Cont'd.)

- ii) Distribution or Transmission System unless Distribution Provider's Distribution System service voltage and frequency is within the ANSI C84.1-1995 Table 1 Range B voltage Range of 106 volts to 127 volts (on a 120 volt basis), inclusive, and a frequency range of 59.3 Hz to 60.5 Hz, inclusive, and are stable for at least 60 seconds; (T)
- iii) A function to prevent the Generating Facility from contributing to the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution System within two seconds of the formation of an Unintended Island; and (T)
- iv) Open Phase Condition: Generating Facility shall detect and cease to energize and trip all phases within 2 seconds of any open phase condition in accordance with IEEE 1547-2018 6.2.2. (N)
|
(N)

The Generating Facility shall cease to energize Distribution Provider's Distribution System for faults on Distribution Provider's Distribution System circuit to which it is connected (IEEE 1547-2018 6.2.1). The Generating Facility shall cease to energize Distribution Provider's Distribution circuit prior to re-closure by Distribution Provider's Distribution System equipment (IEEE 1547-2018 6.3). (T)
(T)

b. Momentary Paralleling Generating Facilities

With Distribution Provider's approval, the transfer switch or scheme used to transfer Producer's loads from Distribution Provider's Distribution or Transmission System to Producer's Generating Facility may be used in lieu of the Protective Functions required for Parallel Operation.

Generating facilities which operate using a momentary parallel scheme are not required to comply with the functional requirements as required in the IEEE 1547-2018 standard. (N)
|
(N)

(L)
(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 168

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

c. Suitable Equipment Required (T)

Circuit breakers or other interrupting equipment located at the Point of Common Coupling (PCC) must be Certified or "Listed" (as defined in Article 100, the Definitions Section of the National Electrical Code) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location. Producer's Generating Facility and Interconnection Facilities shall be designed so that the failure of any single device or component shall not potentially compromise the safety and reliability of Distribution Provider's Distribution and Transmission System. The Generating Facility paralleling-device shall be capable of withstanding 220% of the Interconnection Facility rated voltage (IEEE 1547-2018 4.11). The Interconnection Facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std C62.41.2-2002 or IEEE Std C37.90.1-2002 as applicable and as described in L.3.e (IEEE 1547-2018 4.11). (L)

d. Visible Disconnect Required

When required by Distribution Provider's operating practices, Producer shall furnish and install a ganged, manually-operated isolating switch (or a comparable device mutually agreed upon by Distribution Provider and Producer) near the Point of Interconnection to isolate the Generating Facility from Distribution Provider's Distribution or Transmission System. The device does not have to be rated for load break nor provide over-current protection.

The device must:

- i) allow visible verification that separation has been accomplished. (This requirement may be met by opening the enclosure to observe contact separation.)
- ii) include markings or signage that clearly indicates open and closed positions.

(L)
(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 169

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

d. Visible Disconnect Required (Cont'd.)

iii) be capable of being reached: (T)

a) for Emergency purposes quickly and conveniently 24 hours a day by Distribution Provider personnel for construction, operation, maintenance, inspection, testing or to isolate the Generating Facility from Distribution Provider's Distribution or Transmission System without obstacles or requiring those seeking access to obtain keys, special permission, or security clearances. (L)
|
(L)

b) for Non-Emergency purposes during normal business hours. Distribution Provider, where possible, will provide notice to Customer for gaining access to Customer's premises.

iv) be capable of being locked in the open position,

v) be clearly marked on the submitted single line diagram and its type and location approved by Distribution Provider prior to installation. If the device is not adjacent to the PCC, permanent signage must be installed at a Distribution Provider approved location providing a clear description of the location of the device. If the switch is not accessible outside the locked premises, signage with contact information and a Distribution Provider approved locking device for the premises shall be installed.

Generating Facilities with Non-Islanding inverters totaling one (1) kilovolt-ampere (kVA) or less are exempt from this requirement.

e. Drawings Required

Prior to Parallel Operation or Momentary Parallel Operation of the Generating Facility, Distribution Provider shall approve Producer's Protective Function and control diagrams. Generating Facilities equipped with Protective Functions and a control scheme previously approved by Distribution Provider for system-wide application or only Certified Equipment may satisfy this requirement by reference to previously approved drawings and diagrams.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 170

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

f. Generating Facility Conditions Not Identified

In the event this Rule does not address the Interconnection conditions for a particular Generating Facility, Distribution Provider and Producer may agree upon other arrangements

2. PREVENTION OF INTERFERENCE

Producer shall not operate Generating or Interconnection Facilities that superimpose a voltage or current upon Distribution Provider's Distribution or Transmission System that interferes with Distribution Provider operations, service to Distribution Provider Customers, or communication facilities. If such interference occurs, Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by Distribution Provider. If Producer does not take corrective action in a timely manner, or continues to operate the facilities causing interference without restriction or limit, Distribution Provider may, without liability, disconnect Producer's facilities from Distribution Provider's Distribution or Transmission System, in accordance with Section D.9 of this Rule. To eliminate undesirable interference caused by its operation, each Generating Facility shall meet the following criteria:

Note: Except as otherwise stated, the RPA for all performance requirements shall be met at the PCC.

(N)

When Generating facility is less than 500KVA or when generating facility operates under one of the non-exporting options or inadvertent export of no longer than 30 seconds, the RPA may be the Generating Facility Connection Point (PoC).

(N)

a. Voltage Regulation

The Generating Facility shall not actively regulate the voltage at the PCC while in parallel with Distribution Provider's Distribution System. The Generating Facility shall not cause the service voltage at other customers to go outside the requirements of ANSI C84.1-1995, Range A.

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 174

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

c. Paralleling

The Generating Facility shall parallel with Distribution Provider's Distribution or Transmission System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of Distribution Provider's Distribution or Transmission System at the PCC, and meet the flicker requirements of Section H.2.d. Section L, Certification and Testing Criteria, provides technology-specific tests for evaluating the paralleling Function. (IEEE 1547-2018 4.10.4)

(T)

d. Flicker

The Generating Facility shall not create objectionable flicker for other customers on Distribution Provider's Distribution or Transmission System. To minimize the adverse voltage effects experienced by other customers flicker at the PCC caused by the Generating Facility should not exceed the limits of IEEE 1547-2018 7.2.3. This requirement is necessary to minimize the adverse voltage affects experienced by other Customers on Distribution Provider's Distribution or Transmission System. Generators may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

(T)

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 175

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

e. Integration with Distribution Provider's Distribution System Grounding

The grounding scheme of the Generating Facility shall not cause over-voltages that exceed the rating of the equipment connected to Distribution Provider's Distribution System and shall not disrupt the coordination of the ground fault protection on Distribution Provider's Distribution System (IEEE 1547-2018 4.10) (See Section G.1.i, line configuration).

(T)

f. Frequency

Distribution Provider controls system frequency, and the Generating Facility shall operate in synchronism with Distribution Provider's Distribution or Transmission System. Whenever Distribution Provider's Distribution or Transmission System frequency at the PCC varies from and remains outside normal (nominally 60 Hz) by the predetermined amounts set forth in Table H.2, the Generating Facility's Protective Functions shall cease to energize Distribution Provider's Distribution or Transmission System within the stated maximum trip time.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 177

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

g. Harmonics

When the Generating Facility is serving balanced linear loads, harmonic current injection into Distribution Provider's Distribution or Transmission System at the PCC shall not exceed the limits stated in IEEE 1547-2018 7.3. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in Distribution Provider's Distribution or Transmission System without the Generating Facility connected. The harmonic distortion of a Generating Facility shall be evaluated using the same criteria as for the Host Loads.

(T)

(T)

(D)

(D)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 178

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

h. Direct Current Injection

Generating Facilities should not inject direct current greater than 0.5% of rated output current into Distribution Provider's Distribution or Transmission System.

i. Power Factor

Producer shall provide adequate reactive power compensation on site to maintain the Generating Facility power factor near unity at rated output or a Distribution Provider specified power factor within a power factor range from 0.9 leading to 0.9 lagging, based on local system conditions. While not required, for generators that do not have inherent reactive power control capability Distribution Provider at its option may offer reactive power support in the form of power factor correction capacitors on its Distribution or Transmission System, under a Generator Interconnection Agreement or an Added Facilities or Special Facilities agreement, as described in Rule 2.H, as applicable.

j. Generating Facility Rapid Voltage Changes (RVC)

Generating step or ramp changes shall meet the requirements as specified in IEEE 1547-2018 7.2.2.

k. Limitations of overvoltage over one fundamental frequency period

Generating Facility shall not contribute to instantaneous or fundamental frequency overvoltage conditions per IEEE 1547-2018 7.4.1.

l. Limitation of cumulative instantaneous overvoltage

Generating Facility shall not cause the instantaneous voltage on any portion of the Distribution or Transmission system to exceed the magnitudes per IEEE 1547-2018 7.4.2.

(N)

(N)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 179

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

3. TECHNOLOGY SPECIFIC REQUIREMENTS

a. Technology Specific Requirements

Three-Phase Synchronous Generators: For three phase Generators, the Generating Facility circuit breakers shall be three-phase devices with electronic or electromechanical control. Producer shall be responsible for properly synchronizing its Generating Facility with Distribution Provider's Distribution or Transmission System by means of either manual or automatic synchronous equipment. Automatic synchronizing is required for all synchronous Generators that have a Short Circuit Contribution Ratio (SCCR) exceeding 0.05. Loss of synchronism protection is not required except as may be necessary to meet Section H.2.d (Flicker) (IEEE 1547-2018 7.3). Unless otherwise agreed upon by Producer and Distribution Provider, synchronous Generators shall automatically regulate power factor, not voltage, while operating in parallel with Distribution Provider's Distribution System. A power system stabilization Function is specifically not required for Generating Facilities under 10 MW Net Rating. (T)

b. Induction Generators

Induction Generators (except self-excited Induction Generators) do not require a synchronizing Function. Starting or rapid load fluctuations on induction Generators can adversely impact Distribution Provider's Distribution or Transmission System voltage. Corrective step-switched capacitors or other techniques may be necessary and may cause undesirable ferro-resonance. When these counter measures (e.g. additional capacitors) are installed on Producer's side of the PCC, Distribution Provider must review these measures. Additional equipment may be required as determined in a Supplemental Review or an Interconnection Study.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 181

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

4. SUPPLEMENTAL GENERATING FACILITY REQUIREMENTS (Cont'd.)

b. Transfer Trip

For a Generating Facility that cannot detect Distribution or Transmission System faults (both line-to-line and line-to-ground) or the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution or Transmission System within two seconds, Distribution Provider may require a Transfer Trip system or an equivalent Protective Function.

c. Reclose Blocking

Where the aggregate Generating Facility capacity exceeds 15% of the peak load on any automatic reclosing device, Distribution Provider may require additional Protective Functions, including, but not limited to reclose-blocking on some of the automatic reclosing devices.

(D)

(D)

(D)

(D)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 182

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS

(T)

The inverter requirements are intended to be consistent with UL 1741 and IEEE 1547-2018. In the event of conflict, this Rule shall take precedence.

(T)

(T)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS

The Protective Functions and requirements of this Rule are designed to protect Distribution Provider's Distribution and Transmission System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for its Generating Facility and Interconnection Facilities. Producer's Protective Functions shall not impact the operation of other Protective Functions on Distribution Provider's Distribution and Transmission System in a manner that would affect Distribution Provider's capability of providing reliable service to its customers.

a. Protective Functions Required

Smart Inverters operating in parallel with Distribution Provider's Distribution or Transmission System shall be equipped with the following Protective Functions to sense abnormal conditions on Distribution Provider's Distribution or Transmission System and cause the Smart Inverter to be automatically disconnected from Distribution Provider's Distribution or Transmission System or to prevent the Smart Inverter from being connected to Distribution Provider's Distribution or Transmission System inappropriately:

- (i) Over and under voltage trip functions and over and under frequency trip functions;

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 183

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

a. Protective Functions Required (Cont'd.)

(ii) A voltage and frequency sensing and time-delay function to prevent the Smart Inverter from energizing a de-energized Distribution or Transmission System circuit and to prevent the Smart Inverter from reconnecting with Distribution Provider's Distribution or Transmission System unless Distribution Provider's Distribution System service voltage and frequency is within the ANSI C84.1-1995 Table 1 Range B voltage Range of 106 volts to 127 volts (on a 120 volt basis), inclusive, and a frequency range of 59.0 Hz to 60.5 Hz, inclusive, and are stable for at least 15 seconds; and (T)

(iii) A function to prevent the Smart Inverter from contributing to the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution System within two seconds of the formation of an Unintended Island.

The Smart Inverter shall cease to energize Distribution Provider's Distribution System for faults on Distribution Provider's Distribution System circuit to which it is connected (IEEE 1547-2018 6.2.1). The Smart Inverter shall cease to energize Distribution Provider's Distribution circuit prior to re-closure by Distribution Provider's Distribution System equipment (IEEE 1547-2018 6.3). (N)

(iv) Open Phase Condition: Generating Facility shall detect and cease to energize and trip all phases within 2 seconds of any open phase condition in accordance with IEEE 1547-2018 6.2.2. (N)

(D)
|
(D)

b. Momentary Paralleling Generating Facilities

With Distribution Provider's approval, the transfer switch or scheme used to transfer Producer's loads from Distribution Provider's Distribution or Transmission System to Producer's Generating Facility may be used in lieu of the Protective Functions required for Parallel Operation.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 184

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

c. Suitable Equipment Required

Circuit breakers or other interrupting equipment located at the Point of Common Coupling (PCC) must be Certified or "Listed" (as defined in Article 100, the Definitions Section of the National Electrical Code) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location. Producer's Smart Inverter and Interconnection Facilities shall be designed so that the failure of any single device or component shall not potentially compromise the safety and reliability of Distribution Provider's Distribution and Transmission System. The Smart Inverter paralleling-device shall be capable of withstanding 220% of the Interconnection Facility rated voltage (IEEE 1547-2018 4.11.3). The Interconnection Facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std C62.41.2-2002 or IEEE Std C37.90.1-2002 as applicable and as described in L.3.e (IEEE 1547-2018 4.11.2).

(T)

(T)

d. Visible Disconnect Required

When required by Distribution Provider's operating practices, Producer shall furnish and install a ganged, manually-operated isolating switch (or a comparable device mutually agreed upon by Distribution Provider and Producer) near the Point of Interconnection to isolate the Smart Inverter from Distribution Provider's Distribution or Transmission System. The device does not have to be rated for load break nor provide over-current protection.

The device must:

- (i) allow visible verification that separation has been accomplished. (This requirement may be met by opening the enclosure to observe contact separation.)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 186

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

e. Drawings Required

Prior to Parallel Operation or Momentary Parallel Operation of the Smart Inverter, Distribution Provider shall approve Producer's Protective Function and control diagrams. Generating Facilities equipped with Protective Functions and a control scheme previously approved by Distribution Provider for system-wide application or only Certified Equipment may satisfy this requirement by reference to previously approved drawings and diagrams.

f. Generating Facility Conditions Not Identified

In the event this Rule does not address the Interconnection conditions for a particular Smart Inverter, Distribution Provider and Producer may agree upon other arrangements.

2. PREVENTION OF INTERFERENCE

Producer shall not operate Smart Inverters that superimpose a voltage or current upon Distribution Provider's Distribution or Transmission System that interferes with Distribution Provider operations, service to Distribution Provider Customers, or communication facilities. If such interference occurs, Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by Distribution Provider. If Producer does not take corrective action in a timely manner, or continues to operate the facilities causing interference without restriction or limit, Distribution Provider may, without liability, disconnect Producer's facilities from Distribution Provider's Distribution or Transmission System, in accordance with Section D.9 of this Rule. To eliminate undesirable interference caused by its operation, each Smart Inverter shall meet the following criteria:

Note: Except as otherwise stated, the RPA for all performance requirements shall be met at the PCC.

(N)

When Generating facility is less than 500KVA or when generating facility operates under one of the non-exporting options or inadvertent export of no longer than 30 seconds, the RPA may be the Generating Facility Connection Point (PoC).

(N)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 187

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

a. Voltage Regulation

If approved by the Distribution Provider, the Smart Inverter may actively regulate the voltage at the PCC while in parallel with Distribution Provider's Distribution System. The Smart Inverter shall not cause the service voltage at other customers to go outside the requirements of ANSI C84.1-1995, Range A.

(T)

b. Voltage Trip and Ride-Through Settings

The voltage ranges in Table Hh-.1a define protective trip limits for the Protective Function and are not intended to define or imply a voltage regulation Function. Generating Facilities shall cease to energize Distribution Provider's Distribution System within the prescribed trip time whenever the voltage at the PCC deviates from the allowable voltage operating range. The Protection Function shall detect and respond to voltage on all phases to which the Generating Facility is connected.

(T)

(i) Smart Inverters

Smart Inverters shall be capable of operating within the voltage range normally experienced on Distribution Provider's Distribution System from plus to minus 5% of the nominal voltage (e.g. 114 volts to 126 volts, on a 120 volt base), at the service panel or PCC. The trip settings at the generator terminals may be selected in a manner that minimizes nuisance tripping in accordance with Table Hh-.1b to compensate for voltage drop between the generator terminals and the PCC. Voltage may be detected at either the PCC or the Point of Interconnection. However, the voltage range at the PCC, with the generator on-line, shall stay within +/-5% of nominal.

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 188

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

b. Voltage Trip and Ride-Through Settings (Cont'd.)

(ii) Voltage Disturbances

Whenever Distribution Provider's Distribution System voltage at the RPA varies from and remains the continuous operating region for the predetermined parameters set forth in Table Hh-.1b, the Smart Inverter's Protective Functions shall cause the Smart Inverter(s) to trip and become isolated from Distribution Provider's Distribution System as required in Table Hh-1a:

(T)
|
(T)

1. The Smart Inverter shall stay connected to the Distribution Provider's Transmission or Distribution System while the grid remains within the "Voltage Rang (p.u)" and must stay connected in the corresponding "Operating Mode."

(T)
(T)

(D)
|
(D)

2. If the distribution system voltage does not exit the ride-through region and recovers to normal system voltage, the Smart Inverter shall restore continuous operation within 2 seconds.

(T)

(D)
|
(D)

3. If the Distribution Provider's Transmission or Distribution System voltage does not exit the ride-through region and returns from the $V < 0.5$ pu region to the $0.5 \leq V < 0.7$ or $0.7 \leq V < 0.88$ pu region, the Smart Inverter shall restore available current within 2 seconds.

(N)
|
(N)

4. Different voltage-time settings could be permitted by the Distribution Provider.

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

b. Voltage Trip and Ride-Through Settings (Cont'd.)

(ii) Voltage Disturbances (Cont'd.)

Table Hh.1a: Voltage Trip Table

Shall Trip Function	Voltage Trip Default Settings (p.u. of nominal voltage)	Voltage Range of Shall Trip Function (p.u. of nominal voltage)	Default Clearing Time (s)
OV2	1.20	$V \geq 1.20$	0.16
OV1	1.10	$1.10 \leq V < 1.20$	13.0
Continuous Operation	NA	$0.88 < V < 1.10$	NA
UV1	0.88	$0.50 < V \leq 0.88$	21.0
UV2	0.50	$V \leq 0.50$	2.0

Table Hh-1b – Smart Inverter Voltage ride-through settings

Voltage Range (p.u.)	Operating mode/response	Minimum ride-through time (s)	Maximum response time (s)
$V > 1.20$	Cease to Energize	NA	0.16
$1.10 < V \leq 1.20$	Momentary Cessation	12	0.083
$0.88 \leq V \leq 1.10$	Continuous Operation	Infinite	NA
$0.70 \leq V < 0.88$	Mandatory Operation	20	NA
$0.50 \leq V < 0.70$	Mandatory Operation	10	NA
$V < 0.50$	Momentary Cessation	1	0.083

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 190

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

c. Paralleling

The Generating Facility shall parallel with Distribution Provider's Distribution or Transmission System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of Distribution Provider's Distribution or Transmission System at the PCC, and meet the flicker requirements of Section H.2.d. Section L, Certification and Testing Criteria, provides technology-specific tests for evaluating the paralleling Function. (IEEE 1547-2018 4.10)

(T)

d. Flicker

The Generating Facility shall not create objectionable flicker for other customers on Distribution Provider's Distribution or Transmission System. To minimize the adverse voltage effects experienced by other customers, flicker at the PCC caused by the Generating Facility should not exceed the limits of IEEE 1547-2018 7.2.3. This requirement is necessary to minimize the adverse voltage affects experienced by other Customers on Distribution Provider's Distribution or Transmission System. Generators may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

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e. Integration with Distribution Provider's Distribution System Grounding

The grounding scheme of the Generating Facility shall not cause over-voltages that exceed the rating of the equipment connected to Distribution Provider's Distribution System and shall not disrupt the coordination of the ground fault protection on Distribution Provider's Distribution System (IEEE 1547-2018 4.12) (See Section G.1.i, line configuration).

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 191

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

f. Frequency

Distribution Provider controls system frequency, and the Generating Facility shall operate in synchronism with Distribution Provider's Distribution or Transmission System. Whenever Distribution Provider's Distribution or Transmission System frequency at the PCC varies from and remains outside normal (nominally 60 Hz) by the predetermined amounts set forth in Table H.2a, the Generating Facility's Protective Functions shall cease to energize Distribution Provider's Distribution or Transmission System within the stated maximum trip time.

(T)

(i) Frequency Ride-Through Requirements

Smart Inverter based systems shall remain connected to the Distribution Provider's Distribution or Transmission System while the grid is within the frequency-time range indicated in Table Hh-.2, and shall disconnect from the electric grid during a high or low frequency event that is outside that frequency-time range.

The frequency values are shown in Table Hh.2b. These values provide default interconnection system response to abnormal frequencies. The inverter shall disconnect by the default clearing times. In the high frequency range between 60.2 Hz and 61.5 Hz, or some other mutually agreed range, the Smart Inverter is permitted to reduce real power output until it ceases to export power by 61.5 Hz, or other frequency value mutually agreed between the generating facility operator and the Distribution Provider. Islands and microgrids may need different default frequency settings.

(T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

f. Frequency (Cont'd.)

(i) Frequency Ride-Through Requirements (Cont'd.)

Table Hh.2a: Frequency Trip Settings Table

Shall Trip Function	Frequency Trip Default Setting (Hz)	Resulting Range of Shall Trip Function (Hz)	Default Clearing Time (s)
OF1	62.0	$f \geq 62.0$	0.16
OF2	61.2	$61.2 \leq f < 62$	300
Continuous Operation	NA	$58.5 < f < 61.2$	NA
UF1	58.5	$56.5 < f \leq 58.5$	300
UF2	56.5	$f \leq 56.5$	0.16

Table Hh.2b: Frequency Ride-Through Settings Table

Frequency (Hz)	Operating Mode	Default Clearing Time
$f > 62.0$	No Ride-Through requirements apply to this range	NA
$61.2 < f \leq 61.8$	Mandatory Operation	299
$58.8 \leq f \leq 61.2$	Continuous Operation	Infinite
$57.0 \leq f < 58.8$	Mandatory Operation	299
$F < 57.0$	No Ride-Through requirements apply to this range	NA

ii) Rate of change of frequency (ROCOF) ride-through

Smart Inverter shall not trip for frequency excursion have a rate of change of frequency (ROCOF) magnitude that is less than or equal to 3.0Hz per second as specified in IEEE 1547-2018 6.5.2.5 category III. For ROCOF greater than 3Hz per second, it is preferred for Smart Inverter to ride-through as long as frequency remains in the continuous operating region, low frequency ride-through region (and corresponding duration times), or high frequency region (and corresponding duration times).

iii) Voltage phase angle change ride-through

Voltage phase angle change ride-through as specified in IEEE 1547-2018 6.5.2.6.

(Continued)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 193

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

g. Harmonics

When the Smart Inverter is serving balanced linear loads, harmonic current injection into Distribution Provider's Distribution or Transmission System at the PCC shall not exceed the limits stated in IEEE 1547-2018 7.3 The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in Distribution Provider's Distribution or Transmission System without the Smart Inverter connected. The harmonic distortion of a Smart Inverter shall be evaluated using the same criteria as for the Host Loads.

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h. Direct Current Injection

Smart Inverter should not inject direct current greater than 0.5% of rated output current into Distribution Provider's Distribution or Transmission System.

i. Smart Inverter Reactive Power Requirements

Smart Inverter Reactive Power capabilities shall comply with IEEE 1547-2018 5.2 Category B requirement.

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(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 194

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

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(D)

j. Dynamic Volt/VAR Operations

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(D)

The Distribution Provider may permit or require the Smart Inverter systems to operate in larger power factor ranges, including in 4-quadrant operations for storage systems with the implementation of additional anti-islanding protection as determined by the Distribution Provider.

The Smart Inverter shall be capable of supporting dynamic reactive power compensation (dynamic Volt/VAR operation) within the following constraints:

(T)

- The Smart Inverter shall be able to consume reactive power in response to an increase in line voltage, and produce reactive power in response to a decrease in line voltage as indicated in table Hh-4.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

j. Dynamic Volt/VAR Operations (Cont'd.)

Dynamic Volt/Var Operations Default Settings

Table Hh-4 and Figure Hh-1 depict the default settings, which should be applied for all inverter sizes. Specific volt/var settings may be required for larger Generating Facilities (such as 100 kw or greater), or for specific areas with the Distribution Systems as determined by the Distribution Provider.

Default Open Loop Response Time for volt/var operation should be five (5) seconds.

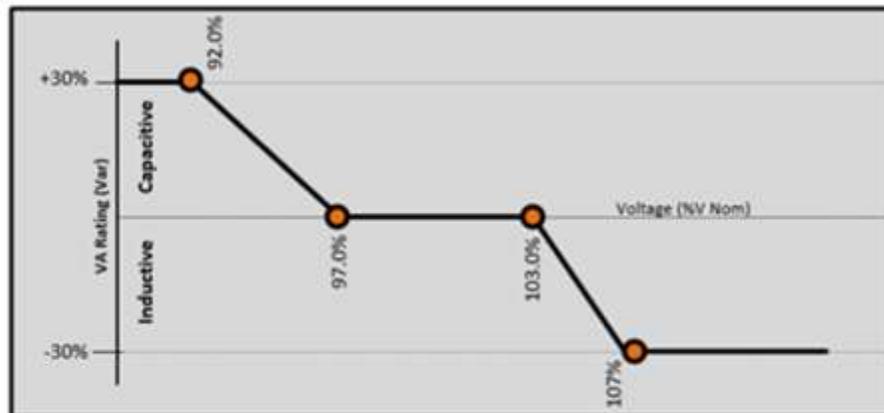
Table Hh-4: Voltage and Reactive Default Settings

Voltage Setpoint	Voltage Value	Reactive Setpoint	Reactive Value	Operation
V1	92.0%	Q1	30%	Reactive Power injection
V2	97.0%	Q2	0	Unity Power Factor
V3	103.0%	Q3	0	Unity Power Factor
V4	107.0%	Q4	30%	Reactive Power Absorption

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Figure Hh-1: Voltage and Reactive Default Settings



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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 196

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

k. Enter Service Ramp Rate Requirements (T)

The Smart Inverter is required to have the following ramp controls. (T)

- Enter Service requirements as outlined in IEEE 1547-2018 section 4.10.3 with following default settings (N)

1. Delay Enter Service per Hh.1.a.ii (15 seconds) (D)

2. Default Enter Service Duration of 300 seconds (N)

l. Frequency Droop (Frequency- Power, Frequency-Watt) Requirements (T)

Smart Inverters shall change their real power production as a function of system frequency, in accordance with IEEE 1547-2018 6.5.2.7 with the following defaults, Deadband 36 mHz kOF and kUF 3.33%. (T)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 197

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

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m. Voltage-Watt Default Settings Requirements

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Smart Inverters shall reduce their real power production as a function of measured voltage at the inverter terminals or at the Generating Facility Point of Common Coupling (PCC) in accordance with the following:

(L)

- When the measured voltage is greater than 106% of nominal voltage (for example: 127.2 volts on a 120 volts nominal), the export of active power at the PCC or the production of active power by the Smart Inverter shall be reduced at a rate of 25% of active power nameplate rating per one percent of nominal voltage. Figure Hh-3 – Volt-Watt Requirements – illustrates the required rate of reduction. When export of active power is controlled, a certified inverter and control system shall be used.

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 200

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

p. Load Shedding or Transfer

The voltage and frequency ride-through requirements of Hh.2.b.(ii) and Hh.2.f.(i) shall not apply if either: a) The real power across the Point of Common Coupling is continuously maintained at a value less than 10% of the aggregate rating of the Smart Inverters connected to the Generation Facility prior to any voltage disturbance, and the Generation Facility disconnects from the Distribution Provider's T&D system, along with Generation Facility load, such that the net change in real power flow from or to the Distribution Provider is less than 10% of the aggregate Smart Inverter capacity; or b) Generation Facility load real power demand equal to 90% to 120% of the pre-disturbance aggregate Smart Inverter real power output is shed within 0.1 seconds of Smart Inverter disconnection.

q. Measurement and Calculation Accuracy

Smart Inverter shall meet minimum steady-state and transient measurement and calculation accuracy as required in IEEE 1547-2018 4.4.

r. Prioritization of Smart Inverter Responses

1. The response to disable permit to service as specified in section Hh.8.a shall take precedence over any other tripping requirements.
2. Prioritization of tripping requirements not related to disabling permit to service shall meet IEEE 1547-2018 4.7.

s. Storage Inverter Normal Operation Ramp Control Requirements

Smart Inverters used for energy storage applications shall include ramp-up rate control. The default value shall be 100% of maximum current output per second or slower if required by applicant. Other ramp-up control settings can be used, when required, as mutually agreed by the Distribution Provider and the Producer.

t. Ride-through of consecutive voltage disturbances

Ride through of Consecutive Voltage Disturbances shall be in accordance with IEEE 1547-2018 6.4.2.5.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 201

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

u. Restore output without dynamic voltage support

Restore output without dynamic voltage shall be accordance with IEEE 1547-2018 6.4.2.7.1.

v. Transition between performance operating region

Transition between performance operating regions should be in accordance with IEEE 1547-2018 6.4.2.7.3.

w. Constant Reactive Power Mode

When in this mode, the Smart Inverter shall maintain a constant reactive power. The target reactive power level and mode (injection or absorption) shall be specified by the Distribution Provider and shall be within the same range specified in IEEE 1547-2018 5.2. The reactive power settings are allowed to be adjusted locally and/or remotely as specified by the Distribution Provider. The maximum Smart Inverter response time to maintain constant reactive power shall be 10 seconds or less.

x. Generating Facility Rapid Voltage Changes (RVC)

Generating step or ramp changes shall meet the requirements as specified in IEEE 1547-2018 7.2.2.

y. Limitations of overvoltage over one fundamental frequency period

Generating Facility shall not contribute to instantaneous or fundamental frequency overvoltage conditions per IEEE 1547-2018 7.4.1.

z. Limitation of cumulative instantaneous overvoltage

Generating Facility shall not cause the instantaneous voltage on any portion of the Distribution or Transmission system to exceed the magnitudes per IEEE 1547-2018 7.4.2

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 202

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

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zz. Phase 3 Functions

Table of Phase 3 Effective Dates Pursuant to Resolution E-4898 and Resolution E-5000 and CPUC Letter of March 20, 2020 responding to a request to extend the date for Functions 1, 2, 3 and 8:

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<u>Phase 3 Function #</u>		
	<u>Description</u>	<u>Effective Date (note)</u>
1	Monitor Key Smart Inverter Data	June 22, 2020
2	Smart Inverter Disconnect and Reconnect Command (Cease to Energize and Return to Service)	June 22, 2020
3	Limit Maximum Active Power Mode	June 22, 2020
4	Set Active Power Mode	12 months after approval of a nationally recognized standard that includes the function.
5	Frequency Watt Mode	February 22, 2019 , which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
6	Volt Watt Mode	February 22, 2019 , which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
7	Dynamic Reactive Support	12 months after approval of a nationally recognized standard that includes the function.
8	Scheduling Power Values and Modes	June 22, 2020

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Note: The utilization of any of these functions is permissible under mutual agreement between the utility and the generating facility before the effective date.

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(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 203

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

3. TECHNOLOGY SPECIFIC REQUIREMENTS

Grid-interactive inverters do not require separate synchronizing equipment. Non grid-interactive or "stand-alone" inverters shall not be used for Parallel Operation with Distribution Provider's Distribution or Transmission System.

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4. SUPPLEMENTAL SMART INVERTER REQUIREMENTS

a. Fault Detection

A Smart Inverter with an SCCR exceeding 0.1 or one that does not cease to energize Distribution Provider's Distribution or Transmission System within two seconds of the formation of an Unintended Island shall be equipped with Protective Functions designed to detect Distribution or Transmission System faults, both line-to-line and line-to-ground, and cease to energize Distribution Provider's Distribution or Transmission System within two seconds of the initiation of a fault.

b. Transfer Trip

For a Generating Facility that cannot detect Distribution or Transmission System faults (both line-to-line and line-to-ground) or the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution or Transmission System within two seconds, Distribution Provider may require a Transfer Trip system or an equivalent Protective Function.

c. Reclose Blocking

Where the aggregate Generating Facility capacity exceeds 15% of the peak load on any automatic reclosing device, Distribution Provider may require additional Protective Functions, including, but not limited to reclose-blocking on some of the automatic reclosing devices.

(Continued)



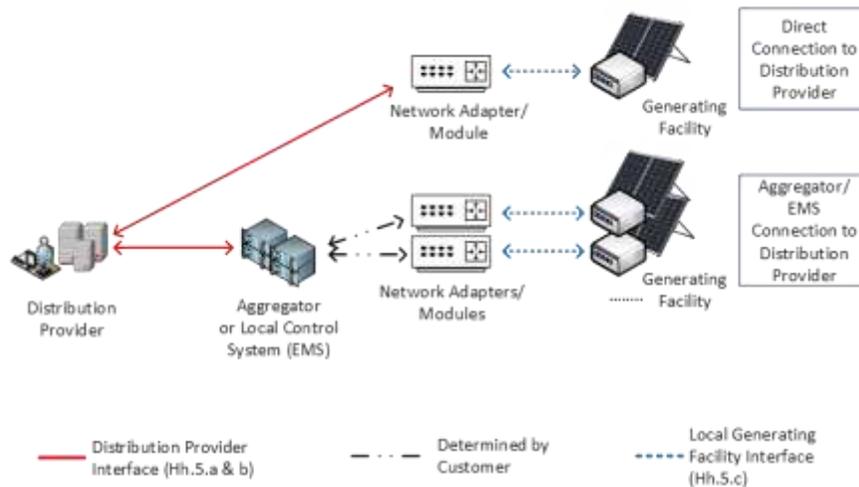
ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS

Generating Facilities utilizing inverter-based technologies must adhere to the following communication protocol requirements for communications between Distribution Provider and the Generating Facility. The diagram below shows the interface requirements as applicable for section Hh.5. The Distribution Provider Interface (solid red line) is described in Sections Hh.5.a and Hh.5.b. The Local Generating Facility Interface (dotted blue line) is described in Section Hh.5.c. The top row shows a direct connection between the Distribution Provider and the Generating Facility network adapter which may be separated from or integrated into the Smart Inverter. The lower row shows a connection between the Distribution Provider and an aggregator or local control system.

(N)



The network adapter depicted in the diagram is a device that connects the Smart Inverter to the local area network (LAN) or the wide area network (WAN). If no upstream control system is managing the Generating Facility (e.g., an aggregator or energy management system) and the Generating Facility is being managed directly by the Distribution Provider, the network adapter is required to be an IEEE 2030.5-2018 DER client as defined by CSIP, unless another protocol is agreed to be used with the Distribution Provider. The network adapter may also support other functions such as protocol translation or Generating Facility management. The network adapter may be integrated into the Smart Inverter or be a separate device.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 205

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS (Cont'd.)

- a. The communications requirements in this section pertain to (i) the Distribution Provider and the individual Generating Facility's inverter control or energy management system; (ii) the Distribution Provider and communication to the Generating Facility through an aggregator not co-located or part of the Generating Facility; or (iii) the Distribution Provider and the Smart Inverter:
 - (i) Software shall be updateable via communications remotely;
 - (ii) The transport level protocol shall be TCP/IP.
 - (iii) The default application-level protocol shall be IEEE 2030.5 (i.e., Smart Energy Profile 2.0) as defined in the latest final version of the Common Smart Inverter Profile (CSIP), the Interconnection Handbook, Cybersecurity Requirements or Programs and Contracts. Other application-level protocols may be used by mutual agreement of the parties including IEEE 1815/DNP3 for SCADA real-time monitoring and control and IEC 61850.

- b. Additional communication protocol requirements shall also apply to Generating Facilities utilizing inverter-based technologies as provided in the following documents:
 - (i) Distribution Provider Generation Interconnection Handbook, which shall include:
 - (a) Details and guidelines for the implementation of communications with Generating Facilities utilizing inverter-based technologies;
 - (b) Requirements for which application-level protocols are supported and references to an application-level protocol implementation guide;
 - (c) Cybersecurity and privacy requirements (these may additionally or alternatively be included in the application-level protocol implementation guide);

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 206

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS (Cont'd.)

- b. Additional communication protocol requirements shall also apply to Generating Facilities utilizing inverter-based technologies as provided in the following documents (Cont'd.):
 - (i) Distribution Provider Generation Interconnection Handbook, which shall include (Cont'd):
 - (d) Generic device communications registration management requirements, including how to register individual Generating Facilities, Generating Facilities with energy management systems, and Aggregators (these additionally or alternatively may be included in the application-level protocol implementation guide); and,
 - (e) Conditions under which communication functions are mandatory.
 - (ii) Application-Level Protocol Implementation Guide, which shall provide:
 - (a) Detailed communication requirements and implementation guidelines to ensure consistent interoperability of the Generating Facilities with all California investor-owned utilities under the Commission's jurisdiction.
 - c. Communication and protocol performance requirements
 - (i) Communication performance requirements
 - Communication performance requirements for the interface to the Generating facility shall comply with IEEE 1547-2018 10.8.
 - (ii) Communication Protocol Requirements
 - The protocol requirements at the Generating Facility shall be per IEEE 1547-2018 10.7.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 207

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

6. SCHEDULING CAPABILITY REQUIREMENTS

- a. Generating Facilities which incorporate Smart Inverters shall incorporate scheduling capabilities with a minimum scheduling memory capability of at least 24 events.

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The utilization of this function is permissible under mutual agreement between the utility and the generating facility before the effective date.

Each event is composed of modifications to each, selected group of, or all of the following Smart Inverter function.

- (i) Modifications to the voltage and reactive set-points of the Dynamic volt/var function.
- (ii) Modifications to the reactive power set-points for the fixed power factor function.
- (iii) Modifications to the voltage and watt-reduction level set-points for the volt/watt function.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 209

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

7. MONITORING AND TELEMETRY REQUIREMENTS

a. Smart Inverter shall have the capability to communicate its performance information per IEEE 1547-2018 10.5 Table 29:

- (i) Smart Inverter production or consumption of active power (Watts).
- (ii) Smart Inverter consumption or production of reactive power (VARs)
- (iii) Phase measured at the AC terminals of the Smart Inverter (Volts)
- (iv) Frequency measured at the AC terminals of the Smart Inverter (Hz)
- (v) Connection Status
- (vi) Alarm Status

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 211

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

7. MONITORING AND TELEMETRY REQUIREMENTS (Cont'd.)

d. Monitoring and performance information should be communicated in aggregate at the Generating Facility as follows:

(i) When the Generating Facility includes only Smart Inverters: The production or consumption of active and reactive power shall be communicated as an aggregate of all Smart Inverters within the Generating Facility.

(ii) When a Generating Facility includes Smart Inverters and other technologies such as synchronous or induction generation systems, the Generating Facility should communicate the following:

a) The production or consumption of active and reactive power shall be communicated in aggregate of all Smart Inverters within the Generating Facility

b) The production or consumption of active and reactive power shall be communicated in aggregate of all the other technologies within the Generating Facility

(iii) When the Generating Facility with Smart Inverters includes one or multiple energy storage systems: The available operational energy should be communicated as an aggregate of all the energy storage systems.

(iv) Nameplate information shall be available through a local Generating Facility Interface as required in IEEE 1547-2018 10.3 and must include the information as required in IEEE 1547-2018 Table 28.

(v) Configuration information shall be available through a Local Generating Facility Interface as required in IEEE 1547-2018 10.4. This information represents the present capacity and ability of the Generating Facility. When a configuration update changes the Generating Facility nameplate information, it may require a study depending on the change.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 212

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

8. CONTROL THROUGH COMMUNICATION CAPABILITIES

- a. The capability for these requirements will be mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted on or after the earlier of the dates shown in the "Table of Phase 3 Effective Dates Pursuant to Resolution E-4898" in Section Hh.2.zz. (T)

The utilization of these functions is permissible under mutual agreement between the utility and the generating facility before the effective date.

Smart Inverters shall have the capabilities of accepting an operational controls through communications in accordance to the following:

- (i) Disable permit to service control command. When the Smart Inverter receives a disable permit service command through communication, the Smart Inverter must cease-to energize and trip within 2 seconds or initiate the opening of the switch referenced in the inverter terminal in order to galvanically isolate the Smart Inverter system from the Distribution System. (T)

- (ii) Return to service control command. When the Smart Inverter receives a return-to-service control command, the Smart Inverter may return to service operation as required by Generating Facility operator or as required by the scheduling control system as required by section H.6. This shall be accomplished by enabling permit service as required in IEEE 1547-2018 4.10.3. (T)

- (iii) Limit Active Power command. When the Smart Inverter receives a command to limit its production of real power, the Smart Inverter shall reduce its real power production to the specified percent of real power capacity of the Smart Inverter or to a specified real power value. In no more than 30 s or in the time it takes for the primary energy source to reduce its active power output to achieve the requirements of the active power limit set point, whichever is greater. (T)

Where the Smart Inverter operates under a non-export provision, the active power limit set point may be implemented as a maximum active power to serve the host customer load. (N)

Under mutual agreement, Smart Inverter may be required to reduce active power below the level needed to support host customer load. (N)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 213

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

8. CONTROL THROUGH COMMUNICATION CAPABILITIES (Cont'd)

a. Smart Inverters shall have the capabilities of accepting an operational controls through communications in accordance to the following (Cont'd):

(iv) Set Active Power Level Mode Function. The capability for this requirement will become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted twelve (12) months after approval of a nationally recognized standard that includes the function.

(v) Suspension of Active Power restriction. When the Smart Inverter receives a command to suspend the command for active power reduction, the Smart Inverter may return to normal operation as required by Generating Facility operator or as required by the scheduling control system as required by section H.6.

(vi) Transition between operating modes. Transition between modes shall commence in no more than 30 s after the mode setting change is received at the local Generating Facility communication interface. Changes of control functional modes shall be executed such that the Smart Inverter output is transitioned smoothly over a time period between 5 s and 300 s.

Ramping of the Smart Inverter output is not required for control parameter setting changes.

For all control and protective function parameter settings, the time following the input to the local Generating Facility communication interface and preceding the point in time when the invoked action begins shall be no greater than 30 s.

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(N)

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GENERATING FACILITY INTERCONNECTIONS

Sheet 214

I. THIRD-PARTY INSTALLATIONS, RESERVATION OF UNUSED FACILITIES, AND REFUND OF SALVAGE VALUE (L)

1. INTERCONNECTION FACILITIES AND DISTRIBUTION UPGRADES

Except as provided for in the Generator Interconnection Agreement of this Rule, Interconnection Facilities connected to Distribution Provider's side of the PCC and Distribution Upgrades shall be provided, installed, owned, and maintained by Distribution Provider at Producer's expense.

2. THIRD-PARTY INSTALLATIONS

Subject to the approval of Distribution Provider, a Producer may, at its option, employ a qualified contractor to provide and install Interconnection Facilities or Distribution Upgrades, to be owned and operated by Distribution Provider, on Distribution Provider's side of the PCC. Such Interconnection Facilities and Distribution Upgrades shall be installed in accordance with Distribution Provider's design and specifications. Upon final inspection and acceptance by Distribution Provider, Producer shall transfer ownership of such Producer installed Interconnection Facilities or Distribution Upgrades to Distribution Provider and such facilities shall thereafter be owned and maintained by Distribution Provider at Producer's expense. Producer shall pay Distribution Provider's reasonable cost of design, administration, and monitoring of the installation for such facilities to ensure compliance with Distribution Provider's requirements. Producer shall also be responsible for all costs, including any income tax liability, associated with the transfer of Producer installed Interconnection Facilities and Distribution Upgrades to Distribution Provider.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 215

I. THIRD-PARTY INSTALLATIONS, RESERVATION OF UNUSED FACILITIES, AND REFUND OF SALVAGE VALUE (Cont'd.) (L)

3. RESERVATION OF UNUSED FACILITIES

When a Producer wishes to reserve Distribution Provider-owned Interconnection Facilities or Distribution Upgrades installed and operated as Added Facilities for Producer at Producer's expense, but idled by a change in the operation of Producer's Generating Facility or otherwise, Producer may elect to abandon or reserve such facilities consistent with the terms of its agreement with Distribution Provider. If Producer elects to reserve idle Interconnection Facilities or Distribution Upgrades, Distribution Provider shall be entitled to continue to charge Producer for the costs related to the ongoing operation and maintenance of the Added Facilities.

4. REFUND OF SALVAGE VALUE

When a Producer elects to abandon the Special Facilities or Added Facilities for which it has either advanced the installed costs or constructed and transferred to Distribution Provider, Producer shall, at a minimum, receive from Distribution Provider a credit for the net salvage value of the Added Facilities.

J. METERING, MONITORING AND TELEMETERING

1. GENERAL REQUIREMENTS

All Generating Facilities shall be metered in accordance with this Section J and shall meet all applicable standards of Distribution Provider contained in Distribution Provider's applicable tariffs and published Distribution Provider manuals dealing with Metering specifications.

2. METERING BY NON-DISTRIBUTION PROVIDER PARTIES

The ownership, installation, operation, reading, and testing of revenue Metering Equipment for Generating Facilities shall be by Distribution Provider except to the extent that the Commission authorizes any or all these services be performed by others. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 216

J. METERING, MONITORING AND TELEMETERING (Cont'd.) (L)

3. NET GENERATION OUTPUT METERING

Generating Facility customers may be required to install Net Generation Output Metering for evaluation, monitoring, and verification purposes and to determine applicable standby and non-bypassable charges as defined in Distribution Provider's tariffs, to satisfy applicable California Independent System Operator (CAISO) reliability requirements, and for Distribution System planning and operations.

However, Generating Facility customers do not need to install Net Generation Output Metering where less intrusive and/or more cost effective options, for Producer/Customer, are available for providing generator data to Distribution Provider. These Generating Facilities may opt to have Distribution Provider estimate load data in accordance with Distribution Provider's applicable tariffs to determine or meet applicable standby and non-bypassable and other applicable charges and tariff requirements. However, if a Generating Facility customer objects to Distribution Provider's estimate of the Generator(s) output, the customer may elect to install the Net Generation Output Metering, or have Distribution Provider install Net Generation Output Metering at the customer's expense.

(a) All metering options available to the customer must conform to the requirements set forth in Distribution Provider's Rule 22. If Distribution Provider does not receive meter data in accordance with Rule 22, Distribution Provider shall have the right to install Distribution Provider-owned Net Generation Output Metering at the customer's expense. The relevant factors in determining the need for Net Generation Output Metering are as listed below:

- i) Data requirements in proportion to need for information;
- ii) Producer's election to install equipment that adequately addresses Distribution Provider's operational requirements;

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(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 217

J. METERING, MONITORING AND TELEMETERING (Cont'd.) (L)

3. NET GENERATION OUTPUT METERING (Cont'd.)

- iii) Accuracy and type of required Metering consistent with purposes of collecting data;
- iv) Cost of Metering relative to the need for and accuracy of the data;
- v) The Generating Facility's size relative to the cost of the Metering/monitoring;
- vi) Other means of obtaining the data (e.g. Generating Facility logs, proxy data, etc.);
- vii) Requirements under any Generator Interconnection Agreement with Producer.

The requirements in this Section may not apply to Metering of Generating Facilities operating under Distribution Provider's Net Energy Metering tariffs. Nothing in this Section J.3 supersedes Section D.4, Compliance with Laws, Rules and Tariff Schedules.

Distribution Provider will report to the Commission or designated authority, on a quarterly basis, the rationale for requiring Net Generation Output Metering equipment in each instance along with the size and location of the facility.

4. POINT OF COMMON COUPLING (PCC) METERING

For purposes of assessing Distribution Provider's charges for retail service, Producer's PCC Metering shall be reviewed by Distribution Provider, and if required, replaced to ensure that it will appropriately measure electric power according to the provisions of the Customer's electric service Tariff. Where required, the Customer's existing meter may be replaced with a bi-directional meter so that power deliveries to and from Producer's site can be separately recorded. Alternately,

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 218

J. METERING, MONITORING AND TELEMETERING (Cont'd.) (L)

4. POINT OF COMMON COUPLING (PCC) METERING (Cont'd.)

Producer may, at its sole option and cost, require Distribution Provider to install multi-metering equipment to separately record power deliveries to Distribution Provider's Distribution System and retail purchases from Distribution Provider. Where necessary, such PCC Metering shall be designed to prevent reverse registration.

Generating Facilities participating in Net Energy Metering shall have metering provided pursuant to the terms of the applicable Net Energy Metering tariff schedule.

5. TELEMETERING

If the nameplate rating of the Generating Facility is 1 MW or greater, Telemetering equipment at the Net Generation Output Metering location may be required at Producer's expense. If the Generating Facility is Interconnected to a portion of Distribution Provider's Distribution System operating at a voltage below 10 kV, then Telemetering equipment may be required on Generating Facilities 250 kW or greater. Distribution Provider shall only require Telemetering to the extent that less intrusive and/or more cost effective options for providing the necessary data in real time are not available. Distribution Provider will report to the Commission or designated authority, on a quarterly basis, the rationale for requiring Telemetering equipment in each instance along with the size and location of the facility.

6. LOCATION

Where Distribution Provider-owned Metering is located on Producer's premises, Producer shall provide, at no expense to Distribution Provider, a suitable location for all such Metering Equipment.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 219

- J. METERING, MONITORING AND TELEMETERING (Cont'd.) (L)
- 7. COSTS OF METERING
 - Producer will bear all costs of the Metering required by this Rule, including the incremental costs of operating and maintaining the Metering Equipment.
- 8. MULTIPLE TARIFF METERING
 - The requirements of Section J.3 may not apply where a Generating Facility includes multiple generators eligible for service under more than one Net Energy Metering (NEM) tariff schedule (e.g. NEM-1, NEM-2, NEMBIO, NEMFC), or where a Generating Facility consists of one or more NEM-eligible generators in combination with one or more non-NEM eligible generators without Non-Export relays (“Reverse Power Protection”). To ensure proper tariff administration, metering will be required at the PCC and at each of the NEM eligible generator groups eligible for service under the same NEM tariff schedule. For combinations of multiple NEM eligible generators under different tariffs, billing administration and metering requirements will be as specified in the appropriate NEM tariff schedule.
 - Where a Generating Facility consists of one or more NEM eligible generator groups in combination with one or more non-NEM generators, metering of the non-NEM generators is not required, except as specified in Section J.3. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 220

K. DISPUTE RESOLUTION PROCESS

(L)

In addition to the informal procedures for timeline-related disputes set out in Section F.1.d, the following procedures will apply for disputes arising from this Rule:

1. SCOPE

The Commission shall have initial jurisdiction to interpret, add, delete or modify any provision of this Rule or of any agreements entered into between Distribution Provider and Applicant or Producer to implement this tariff ("Implementing Agreements") and to resolve disputes regarding Distribution Provider's performance of its obligations under Commission-jurisdictional tariffs, the applicable agreements, and requirements related to the interconnection of Applicant's or Producer's Generating Facility or Interconnection Facilities pursuant to this Rule.

2. PROCEDURES

Any dispute arising between Distribution Provider and Producer (individually referred to in Section K as "Party" and collectively "the Parties") regarding Distribution Provider's or Producer's performance of its obligations under its tariffs, the Implementing Agreements, and requirements related to the interconnection of Producer's Facilities pursuant to this Rule shall be resolved according to the following procedures:

- a. The dispute shall be documented in a written notice ("notice") by the aggrieved Party to the other Party containing the relevant known facts pertaining to the dispute, the specific dispute and the relief sought, and express notice by the aggrieved Party that it is invoking the procedures under this Section. The notice shall be sent to the Party's email address and physical address set forth in the Generator Interconnection Agreement or Interconnection Request, if there is no Generator Interconnection Agreement. A copy of the notice shall also be sent to the Energy Division, Office of the Director, at the Commission. The receiving Party shall acknowledge the notice within five (5) Calendar Days of its receipt.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 221

- K. DISPUTE RESOLUTION PROCESS (Cont'd.) (L)
2. PROCEDURES (Cont'd.)
- a. Upon the aggrieved Party notifying the other Party of the dispute, each Party must designate a representative with the authority to make decisions for its respective Party to review the dispute within seven (7) Calendar Days. In addition, upon receipt of the notice, Distribution Provider shall provide the aggrieved Party with all relevant regulatory and/or technical details and analysis regarding any Distribution Provider interconnection requirements under dispute within twenty-one (21) Calendar Days.
- Within forty-five (45) Calendar Days of the date of the notice, the Parties' authorized representatives will be required to meet and confer to try to resolve the dispute. Parties are expected to operate in good faith and use best efforts to resolve the dispute.
- b. If a resolution is not reached in forty-five (45) Calendar Days from the date of the notice, either 1) a Party may request to continue negotiations for an additional forty-five (45) Calendar Days or 2) the Parties may by mutual agreement make a written request for mediation to the ADR Coordinator in the Commission's ALJ Division. The request may be submitted by electronic mail to adr_program@cpuc.ca.gov. Alternatively, both Parties by mutual agreement may request mediation from an outside third-party mediator with costs to be shared equally between the Parties.
- c. At any time, either Party may file a formal complaint before the Commission pursuant to California PUC section 1702 and Article 4 of the Commission's Rules of Practice and Procedure.
- Nothing in this section shall be construed to limit the rights of any Party to exercise rights and remedies under Commission law. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 222

K. DISPUTE RESOLUTION PROCESS (Cont'd.)

(L)

3. PERFORMANCE DURING DISPUTE

Pending resolution of any dispute under this Section, the Parties shall proceed diligently with the performance of their respective obligations under this Rule and the Implementing Agreements, unless the Implementing Agreements have been terminated. Disputes as to the Interconnection Request and implementation of this Section shall be subject to resolution pursuant to the procedures set forth in this Section.

L. CERTIFICATION AND TESTING CRITERIA

1. INTRODUCTION

This Section describes the test procedures and requirements for equipment used for the Interconnection of Generating Facilities to Distribution Provider's Distribution or Transmission System. Included are Type Testing, Production Testing, Commissioning Testing, and Periodic Testing. The procedures listed rely heavily on those described in appropriate Underwriters Laboratory (UL), Institute of Electrical and Electronic Engineers (IEEE), and International Electrotechnical Commission (IEC) documents—most notably UL 1741 including UL-1741 Supplement A or B as appropriate.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 223

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

1. INTRODUCTION (Cont'd.)

The tests described here, together with the technical requirements in Section H of this Rule, are intended to provide assurance that the Generating Facility's equipment will not adversely affect Distribution Provider's Distribution or Transmission System and that a Generating Facility will cease providing power to Distribution Provider's Distribution or Transmission System under abnormal conditions. The tests were developed assuming a low level of Generating Facility penetration or number of connections to Distribution Provider's Distribution or Transmission System. At high levels of Generating Facility penetration, additional requirements and corresponding test procedures may need to be defined.

Section L also provides criteria for "Certifying" Generators, inverters or converters. Once a Generator, inverter or converter has been Certified per this Rule, it may be considered suitable for Interconnection with Distribution Provider's Distribution or Transmission System. Subject to the exceptions described in Section L, Distribution Provider will not repeat the design review or require retesting of such Certified Equipment. It should be noted that the Certification process is intended to facilitate Generating Facilities Interconnections. Certification is not a prerequisite to interconnect a Generating Facility for Section H, except for Non-Export AC/DC Converters seeking an expedited process, but it is a prerequisite for inverters installed under section Hh.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 224

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 2. CERTIFIED AND NON-CERTIFIED INTERCONNECTION EQUIPMENT
- a. Certified Equipment
 - Equipment tested and approved (i.e. "Listed") by an accredited NRTL as having met both the Type Testing and Production Testing requirements described in this document is considered to be Certified Equipment for purposes of Interconnection with Distribution Provider's Distribution or Transmission System. Certification may apply to either a pre-packaged system or an assembly of components that address the necessary functions. Type Testing may be done in the manufacturer's factory or test laboratory, or in the field. At the discretion of the testing laboratory, field-certification may apply only to the particular installation tested. In such cases, some or all of the tests may need to be repeated at other installations.
 - When equipment is Certified by a NRTL, the NRTL shall provide to the manufacturer, at a minimum, a Certificate with the following information for each device:
 - Administrative:
 - (1) The effective date of Certification or applicable serial number (range or first in series), and/or other proof that certification is current;
 - (2) Equipment model number(s) of the Certified equipment;
 - (3) The software version utilized in the equipment, if applicable;
 - (4) Test procedures specified (including date or revision number); and
 - (5) Laboratory accreditation (by whom and to what standard). (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 225

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

2. CERTIFIED AND NON-CERTIFIED INTERCONNECTION EQUIPMENT (Cont'd.)

a. Certified Equipment (Cont'd.)

Technical (as appropriate):

- (1) Device ratings (kW, kV, Volts, amps, etc.);
- (2) Maximum available fault current in amps, per IEEE 1547-2018 11.4;
- (3) In-rush Current in amps;
- (4) Trip points, if factory set (trip value and timing);
- (5) Trip point and timing ranges for adjustable settings;
- (6) Nominal power factor or range if adjustable;
- (7) If the equipment is Certified as Non-Exporting and the method used (reverse power or underpower);
- (8) If the equipment is Certified as Non-Islanding; and
- (9) If the equipment is Certified as a Non-Export AC/DC Converter.

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It is the responsibility of the equipment manufacturer to ensure that Certification information is made publicly available by the manufacturer, the testing laboratory, or by a third party.

b. Non-Certified Equipment

For non-Certified equipment, some or all of the tests described in this Rule may be required by Distribution Provider for each Generating and/or Interconnection Facility. The manufacturer or a laboratory acceptable to Distribution Provider may perform these tests. Test results for non-Certified equipment must be submitted to Distribution Provider for the Supplemental Review. Approval by Distribution Provider for equipment used in a particular Generating and/or Interconnection Facility does not guarantee Distribution Provider's approval for use in other Generating and/or Interconnection Facilities.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 226

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

3. TYPE TESTING

a. Type Tests and Criteria for Interconnection Equipment Certification

Type testing provides a basis for determining that equipment meets the specifications for being designated as Certified equipment under this Rule. The requirements described in this Section cover only issues related to Interconnection and are not intended to address device safety or other issues.

Table L.1 defines the test criteria by Generator or inverter technology. While UL 1741(1) and UL 1741 – Supplement SA/SB were written specifically for inverters, the requirements are readily adaptable to synchronous Generators, induction Generators, as well as single/multi-function controllers and protection relays. Until a universal test standard is developed, Distribution Provider or NRTL shall adopt the procedures referenced in Table L.1 as appropriate and necessary for a Generating Facility and/or Interconnection Facilities or associated equipment performance and its control and Protection Functions. These tests shall be performed in the sequence shown in Table L.2.

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Non-Export AC/DC Converters must satisfy the requirements in its definition in Section C.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 227

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

a. Type Tests and Criteria for Interconnection Equipment Certification (Cont'd.)

Table L.1, Type Test and Requirements for Interconnection Equipment Certification

Type Test	Reference (1)	Inverter (6)	Smart Inverter (7)	Smart Inverter 2022 (Note 9,10)	Synchronous Generators	Induction Generators
Utility Interaction	UL 1741 - 39, 40	X	X	X	X	X
Utility Compatibility (Required testing to 1547 and 1547.1)	UL 1741 - 46	X	X	X	X	X
DC Isolation	IEEE 1547.1(8) - 5.6	X	X	-	-	-
Dielectric Voltage Withstand	IEEE1547.1(8) - 5.5.3	X	X	-	X	X
Dielectric Voltage Withstand	IEEE1547.1 2020, 5.8.2	-	-	X	-	-
Harmonic Distortion	IEEE-1547.1(8) - 5.11	X	X	-	X	X
Harmonic Distortion	IEEE1547.1 2020, 5.12	-	-	X	-	-
DC Injection	IEEE1547.1(8) -5.6	X	X	-	-	-
DC Injection	1547.1 2020, 5.9	-	-	X	-	-
Distribution Provider Voltage Variations	IEEE1547.1 - 5.2	X	-	-	X	X
Distribution Provider Frequency Variations	IEEE1547.1 - 5.3	X	-	-	X	X
Abnormal Tests	UL 1741 - 47	X	X	X	-	-
Loss of Control Circuit	UL 1741 - 47.8	X	X	X	X	X
Short Circuit	UL 1741 - 47.3	X	X	X	X	X
Load Transfer	UL 1741 - 47.7	X	X	X	X	X
Surge Withstand Capability	L.3.e	X	X	X	X	X
Anti-Islanding (Traditional)	L.3.b	(2)	-	-	(2)	(2)
Non-Export	L.3.c	(3)	(3)	(3)	(3)	(3)
In-rush Current	L.3.d	-	-	-	-	(4)
Synchronization	L.3.f	(5)	(5)	(5)	X	(5)
Anti-islanding (Smart Inverters)	UL 1741 SA - SA8	-	X	-	-	-
Low and High Voltage Ride-through	UL 1741 SA - SA9	-	X	-	-	-
Low and High Frequency Ride-through	UL 1741 SA - SA10	-	X	-	-	-
Limit Active Power(2022)	UL1741SB- SB3	-	-	X	-	-
Markings and Instructions(2022)	UL1741SB- SB5	-	-	X	-	-

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 228

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

Table L.1, Type Test and Requirements for Interconnection Equipment Certification (Cont'd)

Type Test	Reference (1)	Inverter (6)	Smart Inverter (7)	Smart Inverter 2022 (Note 9,10)	Synchronous Generators	Induction Generators
Normal and Soft-Start Ramp Rate	UL 1741 SA - SA11	-	X	-	-	-
Specified Power Factor	UL 1741 SA - SA12	-	X	-	-	-
Volt/Var Mode (Q(V))	UL 1741 SA - SA13	-	X	-	-	-
Frequency-Watt	UL 1741 SA - SA14	-	X	-	-	-
Volt-Watt	UL 1741 SA - SA15	-	X	-	-	-
Markings and Instructions	UL 1741 SA - SA6 , SA16	-	X	-	-	-
Disable Permit Service	UL1741 SA - SA17	-	X	-	-	-
Limit Active Power	UL1741 SA - SA18	-	X	-	-	-
DC Injection (2022)	IEEE1547.1-2020	-	-	X	-	-
Anti-islanding (Smart Inverters) (2022)	UL1741SB- SB3	-	-	X	-	-
Low and High Voltage Ride-through (2022)	UL1741SB- SB3	-	-	X	-	-
Low and High Frequency Ride-through (2022)	UL1741SB- SB3	-	-	X	-	-
Normal and Soft-Start Ramp Rate (2022)	UL1741SB- SB3	-	-	X	-	-
Specified Power Factor (2022)	UL1741SB- SB3	-	-	X	-	-
Volt/Var Mode (Q(V)) (2022)	UL1741SB- SB3	-	-	X	-	-
Frequency-Watt (2022)	UL1741SB- SB3	-	-	X	-	-
Volt-Watt (2022)	UL1741SB- SB3	-	-	X	-	-
Constant Reactive Power(2022)	UL1741SB- SB3	-	-	X	-	-
Disable Permit Service(2022)	UL1741SB- SB3	-	-	X	-	-

(1) References are to section numbers in either UL 1741 and/or UL 1741-Supplement SA (Inverters, Converters and Charge Controllers for Use in Independent Power Systems) or this Rule. References in UL 1741 to "photovoltaics" or "inverter" may have to be adapted to the other technologies by the testing laboratory to appropriately apply in the tests to other technologies.
 (2) Required only if Non-Islanding designation.
 (3) Required only if Non-Export designation is desired.
 (4) Required for Generators that use Distribution Provider power to motor to speed.
 (5) Required for all self-excited induction Generators as well as Inverters that operate as voltage sources when connected to Distribution Provider's Distribution or Transmission System.
 (6) Inverters compliant with Section H.
 (7) Inverters compliant with Section Hh.
 (8) IEEE 1547.1 refers to 2005 revision
 (9)- Smart Inverter which have tested under UL1741SB and IEEE 1547.1-2020
 (10) - Effective January 1, 2022

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Advice 6093-E
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Submitted
Effective
Resolution

February 22, 2021



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 228

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Advice 6093-E
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Submitted
Effective
Resolution

February 22, 2021



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 229

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

3. TYPE TESTING (Cont'd.)

a. Type Tests and Criteria for Interconnection Equipment Certification (Cont'd.)

Table L.2 Type Tests Sequence for Interconnection Equipment Certification

<u>Test No.</u>	<u>Type Test</u>
1	Distribution Provider Voltage and Frequency Variation
2	Synchronization
3	Surge Withstand Capability
4	Distribution Provider Voltage and Frequency Variation, including ride through
5	Synchronization
6	Other Required and Optional Tests

Tests 1, 2, and 3 must be done first and in the order shown. Tests 4 and on follow in order convenient to the test agency.

b. Anti-Islanding Test

Devices that pass the Anti-Islanding test procedure described in UL 1741 Supplement SB will be considered Non-Islanding for the purposes of these Interconnection requirements. The test is required only for devices for which a Certified Non-Islanding designation is desired.

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c. Non-Export Test

Equipment that passes the Non-Export test procedure described in Section L.7.a will be considered Non-Exporting for the purposes of these Interconnection requirements. This test is required only for devices for which a Certified Non-Export designation is desired.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 230

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

3. TYPE TESTING (Cont'd.)

d. In-rush Current Test

Generation equipment that utilizes Distribution Provider power to motor up to speed will be tested using the procedure defined in Section L.7.b to determine the maximum current drawn during this startup process. The resulting In-rush Current is used to estimate the Starting Voltage Drop.

e. Surge Withstand Capability Test

The interconnection equipment shall be tested for the surge withstand requirement in Section H.1.c in all normal operating modes in accordance with IEEE Std C62.45-2002 for equipment rates less than 1000 V to confirm that the surge withstand capability is met by using the selected test level(s) from IEEE Std C62.41.2-2002.

Interconnection equipment rated greater than 1000 V shall be tested in accordance with manufacturer or system integrator designated applicable standards. For interconnection equipment signal and control circuits, use IEEE Std C37.90.1-2002. These tests shall confirm the equipment did not fail, did not misoperate, and did not provide misinformation (IEEE 1547-2018 4.11.2).

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The location/exposure category for which the equipment has been tested shall be clearly marked on the equipment label or in the equipment documentation. External surge protection may be used to protect the equipment in harsher location/exposure categories.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 231

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

3. TYPE TESTING (Cont'd.)

f. Synchronization Test

This test is applied to synchronous Generators, self-excited induction generators, and inverters capable of operating as voltage-source while connected to Distribution Provider's Distribution or Transmission System. The test is also applied to the resynchronization Function (transition from stand-alone to parallel operation) on equipment that provides such functionality. This test may not need to be performed on both the synchronization and re-synchronization functions if the manufacturers can verify to the satisfaction of the testing organization that monitoring and controls hardware and software are common to both functions. This test is not necessary for induction generators or current-source inverters. Instead, the In-rush Current test Section L.3.d shall be applied to those generators.

This test shall demonstrate that at the moment of the paralleling-device closure, all three synchronization parameters in Table L.3 are within the stated limits. This test shall also demonstrate that if any of the parameters are outside of the limits stated in the table, the paralleling-device shall not close (IEEE 1547-2018 4.10). The test will start with only one of the three parameters: (1) voltage difference between Generating Facility and Distribution Provider's Distribution or Transmission System; (2) frequency difference; or (3) phase angle outside of the synchronization specification. Verify that the Generating Facility is brought within specification prior to synchronization. Repeat the test five times for each of the three parameters. For manual synchronization with synch check or manual control with auto synchronization, the test must verify that paralleling does not occur until the parameters are brought within specifications.

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**ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS**

Sheet 232

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

3. TYPE TESTING (Cont'd.)

f. Synchronization Test (Cont'd.)

Table L.3
Synchronization Parameter Limits [1]

Aggregate Rating of Generator Units (kVA)	Frequency Difference (Δf , Hz)	Voltage Difference (ΔV , %)	Phase Angle Difference ($\Delta \Phi$, °)
0-500	0.3	10	20
> 500-1,500	0.2	5	15
> 1,500-10,000	0.1	3	10

[1] – IEEE 1547-2018 4.10.4

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(L)

g. Paralleling Device Withstand Test

The di-electric voltage withstand test specified in Section L.1 shall be performed on the paralleling device to ensure compliance with those requirements specified in Section H.1.c (IEEE 1547-2018 4.11.3).

(L)
(T)/(L)
(L)

h. Backfeed Test

Non-Export AC/DC Converters must satisfy the requirements in its definition in Section C.

4. PRODUCTION TESTING

At a minimum, each interconnection system shall be subjected to Distribution Provider Voltage and Frequency Variation Test procedure described in UL1741 under Manufacturing and Production Tests, Section 68 and the Synchronization test specified in Section L.3.f. Interconnection systems with adjustable set points shall be tested at a single set of set points as specified by the manufacturer. This test may be performed in the factory or as part of a Commissioning Test (Section L.5).

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 233

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

5. COMMISSIONING TESTING

a. Commissioning Testing

Commissioning Testing, where required, will be performed on-site to verify protective settings and functionality. Upon initial Parallel Operation of a Generating Facility, or any time interface hardware or software is changed that may affect the functions listed below, a Commissioning Test must be performed. An individual qualified in testing protective equipment (professional engineer, factory-certified technician, or licensed electrician with experience in testing protective equipment) must perform Commissioning Testing in accordance with the manufacturer's recommended test procedure to verify the settings and requirements per this Rule.

Distribution Provider may require written Commissioning test procedure be submitted to Distribution Provider at least 10 working days prior to the performance of the Commissioning Test. Distribution Provider has the right to witness Commissioning Test. Distribution Provider may also require written certification by the installer describing which tests were performed and their results. Protective Functions to be tested during commissioning, particularly with respect to non-Certified equipment, may consist of the following:

- (1) Over and under voltage
- (2) Over and under frequency
- (3) Anti-Islanding function (if applicable)
- (4) Non-Exporting function (if applicable)
- (5) Inability to energize dead line

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 234

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 5. COMMISSIONING TESTING (Cont'd.)
 - a. Commissioning Testing (Cont'd.)
 - (6) Time delay on restart after Distribution Provider source is stable
 - (7) Distribution Provider system fault detection (if used)
 - (8) Synchronizing controls (if applicable)
 - (9) Other Interconnection Protective Functions that may be required as part of the Generator Interconnection Agreement

Commissioning Test shall include visual inspections of the interconnection equipment and protective settings to confirm compliance with the interconnection requirements.
 - b. Review, Study, and Additional Commissioning Test Verification Costs

A Producer shall be responsible for the reasonably incurred costs of the reviews, studies and additional Commissioning Test verifications conducted pursuant to Section E of this Rule. If the initial Commissioning Test verification is not successful through no fault of Distribution Provider, Distribution Provider may impose upon Producer a cost based charge for subsequent Commissioning Test verifications. All Costs for additional Commissioning Test verifications shall be paid by Producer within thirty days of receipt of Distribution Provider's invoice. The invoice provided by Distribution Provider shall consist of the hourly rate multiplied by the hours incurred by Distribution Provider and will separately specify the amount of time spent on-site from that spent in roundtrip travel to the Commissioning Test site. Additional cost, if any, will be specified on the invoice. If the initial Commissioning Test verification is not successful through the fault of Distribution Provider, that visit will not be considered the initial Commissioning Test verification.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 235

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 5. COMMISSIONING TESTING (Cont'd.)
- c. Other Checks and Tests
 - Other checks and tests that may need to be performed include:
 - (1) Verifying final Protective Function settings
 - (2) Trip test (L.5.g)
 - (3) In-service tests (L.5.h)
- d. Certified Equipment
 - Generating Facilities qualifying for interconnection through the Fast Track process incorporate Certified Equipment that have, at a minimum, passed the Type Tests and Production Tests described in this Rule and are judged to have little or no potential impact on Distribution Provider's Distribution or Transmission System. For such Generating Facilities, it is necessary to perform only the following tests:
 - (1) Protective Function settings that have been changed after Production Testing will require field verification. Tests shall be performed using injected secondary frequencies, voltages and currents, applied waveforms, at a test connection using a Generator to simulate abnormal Distribution Provider voltage or frequency, or varying the set points to show that the device trips at the measured (actual) Distribution Provider voltage or frequency.
 - (2) The Non-Islanding function shall be checked by operating a load break disconnect switch to verify the Interconnection equipment ceases to energize Distribution Provider's Distribution or Transmission System and does not re-energize it for the required time delay after the switch is closed. (L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 236

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 5. COMMISSIONING TESTING (Cont'd.)
- d. Certified Equipment (Cont'd.)
 - (3) The Non-Exporting function shall be checked using secondary injection techniques. This function may also be tested by adjusting the Generating Facility output and local loads to verify that the applicable Non-Exporting criteria (i.e., reverse power or underpower) are met.
 - The Supplemental Review or an Interconnection Study may impose additional components or additional testing.
- e. Non-Certified Equipment
 - Non-certified Equipment shall be subjected to the appropriate tests described in Type Testing (Section L.3) as well as those described in Certified Equipment Commissioning Tests (Section L.5.d). With Distribution Provider's approval, these tests may be performed in the factory, in the field as part of commissioning, or a combination of both. Distribution Provider, at its discretion, may also approve a reduced set of tests for a particular Generating Facility or, for example, if it determines it has sufficient experience with the equipment.
- f. Verification of Settings
 - At the completion of Commission testing, Producer shall confirm all devices are set to Distribution Provider-approved settings. Verification shall be documented in the Commissioning Test Certification. (L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 237

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

5. COMMISSIONING TESTING (Cont'd.)

g. Trip Tests

Interconnection Protective Functions and devices (e.g. reverse power relays) that have not previously been tested as part of the Interconnection Facilities with their associated interrupting devices (e.g. contactor or circuit breaker) shall be trip tested during commissioning. The trip test shall be adequate to prove that the associated interrupting devices open when the protective devices operate. Interlocking circuits between Protective Function devices or between interrupting devices shall be similarly tested unless they are part of a system that has been tested and approved during manufacturing.

h. In-service Tests

Interconnection Protective Functions and devices that have not previously been tested as part of the Interconnection Facilities with their associated instrument transformers or that are wired in the field shall be given an in-service test during commissioning. This test will verify proper wiring, polarity, CT/PT ratios, and proper operation of the measuring circuits. The in-service test shall be made with the power system energized and carrying a known level of current. A measurement shall be made of the magnitude and phase angle of each Alternating Current (AC) voltage and current connected to the protective device and the results compared to expected values. For protective devices with built-in Metering Functions that report current and voltage magnitudes and phase angles, or magnitudes of current, voltage, and real and reactive power, the metered values may be used for in-service testing. Otherwise, portable ammeters, voltmeters, and phase-angle meters shall be used.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 238

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

6. PERIODIC TESTING

Periodic Testing of Interconnection-related Protective Functions shall be performed as specified by the manufacturer, or at least every four years. All Periodic Tests prescribed by the manufacturer shall be performed. Producer shall maintain Periodic Test reports or a log for inspection by Distribution Provider. Periodic Testing conforming to Distribution Provider test intervals for the particular Line Section may be specified by Distribution Provider under special circumstances, such as high fire hazard areas. Batteries used to activate any Protective Function shall be checked and logged once per month for proper voltage. Once every four years, the battery must be either replaced or a discharge test performed.

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS

This Section describes the additional Type Tests necessary to qualify a device as Certified under this Rule. These Type Tests are not contained in Underwriters Laboratories UL 1741 Standard *Inverters, Converters and Controllers for Use in Independent Power Systems*, or other referenced standards.

a. Non-Exporting Test Procedures

The Non-Exporting test is intended to verify the operation of relays, controllers and inverters designed to limit the export of power and certify the equipment as meeting the requirements of Screen I, Options 1 and 2, of the review process. Tests are provided for discrete relay packages and for controllers and inverters with the intended Functions integrated.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 239

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

a. Non-Exporting Test Procedures (Cont'd.)

i) Discrete Reverse Power Relay Test

This version of the Non-Exporting test procedure is intended for discrete reverse power and underpower relay packages provided to meet the requirements of Options 1 and 2 of Screen I. It should be understood that in the reverse power application, the relay will provide a trip output with power flowing in the export (toward Distribution Provider's Distribution or Transmission System) direction.

Step 1: Power Flow Test at Minimum, Midpoint and Maximum Pickup Level Settings

Determine the corresponding secondary pickup current for the desired export power flow of 0.5 secondary watts (the minimum pickup setting, assumes 5 amp and 120V CT/PT secondary). Apply nominal voltage with minimum current setting at zero (0) degrees phase angle in the trip direction. Increase the current to pickup level. Observe the relay's (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat this test at the midpoint, and maximum settings. Repeat at phase angles of 90, 180 and 270 degrees and verify that the relay does not operate (measured watts will be zero or negative).

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 240

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
- a. Non-Exporting Test Procedures (Cont'd.)
 - i) Discrete Reverse Power Relay Test (Cont'd.)
 - Step 2: Leading Power Factor Test

Apply rated voltage with a minimum pickup current setting (calculated value for system application) and apply a leading power factor load current in the non-trip direction (current lagging voltage by 135 degrees). Increase the current to relay rated current and verify that the relay does not operate. For relays with adjustable settings, this test should be repeated at the minimum, midpoint, and maximum settings.
 - Step 3: Minimum Power Factor Test

At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Increase the current level to pickup (about 10 times higher than at 0 degrees) and verify that the relay operates. Repeat for phase angles of 90, 180 and 270 degrees and verify that the relay does not operate.
 - Step 4: Negative Sequence Voltage Test

Using the pickup settings determined in Step 1, apply rated relay voltage and current at 180 degrees from tripping direction, to simulate normal load conditions (for three-phase relays, use Ia at 180, Ib at 60 and Ic at 300 degrees). Remove phase-1 voltage and observe that the relay does not operate. Repeat for phases-2 and 3.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 241

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
- a. Non-Exporting Test Procedures (Cont'd.)
 - i) Discrete Reverse Power Relay Test (Cont'd.)

Step 5: Load Current Test

Using the pickup settings determined in Step 1, apply rated voltage and current at 180 degrees from the tripping direction, to simulate normal load conditions (use Ia at 180, Ib at 300 and Ic at 60 degrees). Observe that the relay does not operate.

Step 6: Unbalanced Fault Test

Using the pickup settings determined in Step 1, apply rated voltage and 2 times rated current, to simulate an unbalanced fault in the non-trip direction (use Va at 0 degrees, Vb and Vc at 180 degrees, Ia at 180 degrees, Ib at 0 degrees, and Ic at 180 degrees). Observe that the relay, especially single phase, does operate properly.

Step 7: Time Delay Settings Test

Apply Step 1 settings and set time delay to minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the timer stops when the relay trips. Repeat at midpoint and maximum delay settings.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 242

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
- a. Non-Exporting Test Procedures (Cont'd.)
 - i) Discrete Reverse Power Relay Test (Cont'd.)
 - Step 8: Dielectric Test
 - Perform the test described in IEC 414 using 2 kV RMS for 1 minute.
 - Step 9: Surge Withstand Test
 - Perform the surge withstand test described in IEEE C37.90.1.1989 or the surge withstand capability test described in L.3.e.
 - ii) Discrete Underpower Relay Test
 - This version of the Non-Exporting test procedure is intended for discrete underpower relay packages and meets the requirements of Option 2 of Screen I. A trip output will be provided when import power (toward Producer's load) drops below the specified level.
 - Note: For an underpower relay, pickup is defined as the highest power level at which the relay indicates that the power is less than the set level. (L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 243

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

a. Non-Exporting Test Procedures (Cont'd.)

ii) Discrete Underpower Relay Test (Cont'd.)

Step 1: Power Flow Test at Minimum, Midpoint and Maximum Pickup Level Settings

Determine the corresponding secondary pickup current for the desired power flow pickup level of 5% of peak load minimum pickup setting. Apply rated voltage and current at 0 (zero) degrees phase angle in the direction of normal load current.

Decrease the current to pickup level. Observe the relay's (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat the test at the midpoint, and maximum settings. Repeat at phase angles of 90, 180 and 270 degrees and verify that the relay operates (measured watts will be zero or negative).

Step 2: Leading Power Factor Test

Using the pickup current setting determined in Step 1, apply rated voltage and rated leading power factor load current in the normal load direction (current leading voltage by 45 degrees). Decrease the current to 145% of the pickup level determined in Step 1 and verify that the relay does not operate. For relays with adjustable settings, repeat the test at the minimum, midpoint, and maximum settings.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 244

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
- a. Non-Exporting Test Procedures (Cont'd.)
- ii) Discrete Underpower Relay Test (Cont'd.)
- Step 3: Minimum Power Factor Test
- At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Decrease the current level to pickup (about 10% of the value at 0 degrees) and verify that the relay operates. Repeat for phase angles 90, 180 and 270 degrees and verify that the relay operates for any current less than rated current.
- Step 4: Negative Sequence Voltage Test
- Using the pickup settings determined in Step 1, apply rated relay voltage and 25% of rated current in the normal load direction, to simulate light load conditions. Remove phase 1 voltage and observe that the relay does not operate. Repeat for Phases-2 and 3.
- Step 5: Unbalanced Fault Test
- Using the pickup settings determined in Step 1, apply rated voltage and two times rated current, to simulate an unbalanced fault in the normal load direction (use Va at 0 degrees, Vb and Vc at 180 degrees, Ia at 0 degrees, Ib at 180 degrees, and Ic at 0 degrees). Observe that the relay (especially single-phase types) operates properly. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 245

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
 - a. Non-Exporting Test Procedures (Cont'd.)
 - ii) Discrete Underpower Relay Test (Cont'd.)
 - Step 6: Time Delay Settings Test

Apply Step 1 settings and set time delay to minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the timer stops when the relay trips. Repeat at midpoint and maximum delay settings.
 - Step 7: Dielectric Test

Perform the test described in IEC 414 using 2 kV RMS for 1 minute.
 - Step 8: Surge Withstand Test

Perform the surge withstand test described in IEEE C37.90.1.1989 or the surge withstand test described in Section L.3.e.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 246

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

(L)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

a. Non-Exporting Test Procedures (Cont'd.)

iii) Tests for Inverters and Controllers with Integrated Functions

Inverters and controllers designed to provide reverse or underpower functions shall be tested to certify the intended operation of this function. Two methods are acceptable:

Method 1: If the inverter or controller utilizes external current/voltage measurement to determine the reverse or underpower condition, then the inverter or controller shall be functionally tested by application of appropriate secondary currents and potentials as described in the Discrete Reverse Power Relay Test, Section L.7.a.i of this Rule.

Method 2: If external secondary current or voltage signals are not used, then unit-specific tests must be conducted to verify that power cannot be exported across the PCC for a period exceeding two seconds. These may be factory tests, if the measurement and control points are integral to the unit, or they may be performed in the field.

iv) Tests for Inadvertent Export Inverters

Test requirements for certified inverters with integrated functions for Inadvertent Export shall verify the performance requirements specified in Section Mm of this Rule.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 247

- L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)
- 7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)
- a. Non-Exporting Test Procedures (Cont'd.)
 - v) Interim Tests for Non-Export AC/DC Converters ("Converter")
 - Step 1: Limitation of Back-feed Under Steady State Conditions

Apply the nominal DC operating voltage of the Converter across its DC terminals with a battery source or simulated equivalent of a battery source. Vary the battery source by 100%, 75%, 50%, 25%, and 10% of Converter rated output power. The measured steady-state DC current component at each of the AC terminals of the Converter is required to be less than 0.5% of the Converter's rated RMS AC current. This test is to be repeated for 80% nominal DC operating voltage and for 125% nominal DC operating voltage. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.
 - Step 2: Back-feed Under Fault Conditions – DC Output Shorted

With a battery source or simulated equivalent of a battery source connected to the DC terminals, apply rated conditions of the Converter then short its DC terminals for 200 milliseconds. After 5 cycles of inducing the short circuit, record the measured peak current at each of the AC terminals of the Converter. These peak currents within this time interval are each required to be less than 0.5% of the Converter's rated RMS AC current. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 248

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

a. Non-Exporting Test Procedures (Cont'd.)

v) Interim Tests for Non-Export AC/DC Converters ("Converter") (Cont'd.)

Step 3: Back-feed Under Fault Conditions – AC Input Shorted: Phase-Ground, Phase-Phase, and 3-Phase

With a battery source or simulated equivalent of a battery source connected to the DC terminals, apply rated conditions of the Converter, then apply a short between any two phases on the grid side of the Converter for 200 milliseconds. After 5 cycles of inducing the short circuit, record the measured peak current at each of the AC terminals of the Converter. These peak currents within this time interval are each required to be less than 0.5% of the Converter's rated RMS AC current. This test is to be repeated for phase-ground and 3-phase shorts. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.

Step 4: Back-feed Under Fault Conditions – Component Faults

Distribution Provider can elect to test for back-feed under the condition of a short circuit across certain components which are internal to the Converter. Potential tests can include inducing a short circuit across different terminals for electronic switches and/or across different terminals for internal transformers. Ultimately, the components used for testing will be chosen on a case-by-case basis and will depend on the Converter's circuit topology. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.

Step 5: Harmonics Testing

Under normal loading conditions at 10%, 25%, 50%, 75%, and 100% of the Converter's rated power output, conduct harmonic current distortion measurements on each of the AC terminals. Measurements should be below the maximum harmonic current distortion requirements given in IEEE 1547-2018 7.3.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 249

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.) (L)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

b. In-rush Current Test Procedures

This test will determine the maximum In-rush Current drawn by the Generator.

i) Locked-Rotor Method

Use the test procedure defined in NEMA MG-1 (manufacturer's data is acceptable if available).

ii) Start-up Method

Install and setup the Generating Facility equipment as specified by the manufacturer. Using a calibrated oscilloscope or data acquisition equipment with appropriate speed and accuracy, measure the current draw at the Point of Interconnection as the Generating Facility starts up and parallels with Distribution Provider's Distribution or Transmission System. Startup shall follow the normal, manufacturer-specified procedure. Sufficient time and current resolution and accuracy shall be used to capture the maximum current draw within 5%. In-rush Current is defined as the maximum current draw from Distribution Provider during the startup process, using a 10-cycle moving average. During the test, Distribution Provider source, real or simulated, must be capable of maintaining voltage within +/- 5% of rated at the connection to the unit under test. Repeat this test five times. Report the highest 10-cycle current as the In-rush Current. A graphical representation of the time-current characteristic along with the certified In-rush Current must be included in the test report and made available to Distribution Provider.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 250

M. INADVERTENT EXPORT

(L)

Under certain operating conditions, an Applicant may choose to completely offset their facility load by installing generation systems which are optimally sized to meet their peak demand with load following functionality on the Generator controls to ensure conditional export of electrical power from the Generating Facility to Distribution Provider's Distribution or Transmission System. In situations where the loading changes rapidly and/or the Generator cannot ramp down quickly enough, the Generating Facility may need to export small amounts of power for limited duration. The event of exporting uncompensated power for a short time is referred to as Inadvertent Export.

The following are the minimum requirements for Inadvertent Export systems. Other factors relevant to the interconnection study process (e.g. 15% screen results, short circuit current ratio, etc.) may necessitate additional technical requirements (e.g. reclose block, transfer trip, ground bank, etc.) that are not explicitly noted here. Inadvertent Export may not be available for interconnections to Networked Secondary Systems.

1. For Inadvertent Export interconnection requests, additional Protective Functions and equipment to detect Distribution or Transmission System faults (per Distribution Provider's standard practices) may be required over and above the basic Protective Functions and equipment associated with the four options in the Export Screen. Protective Functions may include, but are not limited to, directional overcurrent/voltage-restraint overcurrent Protective Functions for line-to-line fault detection and overcurrent/overvoltage Protective Functions for line-to-ground detection. The addition of a ground bank or ground detector may also be necessary.

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 251

- M. INADVERTENT EXPORT (Cont'd.) (L)
2. The effect on equipment ratings can be mitigated by limiting the amount of inadvertent export allowed. To a large degree, Voltage Regulation may be similarly handled. The amount of Inadvertent Export is dependent on specific Distribution Provider requirements and should be limited to the lesser of the following values:
 - a. 50% of the Generating Facility Capacity, or
 - b. 10% of the continuous conductor rating in watts at 0.9 power factor for the lowest rated feeder conductor upstream of the GF (i.e. 200kW @ 12kV), or
 - c. 110% of the largest load block in the facility, or
 - d. 500kW or some other maximum level indicated by Distribution Provider
 3. In addition to the limits above, the following are required:
 - a. A reverse power Protective Function will be provided to trip the connected Generator(s) within two seconds if the proposed amount of Inadvertent Export is exceeded.
 - b. The frequency of Inadvertent Export occurrences should be less than two occurrences per 24-hour period.
 - c. A separate reverse power or underpower Protective Function will be required (in addition to the reverse power Protective Function described in 3a. above) to trip the connected Generator(s) if the duration of reverse power or underpower (i.e. ANY export) exceeds 60 seconds. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 252

Mm. INADVERTENT EXPORT FOR INTERCONNECTION REQUESTS UTILIZING UL-1741 CERTIFIED OR SA LISTED GRID SUPPORT (NON-ISLANDING) INVERTERS (L)

The following are the minimum requirements for Inadvertent Export systems that meet the criteria specified below. Other factors relevant to the interconnection study process (e.g., 15% screen results, short circuit current ratio, etc.) may necessitate additional technical requirements (e.g., reclose block, transfer trip, ground bank, etc.) that are not explicitly noted here. Inadvertent Export may not be available for interconnections to Networked Secondary Systems.

The certified control functions internal to the inverter control or external control system may be used to replace the discrete reverse/under power relay functions described in Section M provided the requirements outlined below are met.

- 1) All of the following requirements must be met by the Generating Facility to qualify for Inadvertent Export under this Section.
 - a. The Generating Facility must utilize only UL-1741 certified or UL-1741 SA listed grid support non-islanding inverters; and,
 - b. The Generating Facility must have an aggregate maximum nameplate capacity of 500 kVA or less; and,
 - c. The Generating Facility's total energy export must not exceed its nameplate rating (kVA-gross) multiplied by 0.1 hours per day over a rolling 30-day period (e.g., for a 100 kVA-gross nameplate Generating Facility, the maximum energy allowed to be exported for a 30-day period is 300 kWh) ; and,
 - d. Export from the Generating Facility across the PCC to the Distribution System is less than 100 kVA. (L)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 253

Mm. INADVERTENT EXPORT FOR INTERCONNECTION REQUESTS UTILIZING UL-1741 CERTIFIED OR SA LISTED GRID SUPPORT (NON-ISLANDING) INVERTERS (Cont'd.) (L)

- 2) To govern the level of Inadvertent Export allowable under this Section, the Generating Facility must utilize a NRTL-certified control system or NRTL-certified inverter system that meets all of the following requirements.
 - a. Must result in the Generating Facility disconnecting from the Distribution System, ceasing to energize the Distribution System or halting energy production within two (2) seconds after either:
 - i. The period of continuous export exceeds 30 seconds;
 - or,
 - ii. The level of export exceeds 100 kVA.
 - b. Must monitor that the total energy export is maintained within the allowable energy export outlined above 1.c and provide an indication or notification (e.g., electronic, alarm) if that energy export limit is exceeded.
 - c. Failure of the of the control or inverter system for more than thirty (30) seconds, resulting from loss of control signal, loss of control power or a single component failure or related control sensing of the control circuitry, must result in the Generating Facility entering Non-Export operation where no energy is exported across to the PCC to the Distribution System.

Interim approval of the control or inverter system may be permitted upon mutual agreement of PG&E and the Producer. (L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 254

Mm. INADVERTENT EXPORT FOR INTERCONNECTION REQUESTS (L)
UTILIZING UL-1741 CERTIFIED OR SA LISTED GRID SUPPORT (NON-ISLANDING) INVERTERS (Cont'd.)

3) Applicability of Engineering Review Screens.

Inadvertent Export systems that meet the requirements described herein are processed under Initial Review Screens A through J as described in Section H. If these systems fail Screen J, they then bypass Screens K and L and are processed under Screens M and M1 as described below.

Screen M: Is the aggregate Generating Facility capacity on the Line Section less than 15% of Line Section peak load for all line sections bound by automatic sectionalizing devices?

- If Yes (pass), Initial Review is complete.
- If No (fail), continue to Screen M1.

Screen M1: Is the aggregate of all distributed energy resources (DER) causing reverse power flow (1) at a line section with a voltage regulator device(s) or (2) at a protection device, including the circuit breaker / field recloser?*,**

- If No (pass), existing DER does not cause reverse power flow at (1) or (2) and Initial Review is complete.
- If Yes (fail), existing DER causes reverse power flow at (1) or (2); fail Initial Review and Supplemental Review is required.

* For the purposes of applying Screen M1 herein, Distribution Provider shall utilize a zero coincidence factor when considering the impact of other Inadvertent Export systems that meet the requirements of Section Mm (i.e., projects that qualify for Option 6 under Section G.1.i) such that those Inadvertent Export systems do not impact Screen M1's aggregate analysis determination for the individual Inadvertent Export project being evaluated.

** The presence of existing non-certified DER on the line section may require additional review to ensure safe and reliable grid operation.

(Continued)



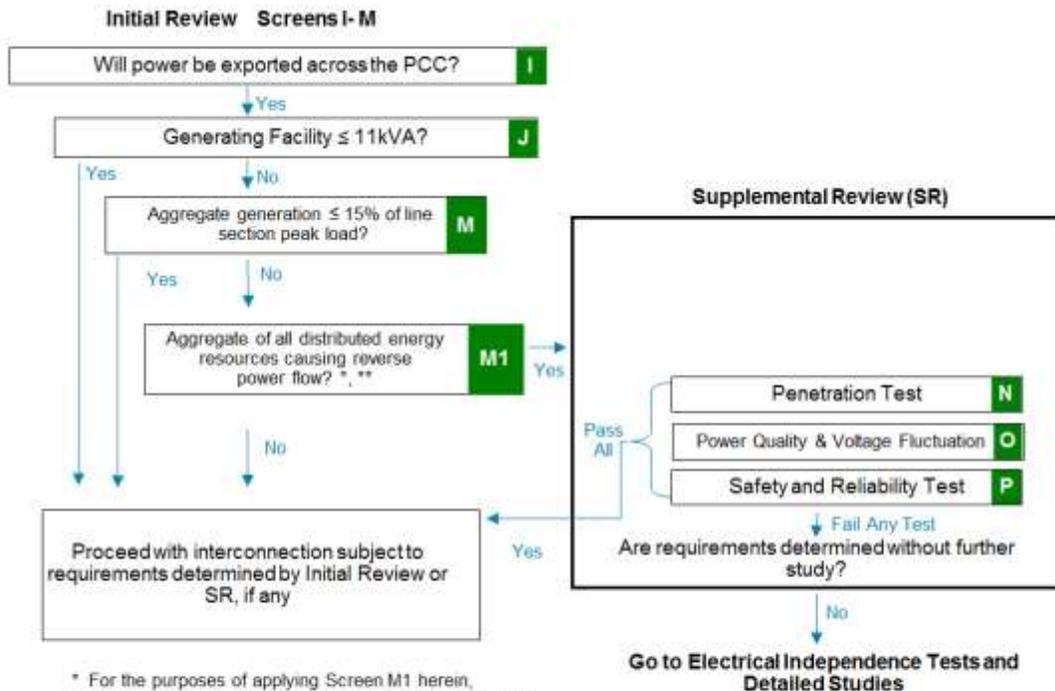
ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 255

Mm. INADVERTENT EXPORT FOR INTERCONNECTION REQUESTS UTILIZING UL-1741 CERTIFIED OR SA LISTED GRID SUPPORT (NON-ISLANDING) INVERTERS (Cont'd.)

(L)

3) Applicability of Engineering Review Screens. (Cont'd.)



* For the purposes of applying Screen M1 herein, Distribution Provider shall utilize a zero coincidence factor when considering the impact of other Inadvertent Export systems that meet with the requirements of Section Mm (i.e., projects that qualify for Option 6 under Section G.1.i) such that those Inadvertent Export systems do not impact Screen M1's aggregate analysis determination for the individual analysis determination for the individual Inadvertent Export project being evaluated.

** The presence of existing non-certified DER on the line section may require additional review to ensure safe and reliable grid operation.

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 256

N. EXPEDITED INTERCONNECTION PROCESS FOR NON-EXPORT ENERGY STORAGE GENERATING FACILITIES (L)

Applicants with Interconnection Requests for Non-Export Energy Storage Generating Facilities who meet the requirements outlined below are eligible for expedited interconnection in accordance with the Fast Track Process technical review requirements of Section F.2.¹ Applicants with Non-Export AC/DC Converters that meet the requirements outlined in O. below are also eligible.

1. ELIGIBILITY REQUIREMENTS

Applicants seeking to interconnect a Generating Facility under the provisions of this Section N must meet the following eligibility requirements.

- a. Applicant must electronically submit a completed Interconnection Request, including completing all application fields and submitting all supporting documentation necessary to facilitate the expedited review as required by Distribution Provider. Such documentation may include, but is not limited to, single line diagrams with specific details, manufacturer data sheets for proposed equipment, description of control systems, validation of the right to do business in the state, etc. Distribution Provider shall clearly communicate these requirements as part of the application process. Applicant shall select this process option in the Interconnection Request.
- b. Applicant's Generating Facility must meet the requirements outlined in Section N.2 below.
- c. Applicant's Interconnection Request must be eligible for and select the Fast Track Process.
- d. Applicant's Interconnection Request must pass Fast Track Initial Review and not require any Interconnection Facilities, Distribution Upgrades or Network Upgrades to remain eligible under this Section. As such, Interconnection Requests that select the Cost Envelope Option are not eligible.
- e. Applicants selecting this section shall use the corresponding interconnection agreement type provided for eligible Generating Facilities.

¹ In accordance with Advice 4941-E-A, the provisions provided for in Section N are being implemented under a pilot approach with a July 1, 2017 through June 30, 2018 reporting period. As such, the provisions may be continued, modified and/or withdrawn as determined by the Commission

(Continued)

(L)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 257

N. EXPEDITED INTERCONNECTION PROCESS FOR NON-EXPORT ENERGY STORAGE GENERATING FACILITIES (Cont'd.) (L)

2. GENERATING FACILITY ELIGIBILITY CRITERIA

An Applicant's Generating Facility must meet and adhere to the following criteria.

- a. The Generating Facility must be comprised solely of the following specific categories of generation technology: Non-Exporting battery storage.
- b. The Generating Facility must have an aggregate maximum inverter nameplate rating of no greater than 500 kW. There is no limitation on an energy storage device's kWh capacity rating.
- c. The Generating Facility must be located behind an existing single retail meter and Point of Common Coupling with a single, clearly marked and accessible disconnect. No other Generators, other than isolated back-up Generators, may be at the same Point of Interconnection or Point of Common Coupling.
- d. The Generating Facility must utilize Option 3 or Option 4 to meet the non-export protection requirements of Screen I in Section G.1.i.
- e. The Generating Facility must have a single or coordinated control system for all charging functions if utilizing multiple inverters. The control system must also ensure that there is no increase in the Interconnection Customer's existing peak load demand.
- f. The Generating Facility must utilize only inverter-based, UL 1741 and UL 1741 SA-listed equipment. Additionally, all installed equipment must meet Distribution Provider's current electric service requirements with no violations or variances.

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 258

O. Non-Export AC/DC CONVERTER ELIGIBILITY CRITERIA

(L)

Applicants with Non-Export AC/DC Converters who meet the eligibility criteria below qualify for the expedited interconnection process outlined in Section N of this Rule.

1. The Non-Export AC/DC Converter must have an aggregate maximum inverter nameplate rating of no greater than 500 kW. There is no limitation on an energy storage device's kWh capacity rating.
2. Applicant's Interconnection Request must be eligible for and select the Fast Track Process.
3. Applicant's Interconnection Request must pass Fast Track Initial Review and not require any Interconnection Facilities, Distribution Upgrades or Network Upgrades to remain eligible under this Section.
4. Applicants selecting this section shall use the corresponding interconnection agreement type provided for Non-Export AC/DC Converters eligible under this Section. As such, Interconnection Requests that select the Cost Envelope Option are not eligible.
5. Applicant's Non-Export AC/DC converter must meet the Certification requirements in the Section C Definition of "Non-Export AC/DC Converters".

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Appendix A Forms Associated with Rule 21 Generating Facility Interconnections			
Form Number	Title	Associated Tariffs	Use Guidance
Pre-Application Request			
79-1181	Rule 21 Pre-Application Report Request	Rule 21	For Generator Developer to request basic info about local distribution circuit
Study Agreement			
79-1162	Rule 21 Detailed Study Agreement	Rule 21	Independent Study and Distribution Group Study Process Study Agreement
NEM and Non-Export Interconnection Forms			
79-978	Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1,000 kW or Less, Other Than Facilities of 30 kW or Less	NEM, Rule 21	Solar and/or Wind > 30 kW and ≤ 1 MW expanded NEM used with Form 79-1174-02
79-978-02	Interconnection Agreement for Net Energy Metering (NEM2) of Solar or Wind Electric Generating Facilities of 1,000 Kilowatts or Less, Other than Facilities of 30 Kilowatts or Less	NEM2, Rule 21	Solar and/or Wind > 30 kW and ≤ 1 MW expanded NEM2 used with Form 79-1174-02
79-997	Interconnection Agreement for Net Energy Metering of Biogas Digester Generating Facilities	NEM, Rule 21	NEMBIO (Closed to new applicants), NEMBIOA Interconnection Agreement used with Form 79-1174
79-1010	Interconnection Agreement for Net Energy Metering of Fuel Cell Generating Facilities	NEM, Rule 21	NEMFC Interconnection Agreement used with Form 79-1174
79-1069	Generating facility Interconnection Agreement (Multiple Tariff)	NEM, Rule 21	NEMMT Interconnection Agreement used with Form 79-1174
79-1069-02	Generating Facility Interconnection Agreement (Multiple Tariff NEM2MT)	NEM2, Rule 21	NEM2MT Interconnection Agreement used with Form 79-1174-02
79-1109 ***	Virtual Net Energy Metering Application and Interconnection Agreement For The Building Owner of Multifamily Affordable Housing With A Solar Generating Facility of 1 Megawatt or Less	NEM, Rule 21	NEMV Interconnection Agreement used with Form 79-974

(L)

(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Appendix A (Cont'd.)			
Forms Associated with Rule 21			
Generating Facility Interconnections			
Form Number	Title	Associated Tariffs	Use Guidance
NEM and Non-Export Interconnection Forms (Cont'd.)			
79-1137	Interconnection Agreement for Net Energy Metering for a Renewable Electrical Generation Facility of 1,000 kW or Less, Except Solar or Wind (SB 489)	NEM, Rule 21	NEMV, NEMEXP, NEMEXPM Interconnection Agreement typically used with Forms 79-974 and 79-1142 Applications
79-1137-02	Interconnection Agreement for Net Energy Metering (NEM2/NEM2V) for a Renewable Electricity Generation Facility of 1,000 Kilowatts or Less, Except Solar or Wind	NEM2, NEM2V, Rule 21	NEM2V, NEM2EXP, NEM2EXPM Interconnection Agreement typically used with Forms 79-1174-02
79-1142 ***	NEMV Interconnection Application for a Renewable Electrical Generation Facility of 1 Megawatt or Less	NEM, Rule 21	Used with Form 79-1137 (L)
79-973	Generating Facility Interconnection Agreement For Non-Export Generating Facilities (Rule 21 Interconnection Agreement)	Rule 21	Interconnection Agreement used for RESBCT and non-NEM generation with Application 79-974 and 79-1112
79-992	Customer Generation Agreement (Third party Generator on Premises, Non-Exporting)	Rule 21	Used with Forms 79-1174
79-1070	Export Addendum to Generating Facility Interconnection Agreement for Non-Export Generating Facilities (Form 79-973) Sized 2 Megawatts or Less	Rule 21	Export addendum used with Form 79-973
79-1136	PG&E Interconnection Agreement For an Existing Small Generating Facility Interconnecting to the Distribution System under Rule 21	Rule 21	Used for existing QFs with Form 79-974 (L)
79-1192	Interconnection Agreement for Non-Export Storage Generating Facilities 500KW or Less	Rule 21	Used for expedited interconnection of non-export energy storage, pursuant to Rule 21 Section N, PG&E AL 4941-E & E-A and D.16-06-052, & Attachment C, Section II.1
79-1199	Agreement And Customer Authorization Non-Export Stand-Alone Energy Storage Of 30 Kilowatts Or Less	Rule 21	Interconnection Agreement For non-export storage ≤ 30 kW
79-1206-02	Eligible Low-Income Development Virtual Net Energy Metering (NEM2VSOM) Interconnection Agreement For The Solar On Multifamily Affordable Housing (SOMAH) Program With Solar Generation Totaling 1 Mw Or Less	NEM2VSOM	NEM2VSOM Interconnection agreement for solar 1 MW or less.

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(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Appendix A (Cont'd.) Forms Associated with Rule 21 Generating Facility Interconnections			
Form Number	Title	Associated Tariffs	Use Guidance
Other NEM and Non-Export Forms (Cont'd.)			
79-1130	Request to Opt-out of / Opt-in to Compensation for Surplus Electricity	NEM	AB 920- Opt not to receive compensation for net annual excess energy
79-1202 ****	Load Aggregation Appendix	NEM, NEM2, Rule 21	Use as an Appendix with Form 79-1151A, 79-1151A-02, 79-978, 79-978-02, 79-1137, 79-1137-02, 79-1069 or 79-1069-02
79-1155	Schedules NEM, NEMV, NEMVMASH, Net Surplus Electricity (NSE) Renewable Energy Credits Compensation	NEM, Rule 21	
79-1155-02	Schedules NEM2, NEM2V, NEM2VMASH, Net Surplus Electricity (NSE) Renewable Energy Credits Compensation	NEM2 NEM2V NEM2VMASH, Rule 21	
79-1174	Rule 21 Generator Interconnection Application	NEM (NEMEXP, NEMMT and NEMA), NEMFC, NEMV, NEMVMASH, RES-BCT, Rule 21	Rule 21 customer interconnection application form for expanded net-energy metered (all NEM > 30 kw and all non-Solar/Wind NEM), NEMFC, NEMV, NEMVMASH, RES-BCT, and non-export and limited export Rule 21 generation. (Standard NEM for solar and/or wind ≤ 30 kw will continue to use the 79-1151B application.)
79-1174-02	Rule 21 Generator Interconnection Application	NEM2 (NEM2EXP, NEM2MT and NEM2A), NEMFC, NEM2V, NEM2VMASH, RES-BCT, Rule 21	Rule 21 customer interconnection application form for expanded net-energy metered (all NEM2 > 30 kw and all non-Solar/Wind NEM), NEMFC, NEM2V, NEM2VMASH, RES-BCT, and non-export and limited export Rule 21 generation. (Standard NEM for solar and/or wind ≤ 30 kw will continue to use the 79-1151B application.)

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(L)

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Appendix A (Cont'd.) Forms Associated with Rule 21 Generating Facility Interconnections			
Form Number	Title	Associated Tariffs	Use Guidance
Export for Sale Interconnection Forms			
79-1145	Rule 21 Exporting Generator Interconnection Request	Rule 21	Preferred online application: https://www.pge.com/en_US/large-business/services/alternatives-to-pge/electric-generation-interconnection.page
79-1197	Local Government Renewable Energy Self-Generation Bill Credit Transfer (RES-BCT) Re-Allocation Request	RES-BCT	Use to establish RES-BCT benefiting account re-allocations
79-1198-02	Interconnection Agreement For Net Energy Metering (NEM2) And Renewable Electrical Generating Facility Sized Greater Than 1,000 Kw	NEM2	FT and Detailed Study Interconnection Agreement for >1MW NEM2 Generating Facilities
79-1200	Rule 21 Generator Interconnection Agreement For Exporting Generating Facilities	Rule 21	FT and Detailed Study Interconnection Agreement for Exporting Generating Facilities
Other Agreements			
79-280	Agreement for Installation of Allocation of Special Facilities for Parallel Operation of Non-Utility-Owned Generation and/or Electrical Standby Service (Electric Rules 2 and 21)	Rule 21	Special Facilities Agreement to be used with Form 79-702
79-702	Appendix A: Detail of Special Facilities Charges to be used in concert with form 79-280	Rule 21	Used with Form 79-280

*** The application section of these forms is replaced by 79-1174.

**** For NEMA expanded customers, use the online 79-1174 form.

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Advice 6093-E
Decision

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Submitted
Effective
Resolution

February 22, 2021



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Attachment 2

Redline Tariff Revisions

Where Electric Rule 21 has been revised, the affected sheets are included in Attachment 1. However, the redline tariff revisions in Attachment 2 do not include pages that merely show location changes.



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GENERATING FACILITY INTERCONNECTIONS

Sheet 1

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Decision 16-06-052

Issued by
Robert S. Kenney
Vice President, Regulatory Affairs

Date Filed May 31, 2018
Effective June 30, 2018
Resolution _____



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B. APPLICABILITY (Cont'd.)

3. APPLICABLE CODES AND STANDARDS

This Rule has been harmonized with the requirements of ~~American National Standards Institute~~/Institute of Electrical and Electronic Engineers (ANSI/IEEE) 1547-2003-2018, ~~Standards for Interconnecting Distributed Resources with Electric Power Systems~~. In some sections, IEEE 1547 language has been adopted directly or by reference, in others, IEEE 1547 requirements were interpreted and this Rule's language was changed to maintain the spirit of both documents.

~~UL1741 Supplement SA has been utilized for certification of phase I Smart Inverters (Phase 1 Smart Inverter Functions) as outlined in section Hh.~~

The language from IEEE 1547-2018 that has been adopted directly (as opposed to paraphrased language or previous language that was determined to be consistent with IEEE 1547-2018) is followed by a citation that lists the clause from which the language derived. For example, IEEE 1547-2018 4.1.1 is a reference to Clause 4.1.1.

In the event of any conflict between this Rule, any of the standards listed herein, or any other applicable standards or codes, the requirements of this Rule shall take precedence.

4. RETAIL CUSTOMER ENERGY STORAGE DEVICES

For retail customers interconnecting energy storage devices pursuant to this Rule, the load aspects of the storage devices will be treated pursuant to Rules 2, 3, 15, and 16 just like other load, using the incremental net load for non-residential customers, if any, of the storage devices.

5. Applicability of IEEE 1547-2018 requirements

The systems voltage at Point of Interconnection (POI) will determine the required generating facility operating requirements. Where voltage at the POI is less than 50kV, for applicable Generating Facility technology, IEEE1547-2018 and related certification requirement are required. Where POI voltage is greater than or equal to 50kV, the IOU Interconnection Handbook will outline operating and performance requirements consistent with NERC and CAISO operating requirements.

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C. DEFINITIONS (Cont'd.)

Cost Envelope Option: A five-year pilot option described in Section F.7 applicable to Interconnection Requests for Generating Facilities that are processed under the Fast Track Process or Independent Study Process.

Cost Envelope Estimate: An estimate prepared by the Distribution Provider and delivered to Applicant pursuant to the Cost Envelope Option that contains (i) the estimated cost of Distribution Provider's required Interconnection Facilities and/or Distribution Upgrades that are offered to Applicant that are subject to the Cost Envelope, and (ii) the estimated costs of related activities and facilities that are excluded from the Cost Envelope and offered on an actual cost basis, both pursuant to Section F.7.

Customer: The entity that receives or is entitled to receive Distribution Service through Distribution Provider's Distribution System or is a retail Customer of Distribution Provider connected to the Transmission System.

db_{HF} - A single-sided deadband value for high-frequency in Hz used in Section Hh.L.

db_{LF} - A single-sided deadband value for low-frequency in Hz used in Section Hh.L.

Dedicated Transformer; Dedicated Distribution Transformer: A transformer that provides electricity service to a single Customer. The Customer may or may not have a Generating Facility.

Delivery Network Upgrades: The transmission facilities at or beyond the point where Distribution Provider's Distribution System interconnects to the CAISO Controlled Grid, other than Reliability Network Upgrades, as defined in the CAISO Tariff.

Detailed Study: An Independent Study, a Distribution Group Study or a Transmission Cluster Study.

Detailed Study Agreement: The agreement entered into by the Interconnection Customer and Distribution Provider which sets forth the Parties' agreement to perform Interconnection Studies under the Independent Study Process or the Distribution Group Study Process.

Device: A mechanism or piece of equipment designed to serve a purpose or perform a function. The term may be used interchangeably with the terms "equipment" and function without intentional difference in meaning. See also

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C. DEFINITIONS (Cont'd.)

Interconnection Request: An Applicant's request to interconnect a new Generating Facility, or to increase the capacity of, or make a Material Modification to the operating characteristics of, an existing Generating Facility that is interconnected with Distribution Provider's Distribution or Transmission System.

Interconnection Study: A study to establish the requirements for Interconnection of a Generating Facility with Distribution Provider's Distribution System or Transmission System, pursuant to this Rule.

Interconnection System Impact Study: An engineering study conducted by Distribution Provider for an Interconnection Customer under the Independent Study Process that evaluates the impact of the proposed interconnection on the safety and reliability of Distribution Provider's Distribution and/or Transmission System and, if applicable, an Affected System. The scope of the study is defined in Section G.3.c.i.

Island; Islanding: A condition on Distribution Provider's Distribution System in which one or more Generating Facilities deliver power to Customers using a portion of Distribution Provider's Distribution System that is electrically isolated from the remainder of Distribution Provider's Distribution System.

k_{OF}: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop) for high frequency conditions, unitless used in Section Hh.2.I.

k_{UF}: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop) for low frequency divisions, unitless used in Section Hh.2.I.

Large Generating Facility: A Generating Facility having a Generating Facility Capacity of more than 20 MW.

Line Section: That portion of Distribution Provider's Distribution or Transmission System connected to a Customer bounded by automatic sectionalizing devices or the end of the distribution line.

Local Generating Facility Communication Interface: Interface at the Generating Facility capable of communicating to support the information exchange requirements specified in this rule and as required in IEEE 1547-2018 for all applicable functions that are in Section Hh.

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Sheet 31

C. DEFINITIONS (Cont'd.)

Parallel Operation: The simultaneous operation of a Generator with power delivered or received by Distribution Provider while Interconnected. For the purpose of this Rule, Parallel Operation includes only those Generating Facilities that are Interconnected with Distribution Provider's Distribution or Transmission System for more than 60 cycles (one second).

Paralleling Device: An electrical device, typically a circuit breaker, operating under the control of a synchronization relay or by a qualified operator to connect an energized generator to an energized electric power system or two energized power systems to each other.

Party, Parties: Applicant or Distribution Provider.

Periodic Test: A test performed on part or all of a Generating Facility/Interconnection Facilities at pre-determined time or operational intervals to achieve one or more of the following: 1) verify specific aspects of its performance; 2) calibrate instrumentation; and 3) verify and re-establish instrument or Protective Function set-points.

Permissive Operation: The Smart Inverter is allowed, but not required, to operate at any current level.

Point of Common Coupling (PCC): The transfer point for electricity between the electrical conductors of Distribution Provider and the electrical conductors of Producer.

Point of Distributed Energy Resources Connection (Point of Generating Resource Connection-PoC): The point where a generating resource unit is electrically connected in a generating facility and meets the requirements of this rule.

Point of Interconnection (POI): The point where the Interconnection Facilities connect with Distribution Provider's Distribution or Transmission System. This may or may not be coincident with the Point of Common Coupling.

Pre-Construction Activities: The actions by Distribution Provider, other than those required by an Engineering and Procurement Agreement under Section F.3.f, undertaken prior to Construction Activities in order to prepare for the construction of Distribution Provider's Interconnection Facilities, Distribution Upgrades, or Network Upgrades assigned to the Interconnection Customer, including, but not limited to, preliminary engineering, permitting activities, environmental analysis, or other activities specifically needed to obtain governmental approvals for Distribution Provider's Interconnection Facilities,

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C. DEFINITIONS (Cont'd.)

Producer: The entity that executes a Generator Interconnection Agreement with Distribution Provider. Producer may or may not own or operate the Generating Facility, but is responsible for the rights and obligations related to the Generator Interconnection Agreement.

Production Test: A test performed on each device coming off the production line to verify certain aspects of its performance.

Protective Function(s): The equipment, hardware and/or software in a Generating Facility (whether discrete or integrated with other functions) whose purpose is to protect against Unsafe Operating Conditions.

Prudent Electrical Practices: Those practices, methods, and equipment, as changed from time to time, that are commonly used in prudent electrical engineering and operations to design and operate electric equipment lawfully and with safety, dependability, efficiency, and economy.

Queue Position: See Section E.5.C.

Queued Capacity: Aggregate queued generation capacity (in MW) for a substation/area bus, bank or circuit (i.e., amount of generation in the queue).

Reference Point of Applicability (RPA): The location where the Generating Facility interconnection and interoperability performance requirements shall be met.

Reasonable Efforts: With respect to an action required to be attempted or taken by a Party under this Rule, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Reliability Network Upgrades: The transmission facilities at or beyond the point where Distribution Provider's Distribution System interconnects to the CAISO Controlled Grid, necessary to interconnect one or more Generating Facility(ies) safely and reliably to the CAISO Controlled Grid, as defined in the CAISO Tariff.

Section 218 Load: Electrical power that is supplied in compliance with California PUC section 218. PUC section 218 defines an "Electric Corporation" and provides conditions under which a transaction involving a Generating Facility would not classify a Producer as an Electric Corporation. These conditions relate to "over-the-fence" sale of electricity from a Generating Facility without using Distribution Provider's Distribution or Transmission System.

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- F. REVIEW PROCESS FOR INTERCONNECTION REQUESTS (Cont'd.)
 - 1. OVERVIEW OF THE INTERCONNECTION REVIEW PROCESS (Cont'd.)
 - b. Fast Track Review

Fast Track evaluation allows for rapid review of the Interconnection of those Generating Facilities that do not require Detailed Study. Regardless of study process, all Generating Facilities shall be designed to meet the applicable requirements of Section H or Hh which identifies Generating Facility Design and Operation Requirements.

Fast Track review consists of an Initial Review and, if required, a Supplemental Review. The need for Supplemental Review will be determined based on the results of Initial Review Screens A through M in Section G.1. Applicants that successfully pass Initial Review Screens A through M will be allowed to interconnect without Supplemental Review.

Non-Export AC/DC Converter installations that have a complete and valid Interconnection Request will be eligible to bypass screens B through D and F through M.

If Supplemental Review is required, Distribution Provider will notify Applicant and Applicant must pay a nonrefundable Supplemental Review fee, per Table E-1 or withdraw its Interconnection Request. Supplemental Review shall consist of the application of Screens N through P in Section G.2. Applicants that pass Screens N through P will be allowed to interconnect without additional review.

If Supplemental Review reveals that a proposed Generating Facility cannot be interconnected to Distribution Provider's Distribution System by means of Fast Track evaluation, Distribution Provider will notify Applicant that Detailed Study will be required.

Failure to pass Fast Track evaluation means only that further review and/or study are required before the Generating Facility can be interconnected with Distribution Provider's Distribution System. It does not mean that the Generating Facility cannot be interconnected.

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Sheet 151

G. ENGINEERING REVIEW DETAILS (Cont'd.)

1. INITIAL REVIEW SCREENS (Cont'd.)

i. Screen I: Will power be exported across the PCC? (Cont'd.)

Option 4 (Relative Generating Facility Rating): This option, when used, requires the Net Rating of the Generating Facility to be so small in comparison to its host facility's minimum load, that the use of additional Protective Functions is not required to ensure that power will not be exported to Distribution Provider's Distribution or Transmission System. This option requires the Generating Facility capacity to be no greater than 50% of Producer's verifiable minimum Host Load over the past 12 months.

Option 5: Inadvertent Export as described in Section M.

Option 6: Inadvertent Export utilizing UL-1741 or UL-1741 SA/SB listed grid support (Non-Islanding) inverters as described in Section Mm.

Significance:

1. If it can be assured that the Generating Facility will not export power, Distribution Provider's Distribution or Transmission System does not need to be studied for load-carrying capability or Generating Facility power flow effects on Distribution Provider voltage regulators.
2. This Screen permits the use of reverse-power or minimum-power relaying as a Non-Islanding Protective Function (Option 1, 2, and 3).
3. This Screen allows, under certain defined conditions, for Generating Facilities that incorporate Certified Non-Islanding protection to qualify for interconnection through the Fast Track process without implementing reverse power or minimum power Protective Functions (Option 3).

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Sheet 156

G. ENGINEERING REVIEW DETAILS (Cont'd.)

2. SUPPLEMENTAL REVIEW SCREENS (Cont'd.)

a. Screen N: Penetration Test (Cont'd.)

Note 4: Distribution Provider will not consider as part of the aggregate Generating Facility capacity for purposes of this screen Generating Facility capacity known to be already reflected in the minimum load data.

Note 5: NEM Generating Facilities with net export less than or equal to 500 kW that may flow across the Point of Common Coupling into Distribution Provider's Distribution or Transmission System will not be studied in the Transmission Cluster Study Process, but may be studied under the Independent Study Process.

Significance: Penetration of Generating Facility capacity that does not result in power flow from the circuit back toward the substation will have a minimal impact on equipment loading, operation, and protection of the Distribution System.

b. Screen O: Power Quality and Voltage Tests

In aggregate with existing Generating Facility capacity on the Line Section, distribution circuit, and/or substation.

- i) Can it be determined within the Supplemental Review that the voltage regulation on the line section can be maintained in compliance with Commission Rule 2 and/or Conservation Voltage Regulation voltage requirements under all system conditions?
- ii) Can it be determined within the Supplemental Review that the voltage fluctuation is within acceptable limits as defined by IEEE ~~1453-1547-2018~~ 7.2 or utility practice similar to IEEE 1547-2018 7.21453?

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Sheet 157

G. ENGINEERING REVIEW DETAILS (Cont'd.)

2. SUPPLEMENTAL REVIEW SCREENS (Cont'd.)

b. Screen O: Power Quality and Voltage Tests (Cont'd.)

In aggregate with existing Generating Facility capacity on the Line Section, distribution circuit, and/or substation. (Cont'd.)

iii) Can it be determined within the Supplemental Review that the harmonic levels meet IEEE 519-1547-2018 7.3 limits at the Point of Common Coupling (PCC)?

- If yes to all of the above (pass), continue to Screen P.
- If no to any of the above (fail), a quick review of the failure may determine the requirements to address the failure; otherwise Electrical Independence Tests and Detailed Studies are required. Continue to Screen P. (Note: If Electrical Independence tests and Detailed Studies are required, Applicants will continue to the Electrical Independence Tests and Detailed Studies after review of the remaining Supplemental Review Screens.)

Significance: Adverse voltages and undesirable interference may be experienced by other Customers on Distribution Provider's Distribution System caused by operation of the Generating Facility(ies).

c. Screen P: Safety and Reliability Tests

Does the location of the proposed Generating Facility or the aggregate generation capacity on the Line Section create impacts to safety or reliability that cannot be adequately addressed without Detailed Study?

- If yes (fail), review of the failure may determine the requirements to address the failure; otherwise Electrical Independence Tests and Detailed Studies are required. Continue to Section G.3.
- If no (pass), Supplemental Review is complete.

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G. ENGINEERING REVIEW DETAILS (Cont'd.)

3. DETAILED STUDY SCREENS (Cont'd.)

c. Independent Study Process and Distribution Group Study Process Interconnection Studies (Cont'd.)

ii) Interconnection Facilities Study and DGS Phase II Interconnection Study. (Cont'd.)

(1) Scope and Purpose of the Interconnection Facilities and DGS Phase II Interconnection Study. (Cont'd.)

Good Utility Practice to physically and electrically connect the Generating Facility to the Distribution or Transmission System. The Interconnection Facilities Study or DGS Phase II Interconnection Study shall also identify (i) the electrical switching configuration of the connection equipment, including, without limitation: the transformer, switchgear, meters, and other station equipment; the nature and estimated cost of any Distribution Provider's Interconnection Facilities, Distribution Upgrades, and Network Upgrades necessary to accomplish the interconnection; and an estimate of the time required to complete the construction and installation of such facilities. The analyses in the Interconnection System Impact Study (or DGS Phase I Interconnection Study in the case of the Distribution Group Study Process) will be updated as necessary in the Interconnection Facilities Study (or DGS Phase II Interconnection Study), to account for withdrawal of interconnection requests in the interconnection queue.

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS

Section H shall be used for interconnection of non-inverter based technologies.

~~Section H shall also continue to be used for interconnection of inverter based technologies until September 8, 2017. Following such date, Section Hh shall apply for interconnection of inverter based technologies. Until such date, Section Hh may be used in all or in part, for inverter based technologies by mutual agreement of the Distribution Provider and the Applicant.~~

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Sheet 166

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS

This section is consistent with the requirements of ~~ANSI/IEEE 1547-2003 2018 Standard for Interconnecting Distributed Resources with Electric Power Systems (IEEE 1547). Exceptions are taken to IEEE 1547 Clauses 4.1.4.2 Distribution Secondary Spot Networks and Clauses 4.1.8.1 or 5.1.3.1, which address Protection from Electromagnetic Interference. These are being studied for inclusion in a subsequent version of this Rule. Also, Rule 21 does not adopt the Generating Facility power limitation of 10 MW incorporated in IEEE 1547. In the event of conflict, this Rule shall take precedent.~~

The Protective Functions and requirements of this Rule are designed to protect Distribution Provider's Distribution and Transmission System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for its Generating Facility and Interconnection Facilities. Producer's Protective Functions shall not impact the operation of other Protective Functions on Distribution Provider's Distribution and Transmission System in a manner that would affect Distribution Provider's capability of providing reliable service to its customers.

a. Protective Functions Required

Generating Facilities operating in parallel with Distribution Provider's Distribution or Transmission System shall be equipped with the following Protective Functions to sense abnormal conditions on Distribution Provider's Distribution or Transmission System and cause the Generating Facility to be automatically disconnected from Distribution Provider's Distribution or Transmission System or to prevent the Generating Facility from being connected to Distribution Provider's Distribution or Transmission System inappropriately:

- i) Over and under voltage trip functions and over and under frequency trip functions;
- ii) A voltage and frequency sensing and time-delay function to prevent the Generating Facility from energizing a de-energized Distribution or Transmission System circuit and to prevent the Generating Facility from reconnecting with Distribution Provider's

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Sheet 167

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

a. Protective Functions Required (Cont'd.)

- ii) Distribution or Transmission System unless Distribution Provider's Distribution System service voltage and frequency is within the ANSI C84.1-1995 Table 1 Range B voltage Range of 106 volts to 127 volts (on a 120 volt basis), inclusive, and a frequency range of 59.3 Hz to 60.5 Hz, inclusive, and are stable for at least 60 seconds; ~~and~~
- iii) A function to prevent the Generating Facility from contributing to the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution System within two seconds of the formation of an Unintended Island; ~~and-~~

(iv) Open Phase Condition: Generating Facility shall detect and cease to energize and trip all phases within 2 seconds of any open phase condition in accordance with IEEE 1547-2018 6.2.2.

The Generating Facility shall cease to energize Distribution Provider's Distribution System for faults on Distribution Provider's Distribution System circuit to which it is connected (IEEE 1547-~~2018 6.2.14.2.1~~). The Generating Facility shall cease to energize Distribution Provider's Distribution circuit prior to re-closure by Distribution Provider's Distribution System equipment (IEEE 1547-~~2018 6.34.2.2~~).

b. Momentary Paralleling Generating Facilities

With Distribution Provider's approval, the transfer switch or scheme used to transfer Producer's loads from Distribution Provider's Distribution or Transmission System to Producer's Generating Facility may be used in lieu of the Protective Functions required for Parallel Operation.

Generating facilities which operate using a momentary parallel scheme are not required to comply with the functional requirements as required in the IEEE 1547-2018 standard.

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Sheet 168

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

c. Suitable Equipment Required ~~(Cont'd.)~~

interrupting the maximum available fault current expected at their location. Producer's Generating Facility and Interconnection Facilities shall be designed so that the failure of any single device or component shall not potentially compromise the safety and reliability of Distribution Provider's Distribution and Transmission System. The Generating Facility paralleling-device shall be capable of withstanding 220% of the Interconnection Facility rated voltage (IEEE 1547-~~2018~~ 4.114.1.8.3). The Interconnection Facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std C62.41.2-2002 or IEEE Std C37.90.1-2002 as applicable and as described in L.3.e (IEEE 1547-~~2018~~ 4.114.1.8.2).

d. Visible Disconnect Required

When required by Distribution Provider's operating practices, Producer shall furnish and install a ganged, manually-operated isolating switch (or a comparable device mutually agreed upon by Distribution Provider and Producer) near the Point of Interconnection to isolate the Generating Facility from Distribution Provider's Distribution or Transmission System. The device does not have to be rated for load break nor provide over-current protection.

The device must:

- i) allow visible verification that separation has been accomplished. (This requirement may be met by opening the enclosure to observe contact separation.)
- ii) include markings or signage that clearly indicates open and closed positions.
- iii) be capable of being reached:
 - a) for Emergency purposes quickly and conveniently 24 hours a day by Distribution Provider personnel for construction,

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H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

d. Visible Disconnect Required (Cont'd.)

iii) be capable of being reached: ~~(Cont'd.)~~

a) operation, maintenance, inspection, testing or to isolate the Generating Facility from Distribution Provider's Distribution or Transmission System without obstacles or requiring those seeking access to obtain keys, special permission, or security clearances.

b) for Non-Emergency purposes during normal business hours. Distribution Provider, where possible, will provide notice to Customer for gaining access to Customer's premises.

iv) be capable of being locked in the open position,

v) be clearly marked on the submitted single line diagram and its type and location approved by Distribution Provider prior to installation. If the device is not adjacent to the PCC, permanent signage must be installed at a Distribution Provider approved location providing a clear description of the location of the device. If the switch is not accessible outside the locked premises, signage with contact information and a Distribution Provider approved locking device for the premises shall be installed.

Generating Facilities with Non-Islanding inverters totaling one (1) kilovolt-ampere (kVA) or less are exempt from this requirement.

e. Drawings Required

Prior to Parallel Operation or Momentary Parallel Operation of the Generating Facility, Distribution Provider shall approve Producer's Protective Function and control diagrams. Generating Facilities equipped with Protective Functions and a control scheme previously approved by Distribution Provider for system-wide application or only Certified Equipment may satisfy this requirement by reference to previously approved drawings and diagrams.

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H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION
REQUIREMENTS (Cont'd.)

f. Generating Facility Conditions Not Identified

In the event this Rule does not address the Interconnection conditions for a particular Generating Facility, Distribution Provider and Producer may agree upon other arrangements

2. PREVENTION OF INTERFERENCE

Producer shall not operate Generating or Interconnection Facilities that superimpose a voltage or current upon Distribution Provider's Distribution or Transmission System that interferes with Distribution Provider operations, service to Distribution Provider Customers, or communication facilities. If such interference occurs, Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by Distribution Provider. If Producer does not take corrective action in a timely manner, or continues to operate the facilities causing interference without restriction or limit, Distribution Provider may, without liability, disconnect Producer's facilities from Distribution Provider's Distribution or Transmission System, in accordance with Section D.9 of this Rule. To eliminate undesirable interference caused by its operation, each Generating Facility shall meet the following criteria:

Note: Except as otherwise stated, the RPA for all performance requirements shall be met at the PCC.

When Generating facility is less than 500KVA or when generating facility operates under one of the non-exporting options or inadvertent export of no longer than 30 seconds, the RPA may be the Generating Facility Connection Point (PoC).

a. Voltage Regulation

The Generating Facility shall not actively regulate the voltage at the PCC while in parallel with Distribution Provider's Distribution System. The Generating Facility shall not cause the service voltage at other customers to go outside the requirements of ANSI C84.1-1995, Range A ~~(IEEE 1547-4.1.1)~~.

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GENERATING FACILITY INTERCONNECTIONS

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H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

c. Paralleling

The Generating Facility shall parallel with Distribution Provider's Distribution or Transmission System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of Distribution Provider's Distribution or Transmission System at the PCC, and meet the flicker requirements of Section H.2.d. Section L, Certification and Testing Criteria, provides technology-specific tests for evaluating the paralleling Function. (IEEE 1547-~~2018 4.10.44.1.3~~)

d. Flicker

The Generating Facility shall not create objectionable flicker for other customers on Distribution Provider's Distribution or Transmission System. To minimize the adverse voltage effects experienced by other customers (~~IEEE 1547 4.3.22018 7.2.3~~), flicker at the PCC caused by the Generating Facility should not exceed the limits ~~defined by the "Maximum Borderline of Irritation Curve" identified in IEEE 519-1992 (IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, IEEE STD 519-1992).~~ of IEEE 1547-2018 7.2.3. This requirement is necessary to minimize the adverse voltage affects experienced by other Customers on Distribution Provider's Distribution or Transmission System. Generators may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

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GENERATING FACILITY INTERCONNECTIONS

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H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

g. Harmonics

When the Generating Facility is serving balanced linear loads, harmonic current injection into Distribution Provider's Distribution or Transmission System at the PCC shall not exceed the limits stated in ~~Table H.3~~ **IEEE 1547-2018 7.3**. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in Distribution Provider's Distribution or Transmission System without the Generating Facility connected (~~IEEE 1547-4.3.3.~~). The harmonic distortion of a Generating Facility shall be evaluated using the same criteria as for the Host Loads.

Table H.3

Maximum harmonic current distortion in percent of current (I) [1,2]

Individual harmonic order, h (odd harmonics) [3]	h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h	Total demand distortion (%)
Max-Distortion	4.0	2.0	1.5	0.6	0.3	5.0

[1] – IEEE 1547-4.3.3 2018 7.3

[2] – I = the greater of the maximum Host Load current average demand over 15 or 30 minutes without the GF, or the GF rated current capacity (transformed to the PCC when a transformer exists between the GF and the PCC).

[3] – Even harmonics are limited to 25% of the odd harmonic limits above.

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GENERATING FACILITY INTERCONNECTIONS

Sheet 178

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

h. Direct Current Injection

Generating Facilities should not inject direct current greater than 0.5% of rated output current into Distribution Provider's Distribution or Transmission System.

i. Power Factor

Producer shall provide adequate reactive power compensation on site to maintain the Generating Facility power factor near unity at rated output or a Distribution Provider specified power factor within a power factor range from 0.9 leading to 0.9 lagging, based on local system conditions. While not required, for generators that do not have inherent reactive power control capability Distribution Provider at its option may offer reactive power support in the form of power factor correction capacitors on its Distribution or Transmission System, under a Generator Interconnection Agreement or an Added Facilities or Special Facilities agreement, as described in Rule 2.H, as applicable.

j. Generating Facility Rapid Voltage Changes (RVC)

Generating step or ramp changes shall meet the requirements as specified in IEEE 1547-2018 7.2.2.

k. Limitations of overvoltage over one fundamental frequency period

Generating Facility shall not contribute to instantaneous or fundamental frequency overvoltage conditions per IEEE 1547-2018 7.4.1.

l. Limitation of cumulative instantaneous overvoltage

Generating Facility shall not cause the instantaneous voltage on any portion of the Distribution or Transmission system to exceed the magnitudes per IEEE 1547-2018 7.4.2.

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Sheet 179

H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

3. TECHNOLOGY SPECIFIC REQUIREMENTS

a. Technology Specific Requirements

Three-Phase Synchronous Generators: For three phase Generators, the Generating Facility circuit breakers shall be three-phase devices with electronic or electromechanical control. Producer shall be responsible for properly synchronizing its Generating Facility with Distribution Provider's Distribution or Transmission System by means of either manual or automatic synchronous equipment. Automatic synchronizing is required for all synchronous Generators that have a Short Circuit Contribution Ratio (SCCR) exceeding 0.05. Loss of synchronism protection is not required except as may be necessary to meet Section H.2.d (Flicker) (IEEE 1547-4.2.52018 7.3). Unless otherwise agreed upon by Producer and Distribution Provider, synchronous Generators shall automatically regulate power factor, not voltage, while operating in parallel with Distribution Provider's Distribution System. A power system stabilization Function is specifically not required for Generating Facilities under 10 MW Net Rating.

b. Induction Generators

Induction Generators (except self-excited Induction Generators) do not require a synchronizing Function. Starting or rapid load fluctuations on induction Generators can adversely impact Distribution Provider's Distribution or Transmission System voltage. Corrective step-switched capacitors or other techniques may be necessary and may cause undesirable ferro-resonance. When these counter measures (e.g. additional capacitors) are installed on Producer's side of the PCC, Distribution Provider must review these measures. Additional equipment may be required as determined in a Supplemental Review or an Interconnection Study.

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H. GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS
(Cont'd.)

4. SUPPLEMENTAL GENERATING FACILITY REQUIREMENTS (Cont'd.)

b. Transfer Trip

For a Generating Facility that cannot detect Distribution or Transmission System faults (both line-to-line and line-to-ground) or the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution or Transmission System within two seconds, Distribution Provider may require a Transfer Trip system or an equivalent Protective Function.

c. Reclose Blocking

Where the aggregate Generating Facility capacity exceeds 15% of the peak load on any automatic reclosing device, Distribution Provider may require additional Protective Functions, including, but not limited to reclose-blocking on some of the automatic reclosing devices.

~~Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS~~

~~Section H shall continue to be used for interconnection of inverter based technologies until September 8, 2017. Following such date, Section Hh shall apply for interconnection of inverter based technologies. Until such date, Section Hh may be used in all or in part, for inverter based technologies by mutual agreement of the Distribution Provider and the Applicant.~~

~~⁴ "The Standard for Inverters, Converters, and Controllers for Use in Independent Power Systems".~~

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS ~~(Cont'd.)~~

The inverter requirements are intended to be consistent with UL 1741 and IEEE 1547-2018 – Supplement SA using Section Hh of Rule 21 as the source requirement document and ANSI/IEEE 1547-2003 and 1547a Standard for Interconnecting Distributed Resources with Electric Power Systems (IEEE 1547 including amendment 1547a), where possible. In the event of conflict between this Rule, and UL 1741 – Supplement SA, and/or IEEE 1547-2003 or IEEE 1547a, this Rule shall take precedence. ~~Exceptions are taken to IEEE 1547 Clauses 4.1.4.2 Distribution Secondary Spot Networks and Clauses 4.1.8.1 or 5.1.3.1, which address Protection from Electromagnetic Interference. Rule 21 does not adopt the Generating Facility power limitation of 10 MW incorporated in IEEE 1547.~~

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS

The Protective Functions and requirements of this Rule are designed to protect Distribution Provider’s Distribution and Transmission System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for its Generating Facility and Interconnection Facilities. Producer’s Protective Functions shall not impact the operation of other Protective Functions on Distribution Provider’s Distribution and Transmission System in a manner that would affect Distribution Provider’s capability of providing reliable service to its customers.

a. Protective Functions Required

Smart Inverters operating in parallel with Distribution Provider’s Distribution or Transmission System shall be equipped with the following Protective Functions to sense abnormal conditions on Distribution Provider’s Distribution or Transmission System and cause the Smart Inverter to be automatically disconnected from Distribution Provider’s Distribution or Transmission System or to prevent the Smart Inverter from being connected to Distribution Provider’s Distribution or Transmission System inappropriately:

- (i) Over and under voltage trip functions and over and under frequency trip functions;

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

a. Protective Functions Required (Cont'd.)

- (ii) A voltage and frequency sensing and time-delay function to prevent the Smart Inverter from energizing a de-energized Distribution or Transmission System circuit and to prevent the Smart Inverter from reconnecting with Distribution Provider's Distribution or Transmission System unless Distribution Provider's Distribution System service voltage and frequency is within the ANSI C84.1-1995 Table 1 Range B voltage Range of 106 volts to 127 volts (on a 120 volt basis), inclusive, and a frequency range of ~~58-559.0~~ Hz to 60.5 Hz, inclusive, and are stable for at least 15 seconds; and
- (iii) A function to prevent the Smart Inverter from contributing to the formation of an Unintended Island, and cease to energize Distribution Provider's Distribution System within two seconds of the formation of an Unintended Island.

The Smart Inverter shall cease to energize Distribution Provider's Distribution System for faults on Distribution Provider's Distribution System circuit to which it is connected (IEEE 1547-2018 6.2.1). The Smart Inverter shall cease to energize Distribution Provider's Distribution circuit prior to re-closure by Distribution Provider's Distribution System equipment (IEEE 1547-2018 6.3).

(iv) Open Phase Condition: Smart Inverter Generating Facility shall detect and cease to energize and trip all phases within 2 seconds of any open phase condition in accordance with (IEEE 1547-2018 6.2.2.)

~~The Smart Inverter shall cease to energize Distribution Provider's Distribution System for faults on Distribution Provider's Distribution System circuit to which it is connected (IEEE 1547-4.2.1). The Smart Inverter shall cease to energize Distribution Provider's Distribution circuit prior to re-closure by Distribution Provider's Distribution System equipment (IEEE 1547-4.2.2).~~

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

c. Suitable Equipment Required

Circuit breakers or other interrupting equipment located at the Point of Common Coupling (PCC) must be Certified or "Listed" (as defined in Article 100, the Definitions Section of the National Electrical Code) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location. Producer's Smart Inverter and Interconnection Facilities shall be designed so that the failure of any single device or component shall not potentially compromise the safety and reliability of Distribution Provider's Distribution and Transmission System. The Smart Inverter paralleling-device shall be capable of withstanding 220% of the Interconnection Facility rated voltage (IEEE 1547-4.1.8-32018 4.11.3). The Interconnection Facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std C62.41.2-2002 or IEEE Std C37.90.1-2002 as applicable and as described in L.3.e (IEEE 1547-4.1.8-22018 4.11.2).

d. Visible Disconnect Required

When required by Distribution Provider's operating practices, Producer shall furnish and install a ganged, manually-operated isolating switch (or a comparable device mutually agreed upon by Distribution Provider and Producer) near the Point of Interconnection to isolate the Smart Inverter from Distribution Provider's Distribution or Transmission System. The device does not have to be rated for load break nor provide over-current protection.

The device must:

- (i) allow visible verification that separation has been accomplished. (This requirement may be met by opening the enclosure to observe contact separation.)

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

1. GENERAL INTERCONNECTION AND PROTECTIVE FUNCTION REQUIREMENTS (Cont'd.)

e. Drawings Required

Prior to Parallel Operation or Momentary Parallel Operation of the Smart Inverter, Distribution Provider shall approve Producer's Protective Function and control diagrams. Generating Facilities equipped with Protective Functions and a control scheme previously approved by Distribution Provider for system-wide application or only Certified Equipment may satisfy this requirement by reference to previously approved drawings and diagrams.

f. Generating Facility Conditions Not Identified

In the event this Rule does not address the Interconnection conditions for a particular Smart Inverter, Distribution Provider and Producer may agree upon other arrangements.

2. PREVENTION OF INTERFERENCE

Producer shall not operate Smart Inverters that superimpose a voltage or current upon Distribution Provider's Distribution or Transmission System that interferes with Distribution Provider operations, service to Distribution Provider Customers, or communication facilities. If such interference occurs, Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by Distribution Provider. If Producer does not take corrective action in a timely manner, or continues to operate the facilities causing interference without restriction or limit, Distribution Provider may, without liability, disconnect Producer's facilities from Distribution Provider's Distribution or Transmission System, in accordance with Section D.9 of this Rule. To eliminate undesirable interference caused by its operation, each Smart Inverter shall meet the following criteria:

Note: Except as otherwise stated, the RPA for all performance requirements shall be met at the PCC.

When Generating facility is less than 500KVA or when generating facility operates under one of the non-exporting options or inadvertent export of no longer than 30 seconds, the RPA may be the Generating Facility Connection Point (PoC).

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Sheet 187

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

a. Voltage Regulation

If approved by the Distribution Provider, the Smart Inverter may actively regulate the voltage at the PCC while in parallel with Distribution Provider's Distribution System. The Smart Inverter shall not cause the service voltage at other customers to go outside the requirements of ANSI C84.1-1995, Range A ~~(IEEE 1547-4.1.1)~~.

b. Voltage Trip and Ride-Through Settings

The voltage ranges in Table Hh-.1a define protective trip limits for the Protective Function and are not intended to define or imply a voltage regulation Function. Generating Facilities shall cease to energize Distribution Provider's Distribution System within the prescribed trip time whenever the voltage at the PCC deviates from the allowable voltage operating range. The Protection Function shall detect and respond to voltage on all phases to which the Generating Facility is connected.

(i) Smart Inverters

Smart Inverters shall be capable of operating within the voltage range normally experienced on Distribution Provider's Distribution System from plus to minus 5% of the nominal voltage (e.g. 114 volts to 126 volts, on a 120 volt base), at the service panel or PCC. The trip settings at the generator terminals may be selected in a manner that minimizes nuisance tripping in accordance with Table Hh-.1b to compensate for voltage drop between the generator terminals and the PCC. Voltage may be detected at either the PCC or the Point of Interconnection. However, the voltage range at the PCC, with the generator on-line, shall stay within +/-5% of nominal.

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

b. Voltage Trip and Ride-Through Settings (Cont'd.)

(ii) Voltage Disturbances

Whenever Distribution Provider's Distribution System voltage at the ~~PCC-RPA~~ varies from and remains ~~outside near Nominal voltage~~ the continuous operating region for the predetermined parameters set forth in Table Hh-.1b, the Smart Inverter's Protective Functions shall cause the Smart Inverter(s) to trip and become isolated from Distribution Provider's Distribution System as required in Table Hh-1a:

1. The Smart Inverter shall stay connected to the Distribution Provider's Transmission or Distribution System while the grid remains within the "Voltage Range (p.u)" ~~Ride-Through Until voltage-time range~~ and must stay connected in the corresponding "Operating Mode."
2. ~~For voltage excursions beyond the near Nominal (NN) magnitude range and within the range of the HV1 or LV3 regions, the Smart Inverter shall momentarily cease to energize within 0.16 seconds.~~
3. ~~In the HV1 region, the Smart Inverter is permitted to reduce power output as a function of voltage under mutual agreement between the Producer and the Distribution Provider.~~
4. If the distribution system voltage does not exit the ride-through region and recovers to normal system voltage, the Smart Inverter shall restore continuous operation within 2 seconds.
5. ~~If the Distribution Provider's Transmission or Distribution System voltage does not exit the ride through region and returns from the LV3 region to the LV2 or LV1 region, the Smart Inverter shall restore available current within 2 seconds.~~
3. If the Distribution Provider's Transmission or Distribution System voltage does not exit the ride-through region and returns from the $V < 0.5$ pu region to the $0.5 \leq V < 0.7$ or $0.7 \leq V < 0.88$ pu region, the Smart Inverter shall restore available

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

b. Voltage Trip and Ride-Through Settings (Cont'd.)

(ii) Voltage Disturbances (Cont'd.)

Table Hh.1a: Voltage ~~Ride-Through~~Trip Table

Shall Trip Function	Voltage Trip Default Settings (p.u. of nominal voltage)	Voltage Range of Shall Trip Function (p.u. of nominal voltage)	Default Clearing Time (s)
OV2	1.20	$V \geq 1.20$	0.16
OV1	1.10	$1.10 \leq V < 1.20$	13.0
Continuous Operation	NA	$0.88 < V < 1.10$	NA
UV1	0.88	$0.50 < V \leq 0.88$	21.0
UV2	0.50	$V \leq 0.50$	2.0

Table Hh-1b – Smart Inverter Voltage ride-through settings

Voltage Range (p.u.)	Operating mode/response	Minimum ride-through time (s)	Maximum response time (s)
$V > 1.20$	Cease to Energize	NA	0.16
$1.10 < V \leq 1.20$	Momentary Cessation	12	0.083
$0.88 \leq V \leq 1.10$	Continuous Operation	Infinite	NA
$0.70 \leq V < 0.88$	Mandatory Operation	20	NA
$0.50 \leq V < 0.70$	Mandatory Operation	10	NA
$V < 0.50$	Momentary Cessation	1	0.083

Region	Voltage at Point of Common Coupling (% Nominal Voltage)	Ride-Through Until	Operating Mode	Maximum Trip Time
High Voltage-2 (HV2)	$V \geq 120$			0.16 seconds

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High Voltage-1 (HV1)	$110 < V < 120$	12 seconds	Momentary Cessation	13 seconds
Near Nominal (NN)	$88 \leq V \leq 110$	Indefinite	Continuous Operation	Not Applicable
Low Voltage-1 (LV1)	$70 \leq V < 88$	20 seconds	Mandatory Operation	21 seconds
Low Voltage-2 (LV2)	$50 \leq V < 70$	10 seconds	Mandatory Operation	11 seconds
Low Voltage-3 (LV3)	$V < 50$	1 seconds	Momentary Cessation	1.5 seconds

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

c. Paralleling

The Generating Facility shall parallel with Distribution Provider's Distribution or Transmission System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of Distribution Provider's Distribution or Transmission System at the PCC, and meet the flicker requirements of Section H.2.d. Section L, Certification and Testing Criteria, provides technology-specific tests for evaluating the paralleling Function. (IEEE 1547-~~4.1.3~~2018 4.10)

d. Flicker

The Generating Facility shall not create objectionable flicker for other customers on Distribution Provider's Distribution or Transmission System. To minimize the adverse voltage effects experienced by other customers (~~IEEE 1547-4.3.27.2.3~~), flicker at the PCC caused by the Generating Facility should not exceed the limits ~~defined by the "Maximum Borderline of Irritation Curve" identified in IEEE 519-1992 (IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, IEEE STD 519-1992).~~ of IEEE 1547--2018 7.2.3. This requirement is necessary to minimize the adverse voltage affects experienced by other Customers on Distribution Provider's Distribution or Transmission System. Generators may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

e. Integration with Distribution Provider's Distribution System Grounding

The grounding scheme of the Generating Facility shall not cause over-voltages that exceed the rating of the equipment connected to Distribution Provider's Distribution System and shall not disrupt the coordination of the ground fault protection on Distribution Provider's Distribution System (IEEE 1547-2018 4.12 4.1.2) (See Section G.1.i, line configuration).

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Sheet 191

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

f. Frequency

Distribution Provider controls system frequency, and the Generating Facility shall operate in synchronism with Distribution Provider's Distribution or Transmission System. Whenever Distribution Provider's Distribution or Transmission System frequency at the PCC varies from and remains outside normal (nominally 60 Hz) by the predetermined amounts set forth in Table H.2a, the Generating Facility's Protective Functions shall cease to energize Distribution Provider's Distribution or Transmission System within the stated maximum trip time.

(i) Frequency Ride-Through Requirements

Smart Inverter based systems shall remain connected to the Distribution Provider's Distribution or Transmission System while the grid is within the frequency-time range indicated in Table Hh-.2, and shall disconnect from the electric grid during a high or low frequency event that is outside that frequency-time range.

The frequency values are shown in Table Hh.2b. These values provide default interconnection system response to abnormal frequencies. The inverter shall disconnect by the default clearing times. In the high frequency range between 60.2 Hz and 61.5 Hz, or some other mutually agreed range, the Smart Inverter is permitted to reduce real power output until it ceases to export power by 61.5 Hz, or other frequency value mutually agreed between the generating facility operator and the Distribution Provider. Islands and microgrids may need different default frequency settings.

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Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

f. Frequency (Cont'd.)

(i) Frequency Ride-Through Requirements(Cont'd.)

Table Hh.2a: Frequency ~~Ride-Through and~~ Trip Settings Table

<u>Shall Trip Function</u>	<u>Frequency Trip Default Setting (Hz)</u>	<u>Resulting Range of Shall Trip Function (Hz)</u>	<u>Default Clearing Time (s)</u>
<u>OF1</u>	<u>62.0</u>	<u>$f \geq 62.0$</u>	<u>0.16</u>
<u>OF2</u>	<u>61.2</u>	<u>$61.2 \leq f < 62$</u>	<u>300</u>
<u>Continuous Operation</u>	<u>NA</u>	<u>$58.5 < f < 61.2$</u>	<u>NA</u>
<u>UF1</u>	<u>58.5</u>	<u>$56.5 < f \leq 58.5$</u>	<u>300</u>
<u>UF2</u>	<u>56.5</u>	<u>$f \leq 56.5$</u>	<u>0.16</u>

Table Hh.2b: Frequency Ride-Through Settings Table

<u>Frequency (Hz)</u>	<u>Operating Mode</u>	<u>Default Clearing Time</u>
<u>$f > 62.0$</u>	<u>No Ride-Through requirements apply to this range</u>	<u>NA</u>
<u>$61.2 < f \leq 61.8$</u>	<u>Mandatory Operation</u>	<u>299</u>
<u>$58.8 \leq f \leq 61.2$</u>	<u>Continuous Operation</u>	<u>Infinite</u>
<u>$57.0 \leq f < 58.8$</u>	<u>Mandatory Operation</u>	<u>299</u>
<u>$F < 57.0$</u>	<u>No Ride-Through requirements apply to this range</u>	<u>NA</u>

System Frequency Default Settings (Hz)	Minimum Range of Adjustability (Hz)	Ride-Through Until	Ride-Through Operational Mode	Maximum Trip Time
$f > 62$	62–64	No Ride Through	Not Applicable	0.16 seconds
$60.5 < f \leq 62$	60.1–62	299 seconds	Mandatory	300 seconds

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 192

			Operation	
$58.5 \leq f \leq 60.5$	Not Applicable	Indefinite	Continuous Operation	Not Applicable
$57.0 \leq f < 58.5$	57-59.9	299-seconds	Mandatory Operation	300-seconds
$f < 57.0$	53-57	No-Ride Through	Not Applicable	0.16-seconds

ii) Rate of change of frequency (ROCOF) ride-through

Smart Inverter shall not trip for frequency excursion have a rate of change of frequency (ROCOF) magnitude that is less than or equal to 3.0Hz per second as specified in IEEE 1547-2018 6.5.2.5 category III. For ROCOF greater than 3Hz per second, it is preferred for Smart Inverter to ride-through as long as frequency remains in the continuous operating region, low frequency ride-through region (and corresponding duration times), or high frequency region (and corresponding duration times).

iii) Voltage phase angle change ride-through

Voltage phase angle change ride-through as specified in IEEE 1547-2018 6.5.2.6.

g. Harmonics

When the Smart Inverter is serving balanced linear loads, harmonic current injection into Distribution Provider's Distribution or Transmission System at the PCC shall not exceed the limits stated in ~~Table Hh-43~~ IEEE 1547-2018 7.3. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in Distribution Provider's Distribution or Transmission System without the Smart Inverter connected (~~IEEE 1547-2018 4.3.37.3~~). The harmonic distortion of a Smart Inverter shall be evaluated using the same criteria as for the Host Loads.

(Continued)



**ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS**

Sheet 193

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

g. Harmonics ~~(Cont'd.)~~

Table Hh.3

Maximum harmonic current distortion in percent of current (I) [1,2]

Individual harmonic order, h (odd harmonics) [3]	h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h	Total demand distortion
Max-Distortion (%)	4.0	2.0	1.5	0.6	0.3	5.0

[1] – IEEE 1547-4.3.32018 7.3

[2] – I = the greater of the maximum Host Load current average demand over 15 or 30 minutes without the GF, or the GF rated current capacity (transformed to the PCC when a transformer exists between the GF and the PCC).

[3] – Even harmonics are limited to 25% of the odd harmonic limits above.

h. Direct Current Injection

Smart Inverter should not inject direct current greater than 0.5% of rated output current into Distribution Provider's Distribution or Transmission System.

~~i. Smart Inverter Reactive Power Requirements Fixed Power Factor~~

~~Smart Inverter Reactive Power capabilities shall comply with IEEE 1547-2018 5.2 Category B requirement.~~

~~Producer shall provide adequate reactive power compensation on site to maintain the Smart Inverter power factor near unity at rated output or a Distribution Provider specified power factor in accordance with the following requirements:~~

~~(ii) Default Power Factor setting: Absorbing reactive power at 0.95 lagging power factor.~~

~~(iii) Aggregate generating facility is greater than 15 kW: 1.0 +/- 0.15 (0.85 Lagging to 0.85 Leading) down to 20% rated power irrespective of Real Power Production.~~

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 194

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

i. ~~Fixed Power Factor (Cont'd.)~~

~~(iii) Aggregate generating facility is less than or equal to 15 kW: 1.0 +/- 0.10 (0.90 Lagging to 0.90 Leading) down to 20% rated power irrespective of Real Power Production.~~

j. Dynamic Volt/VAR Operations

~~The Smart Inverter shall be capable of operating dynamically within a power factor range of +/- 0.85 PF for larger (>15 kW) systems, down to 20% of rated active power, and +/- 0.9 PF for smaller systems (≤15 kW), down to 20% of rated active power, irrespective of Real Power Production. This dynamic Volt/VAR capability shall be able to be activated or deactivated in accordance with Distribution Provider requirements.~~

The Distribution Provider may permit or require the Smart Inverter systems to operate in larger power factor ranges, including in 4-quadrant operations for storage systems with the implementation of additional anti-islanding protection as determined by the Distribution Provider.

The Smart Inverter shall be capable of providing supporting dynamic reactive power compensation (dynamic Volt/VAR operation) within the following constraints:

- The Smart Inverter shall be able to consume reactive power in response to an increase in line voltage, and produce reactive power in response to a decrease in line voltage as indicated in table Hh-4.
- ~~The reactive power provided shall be per the range irrespective of real power production, but the maximum reactive power provided to the system shall be as directed by the Distribution Provide~~
- ~~Reduction of real power production is allowed to meet the required reactive power ranges.~~

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

j. Dynamic Volt/VAR Operations (Cont'd.)

Dynamic Volt/Var Operations Default Settings

Table Hh-4 and Figure Hh-1 depict the default settings, which should be applied for all inverter sizes. Specific volt/var settings may be required for larger Generating Facilities (such as 100 kw or greater), or for specific areas with the Distribution Systems as determined by the Distribution Provider.

Default Open Loop Response Time for volt/var operation should be five (5) seconds.

Table Hh-4: Voltage and Reactive Default Settings

Table below deleted:

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

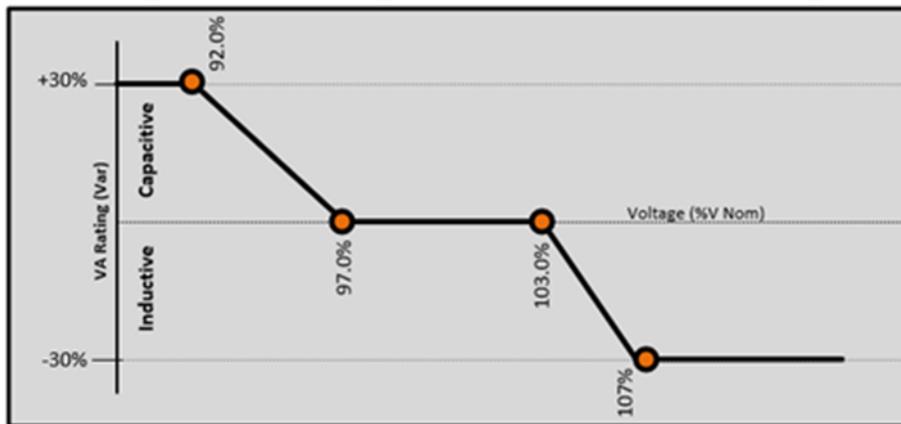
<u>Voltage Setpoint</u>	<u>Voltage Value</u>	<u>Reactive Setpoint</u>	<u>Reactive Value</u>	<u>Operation</u>
<u>V1</u>	<u>92.0%</u>	<u>Q1</u>	<u>30%</u>	<u>Reactive Power injection</u>
<u>V2</u>	<u>97.0%</u>	<u>Q2</u>	<u>0</u>	<u>Unity Power Factor</u>
<u>V3</u>	<u>103.0%</u>	<u>Q3</u>	<u>0</u>	<u>Unity Power Factor</u>
<u>V4</u>	<u>107.0%</u>	<u>Q4</u>	<u>30%</u>	<u>Reactive Power Absorption</u>

(Continued)

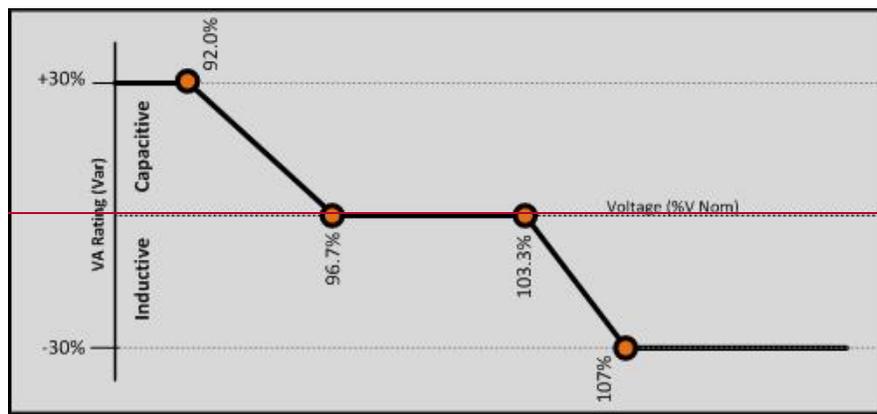


ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Figure Hh-1: Voltage and Reactive Default Settings



Graph below deleted:



(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 196

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

k. Enter Service Ramp Rate Requirements

~~The Smart Inverter is required to have the following ramp controls for at least the following four conditions. These functions can be established by multiple control functions or by one general ramp rate control function. Ramp rates are contingent upon sufficient energy available from the Smart Inverter.~~

- ~~• Normal ramp-up rate: For transitions between energy output levels over the normal course of operation. The default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%, with specific settings as mutually agreed by the Distributor Provider and the Producer.~~
- ~~• Connect/Reconnect Ramp-up rate: Upon starting to inject power into the grid, following a period of inactivity or a disconnection, the inverter shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second, with specific settings as mutually agreed upon by the Distribution Provider and the Producer.~~

Enter Service requirements as outlined in IEEE 1547-2018 section 4.10.3 with following default settings

1. Delay Enter Service per Hh.1.a.ii (15 seconds)
2. Default Enter Service Duration of 300 seconds

l. Frequency Droop (Frequency – Power, Frequency-Watt) Requirements

~~This requirement will become mandatory for Generating Facilities utilizing inverter based technologies for which an Interconnection Request is submitted on or after February 22, 2019, nine (9) months following the approval of the SunSpec Alliance Communication~~

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

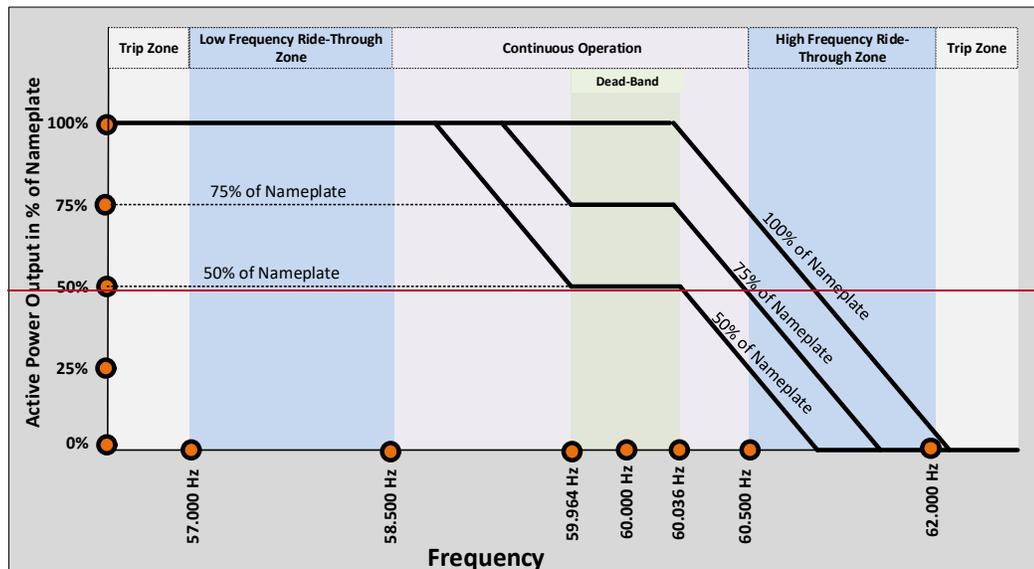
Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

~~I.— Frequency Watt Requirements (Cont'd.)~~

- ~~• When system frequency moves under 59.964 Hz, the active power output produced by the Smart Inverter shall be increased by 50% of real power nameplate rating per hertz (5% of real power nameplate rating increase per 0.1 hertz) when inverter is capable of increasing real power production.~~
- ~~• The default dead-band should be +/- 0.036 Hz from 60 Hertz (59.964 Hz to 60.036 Hz). When the system frequency is in range of 59.964 Hz and 60.036 Hz, the Smart Inverter is not required to decrease power as a function of system frequency.~~
- ~~• Open loop response time for Frequency—Watt shall be 5 seconds.~~
- ~~• Figure Hh-2 illustrated this requirement for three levels of output power. Figure Hh-2 is for illustration purposes only.~~

~~Figure Hh-2: Active Power as a Function of System Frequency~~



Note: the frequency markers on the horizontal axis are not drawn to scale.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

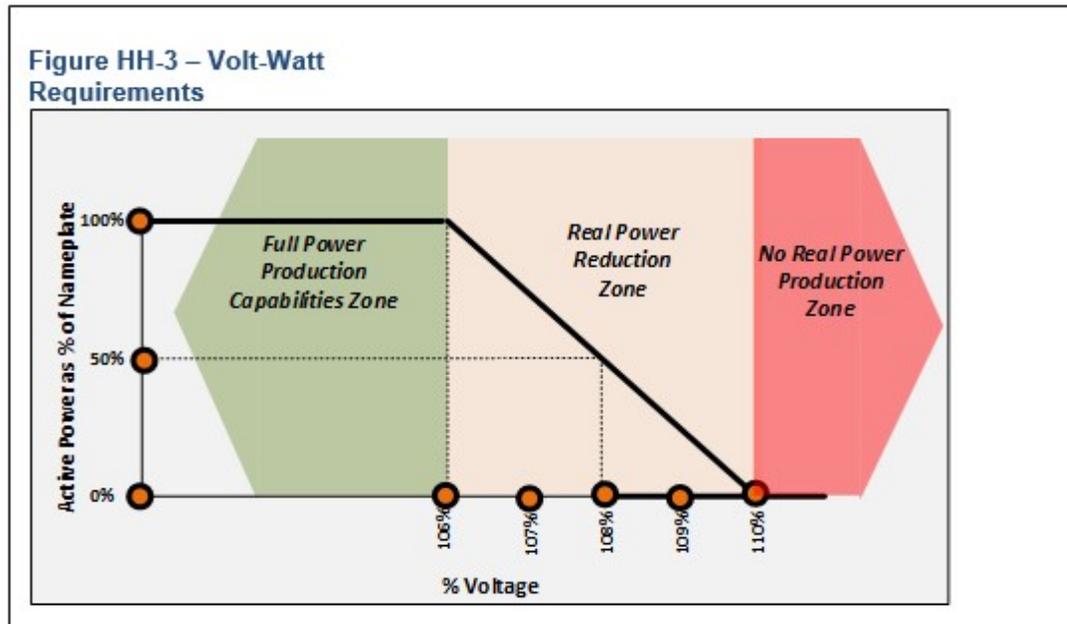
Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

m. (Cont'd.)

- When the measured voltage is greater than 110% of nominal voltage (Example: 132 volts on a 120 volts nominal), the export of active power output to the grid at the PCC or the production of active power by the Smart Inverter shall be reduced to 0 watts

- Open Loop response time shall be 5 seconds.



Percent (%) of nominal voltage

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 200

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

n. Dynamic Reactive Power Support Function

The capability for this requirement will become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted twelve (12) months after approval of a nationally recognized standard that includes the function.

The utilization of this function is allowed and optional upon the mutual agreement of the Distribution Provider and the Applicant, before the effective date.

o. Default Activation States

Unless otherwise provided by Distribution Provider, pursuant to Distribution Provider's Distribution Generation Interconnection Handbook, the default settings will be as follows:

	<u>Function</u>	<u>State</u>
<u>1</u>	<u>Anti-islanding</u>	<u>activated</u>
<u>2</u>	<u>Low/High Voltage Ride-Through</u>	<u>activated</u>
<u>3</u>	<u>Low/High Frequency Ride-Through</u>	<u>activated</u>
<u>4</u>	<u>Dynamic Volt/VAR operations</u>	<u>activated</u>
<u>5</u>	<u>Enter Service Ram Control</u>	<u>activate</u>
<u>6</u>	<u>Storage Inverter Normal Operation Ramp Control</u>	<u>activate</u>
<u>7</u>	<u>Fixed power factor</u>	<u>deactivated</u>
<u>8</u>	<u>Reconnect by "soft-start" methods</u>	<u>activated</u>
<u>9</u>	<u>Frequency-Watt*</u>	<u>activated</u>
<u>10</u>	<u>Volt/Watt*</u>	<u>activated</u>
<u>11</u>	<u>Constant Reactive Power Mode</u>	<u>deactivated</u>
<u>12</u>	<u>Set Active Power Function Mode (Optional)</u>	<u>activated under mutual agreement</u>
<u>13</u>	<u>Dynamic Reactive Power Support Mode (Optional)</u>	<u>activated under mutual agreement</u>

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

	<u>Function</u>	<u>State</u>
1	Anti-islanding	activated
2	Low/High Voltage Ride-Through	activated
3	Low/High Frequency Ride-Through	activated
4	Dynamic Volt/VAR operations	activated
5	Ramp rates	activated
6	Fixed power factor	deactivated
7	Reconnect by "soft-start" methods	activated
8	Frequency-Watt*	activated
9	Volt/Watt*	activated
10	Set Active Power Function Mode (Optional)	activated under mutual agreement
11	Dynamic Reactive Power Support Mode (Optional)	activated under mutual agreement

These default activation states may be modified by mutual agreement between Distribution Provider and Producer.

* These functions must be activated for Interconnection Requests submitted on or after February 22, 2019.

(Continued)



**ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS**

Sheet 201

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

~~p. Phase 3 Functions~~

~~Table of Phase 3 Effective Dates Pursuant to Resolution E-4898 and Resolution E-5000 and CPUC Letter of March 20, 2020 responding to a request to extend the date for Functions 1, 2, 3 and 8:~~

<u>Phase 3 Function #</u>		
	<u>Description</u>	<u>Effective Date (note)</u>
1	Monitor Key DER Data	June 22, 2020
2	DER Disconnect and Reconnect Command (Cease to Energize and Return to Service)	June 22, 2020
3	Limit Maximum Active Power Mode	June 22, 2020
4	Set Active Power Mode	12 months after approval of a nationally recognized standard that includes the function.
5	Frequency Watt Mode	February 22, 2019, which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
6	Volt Watt Mode	February 22, 2019, which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
7	Dynamic Reactive Support	12 months after approval of a nationally recognized standard that includes the function.
8	Scheduling Power Values and Modes	June 22, 2020

~~Note: The utilization of any of these functions is permissible under mutual agreement between the utility and the generating facility before the effective date.~~

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 202

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

2. PREVENTION OF INTERFERENCE (Cont'd.)

pp. Load Shedding or Transfer

The voltage and frequency ride-through requirements of Hh.2.b.(ii) and Hh.2.f.(i) shall not apply if either: a) The real power across the Point of Common Coupling is continuously maintained at a value less than 10% of the aggregate rating of the Smart Inverters connected to the Generation Facility prior to any voltage disturbance, and the Generation Facility disconnects from the Distribution Provider's T&D system, along with Generation Facility load, such that the net change in real power flow from or to the Distribution Provider is less than 10% of the aggregate Smart Inverter capacity; or b) Generation Facility load real power demand equal to 90% to 120% of the pre-disturbance aggregate Smart Inverter real power output is shed within 0.1 seconds of Smart Inverter disconnection.

q. Measurement and Calculation Accuracy

Smart Inverter shall meet minimum steady-state and transient measurement and calculation accuracy as required in IEEE1547-2018 4.4.

r. Prioritization of Smart Inverter Responses

1. The response to disable permit to service as specified in section Hh.8.a shall take precedence over any other tripping requirements

2. Prioritization of tripping requirements not related to disabling permit to service shall meet IEEE 1547-2018 4.7.

s. Storage Inverter Normal Operation Ramp Control Requirements

Smart Inverters used for energy storage applications shall include ramp-up rate control. The default value shall be 100% of maximum current output per second or slower if required by applicant. Other ramp-up control settings can be used, when required, as mutually agreed by the Distribution Provider and the Producer.

t. Ride-through of consecutive voltage disturbances

Ride through of Consecutive Voltage Disturbances shall be in accordance with IEEE 1547-2018 6.4.2.5.

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 202

u. Restore output without dynamic voltage support

Restore output without dynamic voltage shall be accordance with IEEE 1547-2018 6.4.2.7.1.

v. Transition between performance operating region

Transition between performance operating regions should be in accordance with IEEE 1547-2018 6.4.2.7.3.

w. Constant Reactive Power Mode

When in this mode, the Smart Inverter shall maintain a constant reactive power. The target reactive power level and mode (injection or absorption) shall be specified by the Distribution Provider and shall be within the same range specified in IEEE 1547-2018 5.2. The reactive power settings are allowed to be adjusted locally and/or remotely as specified by the Distribution Provider. The maximum Smart Inverter response time to maintain constant reactive power shall be 10 seconds or less.

x. Generating Facility Rapid Voltage Changes (RVC)

Generating step or ramp changes shall meet the requirements as specified in IEEE 1547-2018 7.2.2.

y. Limitations of overvoltage over one fundamental frequency period

Generating Facility shall not contribute to instantaneous or fundamental frequency overvoltage conditions per IEEE 1547-2018 7.4.1.

z. Limitation of cumulative instantaneous overvoltage

Generating Facility shall not cause the instantaneous voltage on any portion of the Distribution or Transmission system to exceed the magnitudes per IEEE 1547-2018 7.4.2

zz. Phase 3 Functions

Table of Phase 3 Effective Dates Pursuant to Resolution E-4898 and Resolution E-5000 and CPUC Letter of March 20, 2020 responding to a request to extend the date for Functions 1, 2, 3 and 8:

(Continued)



**ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS**

Sheet 202

<u>Phase 3 Function #</u>		
	<u>Description</u>	<u>Effective Date (note)</u>
<u>1</u>	<u>Monitor Key DERSmart Inverter Data</u>	<u>June 22, 2020</u>
<u>2</u>	<u>DERSmart Inverter Disconnect and Reconnect Command (Cease to Energize and Return to Service)</u>	<u>June 22, 2020</u>
<u>3</u>	<u>Limit Maximum Active Power Mode</u>	<u>June 22, 2020</u>
<u>4</u>	<u>Set Active Power Mode</u>	<u>12 months after approval of a nationally recognized standard that includes the function.</u>
<u>5</u>	<u>Frequency Watt Mode</u>	<u>February 22, 2019</u> , which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
<u>6</u>	<u>Volt Watt Mode</u>	<u>February 22, 2019</u> , which is 9 months following SunSpec Alliance Communication Protocol Certification Test Standard.
<u>7</u>	<u>Dynamic Reactive Support</u>	<u>12 months after approval of a nationally recognized standard that includes the function.</u>
<u>8</u>	<u>Scheduling Power Values and Modes</u>	<u>June 22, 2020</u>

Note: The utilization of any of these functions is permissible under mutual agreement between the utility and the generating facility before the effective date.

3. TECHNOLOGY SPECIFIC REQUIREMENTS

Grid-interactive inverters do not require separate synchronizing equipment. Non grid-interactive or “stand-alone” inverters shall not be used for Parallel Operation with Distribution Provider’s Distribution or Transmission System.

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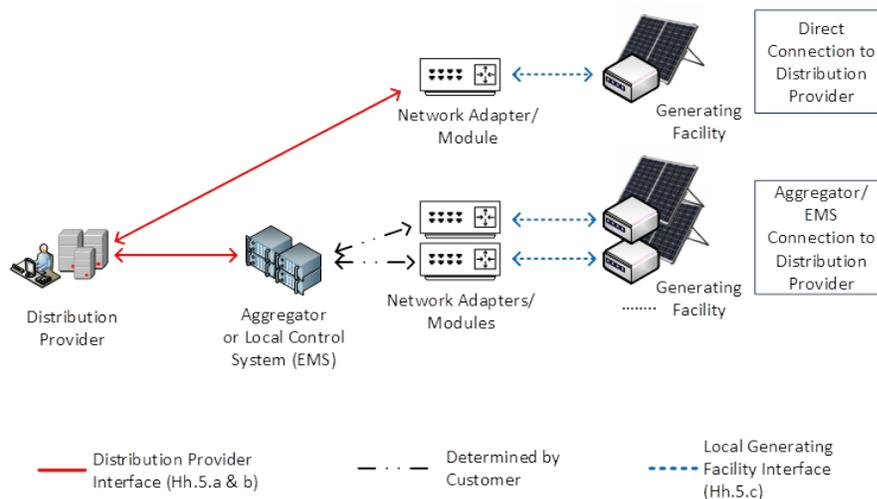
ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 204

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS

Generating Facilities utilizing inverter-based technologies must adhere to the following communication protocol requirements for communications between Distribution Provider and the Generating Facility. The diagram below shows the interface requirements as applicable for section Hh.5. The Distribution Provider Interface (solid red line) is described in Sections Hh.5.a and Hh.5.b. The Local Generating Facility Interface (dotted blue line) is described in Section Hh.5.c. The top row shows a direct connection between the Distribution Provider and the Generating Facility network adapter which may be separated from or integrated into the Smart Inverter. The lower row shows a connection between the Distribution Provider and an aggregator or local control system.



The network adapter depicted in the diagram is a device that connects the Smart Inverter to the local area network (LAN) or the wide area network (WAN). If no upstream control system is managing the Generating Facility (e.g., an aggregator or energy management system) and the Generating Facility is being managed directly by the Distribution Provider, the network adapter is required to be an IEEE 2030.5-2018 DER client as defined by CSIP, unless another protocol is agreed to be used with the Distribution Provider. The network adapter may also support other functions such as protocol translation or Generating Facility management. The network

(Continued)



ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

adapter may be integrated into the Smart Inverter or be a separate device.

~~a. The communication protocol requirements included in this section Hh.5 ; shall become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted June 22, 2020. Until such date, this subsection may be used in all or in part by inverter-based technologies by mutual agreement of the Distribution Provider and the Applicant. The communications requirements herein shall be between:~~

- ~~(i) the Distribution Provider and the individual Generating Facility's inverter control or energy management system;~~
- ~~(ii) the Distribution Provider and communication to the Generating Facility through an aggregator not co-located or part of the Generating Facility; or~~
- ~~(iii) other communication options as are mutually agreed to are by Applicant and the Distribution Provider.~~

a. The communications requirements in this section pertain to (i) the Distribution Provider and the individual Generating Facility's inverter control or energy management system; (ii) the Distribution Provider and communication to the Generating Facility through an aggregator not co-located or part of the Generating Facility; or (iii) the Distribution Provider and the Smart Inverter:

- (i) Software shall be updateable via communications remotely;
- (ii) The transport level protocol shall be TCP/IP;
- (iii) The default application-level protocol shall be IEEE 2030.5 (i.e., Smart Energy Profile 2.0) as defined in the latest final version of the Common Smart Inverter Profile (CSIP), the Interconnection Handbook, Cybersecurity Requirements or Programs and Contracts. Other application-level protocols may be used by mutual agreement of the parties including IEEE 1815/DNP3 for SCADA real-time monitoring and control and IEC 61850.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 205

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS (Cont'd.)

~~b. Generating Facilities utilizing inverter-based technologies must adhere to all of the following communication protocol requirements for communications between Distribution Provider and communication option selected in section Hh. 5. This Rule does not specify the communication between the selected communication option and Smart Inverter but performance will be enforced by in compliance with this Rule:~~

~~(i) Shall be capable of communications;~~

~~(ii) Software shall be updateable via communications remotely;~~

~~(iii) The transport level protocol shall be TCP/IP; and,~~

~~(iv) The default application level protocol shall be IEEE 2030.5 (i.e., Smart Energy Profile 2.0 (SEP 2)) as defined in the California IEEE 2030.5 Implementation Guide, but other application level protocols may be used by mutual agreement of the parties including IEEE 1815/DNP3 for SCADA real-time monitoring and control and IEC 61850.~~

b. Additional communication protocol requirements shall also apply to Generating Facilities utilizing inverter-based technologies as provided in the following documents:

(i) Distribution Provider Generation Interconnection Handbook, which shall include:

(a) Details and guidelines for the implementation of communications with Generating Facilities utilizing inverter-based technologies;

(b) Requirements for which application-level protocols are supported and references to an application-level protocol implementation guide;

(c) Cybersecurity and privacy requirements (these may additionally or alternatively be included in the application-level protocol implementation guide);

(d) Generic device communications registration management requirements, including how to register individual Generating

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 205

Facilities, Generating Facilities with energy management systems, and Aggregators (these additionally or alternatively may be included in the application-level protocol implementation guide); and,

(e) Conditions under which communication functions are mandatory.

(ii) Application-Level Protocol Implementation Guide, which shall provide:

(a) Detailed communication requirements and implementation guidelines to ensure consistent interoperability of the Generating Facilities with all California investor-owned utilities under the Commission's jurisdiction.

(Continued)

<i>Advice</i>	5187-E-A	<i>Issued by</i>	<i>Date Filed</i>	May 31, 2018
<i>Decision</i>	16-06-052	Robert S. Kenney	<i>Effective</i>	June 30, 2018
		<i>Vice President, Regulatory Affairs</i>	<i>Resolution</i>	



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GENERATING FACILITY INTERCONNECTIONS

Sheet 206

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

5. COMMUNICATION REQUIREMENTS (Cont'd.)

~~c. Additional communication protocol requirements shall also apply to Generating Facilities utilizing inverter based technologies as provided in the following documents:~~

~~(i) Distribution Provider Generation Interconnection Handbook, which shall include:~~

~~a) Details and guidelines for the implementation of communications with Generating Facilities utilizing inverter based technologies;~~

~~b) Cybersecurity and privacy requirements (these may additionally or alternatively be included in the application level protocol implementation guide); and,~~

~~c) Generic device communications registration management requirements, including how to register individual Generating Facilities, Generating Facilities with energy management systems, and aggregators (these requirements additionally or alternatively may be included in the application level protocol implementation guide).~~

~~(ii) Application Level Protocol Implementation Guide, which shall provide:~~

~~a) Communication requirements and implementation guidelines to ensure consistent interoperability of the Generating Facilities with all California investor owned utilities under the Commission's jurisdiction.~~

c. Communication and protocol performance requirements

i) Communication performance requirements

Communication performance requirements for the interface to the Generating facility shall comply with IEEE 1547-2018 10.8.

ii) Communication Protocol Requirements

The protocol requirements at the Generating Facility shall be per IEEE 1547-2018 10.7.

(Continued)

Advice	5187-E-A	Issued by	Date Filed	May 31, 2018
Decision	16-06-052	Robert S. Kenney	Effective	June 30, 2018
		Vice President, Regulatory Affairs	Resolution	



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GENERATING FACILITY INTERCONNECTIONS

Sheet 207

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

6. SCHEDULING CAPABILITY REQUIREMENTS

- a. Generating Facilities which incorporate Smart Inverters shall incorporate scheduling capabilities with a minimum scheduling memory capability of at least 24 events. ~~The capability for this requirement will be mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted on or after June 22, 2020.~~

The utilization of this function is permissible under mutual agreement between the utility and the generating facility before the effective date.

Each event is composed of modifications to each, selected group of, or all of the following Smart Inverter function.

- (i) Modifications to the voltage and reactive set-points of the Dynamic volt/var function.
- (ii) Modifications to the reactive power set-points for the fixed power factor function.
- (iii) Modifications to the voltage and watt-reduction level set-points for the volt/watt function.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 209

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

7. MONITORING AND TELEMETRY REQUIREMENTS

a. ~~The capability for this requirement will be mandatory for Generating Facilities utilizing inverter based technologies for which an Interconnection Request is submitted on or after June 22, 2020.~~

~~The utilization of this function is permissible under mutual agreement between the utility and the generating facility before the effective date.~~

Smart Inverter shall have the capability to communicate its performance information including per IEEE 1547-2018 10.5 Table 29:

- (i) Smart Inverter production or consumption of active power (Watts).
- (ii) Smart Inverter consumption or production of reactive power (VARs)
- (iii) Phase measured at the AC terminals of the Smart Inverter (Volts)
- (iv) Frequency measured at the AC terminals of the Smart Inverter (Hz)

(v) Connection Status

(vi) Alarm Status

(Continued)



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GENERATING FACILITY INTERCONNECTIONS**

Sheet 211

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

7. MONITORING AND TELEMETRY REQUIREMENTS (Cont'd.)

d. Monitoring and performance information should be communicated in aggregate at the Generating Facility as follows:

(i) When the Generating Facility includes only Smart Inverters: The production or consumption of active and reactive power shall be communicated as an aggregate of all Smart Inverters within the Generating Facility.

(ii) When a Generating Facility includes Smart Inverters and other technologies such as synchronous or induction generation systems, the Generating Facility should communicate the following:

a) The production or consumption of active and reactive power shall be communicated in aggregate of all Smart Inverters within the Generating Facility

b) The production or consumption of active and reactive power shall be communicated in aggregate of all the other technologies within the Generating Facility

(iii) When the Generating Facility with Smart Inverters includes one or multiple energy storage systems: The available operational energy should be communicated as an aggregate of all the energy storage systems.

(iv) Nameplate information shall be available through a local Generating Facility Interface as required in IEEE 1547-2018 10.3 and must include the information as required in IEEE 1547-2018 Table 28.

(v) Configuration information shall be available through a Local Generating Facility Interface as required in IEEE 1547-2018 10.4. This information represents the present capacity and ability of the Generating Facility. When a configuration update changes the Generating Facility nameplate information, it may require a study depending on the change.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 212

Hh. SMART INVERTER GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS (Cont'd.)

8. CONTROL THROUGH COMMUNICATION CAPABILITIES

- a. The capability for these requirements will be mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted on or after the earlier of the dates shown in the "Table of Phase 3 Effective Dates Pursuant to Resolution E-4898" in Section Hh.2. ~~øZZ~~.

The utilization of these functions is permissible under mutual agreement between the utility and the generating facility before the effective date.

Smart Inverters shall have the capabilities of accepting an operational controls through communications in accordance to the following:

- (i) ~~Cease to energize~~ Disable permit to service control command.
When the Smart Inverter receives a disable permit service command through communication, the Smart Inverter must cease-to energize and trip within 2 seconds or initiate the opening of the switch referenced in the inverter terminal in order to galvanically isolate the Smart Inverter from the Distribution System.

~~When the Smart Inverter receives a cease to energize command through communication it must enter into a cease to energize state of operation or shall initiate the opening of the DER switch referenced in the ECP in order to galvanically isolate the DER system from the Distribution System~~

- (ii) Return to service control command. When the Smart Inverter receives a return-to-service control command, the Smart Inverter may return to service operation as required by Generating Facility operator or as required by the scheduling control system as required by section H.6. This shall be accomplished by enabling permit service as required in IEEE 1547-2018 4.10.3.

- (iii) Limit Active Power command. When the Smart Inverter receives a command to limit its production of real power, the Smart Inverter shall reduce its real power production to the specified percent of real power capacity of the Smart Inverter or to a specified real power value. In no more than 30 s or in the time it takes for the primary energy source to reduce its active power output to achieve the requirements of the active power limit set point, whichever is greater.

Where the Smart Inverter operates under a non-export provision, the active power limit set point may be implemented as a maximum active power to serve the host customer load.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 212

Under mutual agreement, Smart Inverter may be required to reduce active power below the level needed to support host customer load.

- (iv) Set Active Power Level Mode Function. The capability for this requirement will become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted twelve (12) months after approval of a nationally recognized standard that includes the function.
- (v) Suspension of Active Power restriction. When the Smart Inverter receives a command to suspend the command for active power reduction, the Smart Inverter may return to normal operation as required by Generating Facility operator or as required by the scheduling control system as required by section H.6.

(vi) Transition between operating modes. Transition between modes shall commence in no more than 30 s after the mode setting change is received at the local Generating Facility communication interface. Changes of control functional modes shall be executed such that the Smart Inverter output is transitioned smoothly over a time period between 5 s and 300 s.

Ramping of the Smart Inverter output is not required for control parameter setting changes.

For all control and protective function parameter settings, the time following the input to the local Generating Facility communication interface and preceding the point in time when the invoked action begins shall be no greater than 30 s.

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 221

K. DISPUTE RESOLUTION PROCESS (Cont'd.)

3. PERFORMANCE DURING DISPUTE

Pending resolution of any dispute under this Section, the Parties shall proceed diligently with the performance of their respective obligations under this Rule and the Implementing Agreements, unless the Implementing Agreements have been terminated. Disputes as to the Interconnection Request and implementation of this Section shall be subject to resolution pursuant to the procedures set forth in this Section.

L. CERTIFICATION AND TESTING CRITERIA

1. INTRODUCTION

This Section describes the test procedures and requirements for equipment used for the Interconnection of Generating Facilities to Distribution Provider's Distribution or Transmission System. Included are Type Testing, Production Testing, Commissioning Testing, and Periodic Testing. The procedures listed rely heavily on those described in appropriate Underwriters Laboratory (UL), Institute of Electrical and Electronic Engineers (IEEE), and International Electrotechnical Commission (IEC) documents—most notably UL 1741 including UL-1741 Supplement A or B as appropriate, and IEEE 929 as well as the testing described in May 1999 New York State Public Service Commission's Interconnection Requirements. ~~As noted in Section B, this Rule has been revised to be consistent with ANSI/IEEE 1547-2003 Standard for Interconnecting Distribution Resources with Electric Power Systems.~~

(Continued)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 222

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

1. INTRODUCTION (Cont'd.)

The tests described here, together with the technical requirements in Section H of this Rule, are intended to provide assurance that the Generating Facility's equipment will not adversely affect Distribution Provider's Distribution or Transmission System and that a Generating Facility will cease providing power to Distribution Provider's Distribution or Transmission System under abnormal conditions. The tests were developed assuming a low level of Generating Facility penetration or number of connections to Distribution Provider's Distribution or Transmission System. At high levels of Generating Facility penetration, additional requirements and corresponding test procedures may need to be defined.

Section L also provides criteria for "Certifying" Generators, inverters or converters. Once a Generator, inverter or converter has been Certified per this Rule, it may be considered suitable for Interconnection with Distribution Provider's Distribution or Transmission System. Subject to the exceptions described in Section L, Distribution Provider will not repeat the design review or require retesting of such Certified Equipment. It should be noted that the Certification process is intended to facilitate Generating Facilities Interconnections. Certification is not a prerequisite to interconnect a Generating Facility for Section H, except for Non-Export AC/DC Converters seeking an expedited process, but it is a prerequisite for inverters installed ~~under section Hh. after September 8, 2017, pursuant to Section Hh of this Rule.~~

(Continued)

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GENERATING FACILITY INTERCONNECTIONS

Sheet 224

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

2. CERTIFIED AND NON-CERTIFIED INTERCONNECTION EQUIPMENT (Cont'd.)

a. Certified Equipment (Cont'd.)

Technical (as appropriate):

- (1) Device ratings (kW, kV, Volts, amps, etc.);
- (2) Maximum available fault current in amps, per IEEE 1547-2018 11.4;
- (3) In-rush Current in amps;
- (4) Trip points, if factory set (trip value and timing);
- (5) Trip point and timing ranges for adjustable settings;
- (6) Nominal power factor or range if adjustable;
- (7) If the equipment is Certified as Non-Exporting and the method used (reverse power or underpower);
- (8) If the equipment is Certified as Non-Islanding; and
- (9) If the equipment is Certified as a Non-Export AC/DC Converter.

It is the responsibility of the equipment manufacturer to ensure that Certification information is made publicly available by the manufacturer, the testing laboratory, or by a third party.

b. Non-Certified Equipment

For non-Certified equipment, some or all of the tests described in this Rule may be required by Distribution Provider for each Generating and/or Interconnection Facility. The manufacturer or a laboratory acceptable to Distribution Provider may perform these tests. Test results for non-Certified equipment must be submitted to Distribution Provider for the Supplemental Review. Approval by Distribution Provider for equipment used in a particular Generating and/or Interconnection Facility does not guarantee Distribution Provider's approval for use in other Generating and/or Interconnection Facilities.

(Continued)

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ELECTRIC RULE NO. 21
GENERATING FACILITY INTERCONNECTIONS

Sheet 225

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING

a. Type Tests and Criteria for Interconnection Equipment Certification

Type testing provides a basis for determining that equipment meets the specifications for being designated as Certified equipment under this Rule. The requirements described in this Section cover only issues related to Interconnection and are not intended to address device safety or other issues.

Table L.1 defines the test criteria by Generator or inverter technology. While UL 1741(1) and UL 1741 – Supplement SA/SB were written specifically for inverters, the requirements are readily adaptable to synchronous Generators, induction Generators, as well as single/multi-function controllers and protection relays. Until a universal test standard is developed, Distribution Provider or NRTL shall adopt the procedures referenced in Table L.1 as appropriate and necessary for a Generating Facility and/or Interconnection Facilities or associated equipment performance and its control and Protection Functions. These tests shall be performed in the sequence shown in Table L.2.

Non-Export AC/DC Converters must satisfy the requirements in its definition in Section C.

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GENERATING FACILITY INTERCONNECTIONS

Sheet 226

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

a. Type Tests and Criteria for Interconnection Equipment Certification (Cont'd.)

Table L.1, Type Test and Requirements for Interconnection Equipment Certification

Type Test	Reference (1)	Inverter (6)	Smart Inverter (7)	Smart Inverter 2022 (Note 9,10)	Synchronous Generators	Induction Generators
Utility Interaction	UL 1741 - 39, 40	X	X	X	X	X
Utility Compatibility (Required testing to 1547 and 1547.1)	UL 1741 - 46	X	X	X	X	X
DC Isolation	IEEE 1547.1(8) - 5.6	X	X	-	-	-
Dielectric Voltage Withstand	IEEE1547.1(8) - 5.5.3	X	X	-	X	X
Dielectric Voltage Withstand	IEEE1547.1 2020, 5.8.2	-	-	X	-	-
Harmonic Distortion	IEEE-1547.1(8) - 5.11	X	X	-	X	X
Harmonic Distortion	IEEE1547.1 2020, 5.12	-	-	X	-	-
DC Injection	IEEE1547.1(8) - 5.6	X	X	-	-	-
DC Injection	1547.1 2020, 5.9	-	-	X	-	-
Distribution Provider Voltage Variations	IEEE1547.1 - 5.2	X	-	-	X	X
Distribution Provider Frequency Variations	IEEE1547.1 - 5.3	X	-	-	X	X
Abnormal Tests	UL 1741 - 47	X	X	X	-	-
Loss of Control Circuit	UL 1741 - 47.8	X	X	X	X	X
Short Circuit	UL 1741 - 47.3	X	X	X	X	X
Load Transfer	UL 1741 - 47.7	X	X	X	X	X
Surge Withstand Capability	L.3.e	X	X	X	X	X
Anti-Islanding (Traditional)	L.3.b	(2)	-	-	(2)	(2)
Non-Export	L.3.c	(3)	(3)	(3)	(3)	(3)
In-rush Current	L.3.d	-	-	-	-	(4)
Synchronization	L.3.f	(5)	(5)	(5)	X	(5)
Anti-islanding (Smart Inverters)	UL 1741 SA - SA8	-	X	-	-	-
Low and High Voltage Ride-through	UL 1741 SA - SA9	-	X	-	-	-
Low and High Frequency Ride-through	UL 1741 SA - SA10	-	X	-	-	-

(Continued)



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Normal and Soft-Start Ramp Rate	UL 1741 SA - SA11	-	X	-	-	-
Specified Power Factor	UL 1741 SA - SA12	-	X	-	-	-
Volt/Var Mode (Q(V))	UL 1741 SA - SA13	-	X	-	-	-
Frequency-Watt (optional)	UL 1741 SA - SA14	-	X	-	-	-
Volt-Watt (optional)	UL 1741 SA - SA15	-	X	-	-	-
Markings and Instructions	UL 1741 SA - SA6 , SA16	-	X	-	-	-
Disable Permit Service	UL1741 SA - SA17	-	X	-	-	-
Limit Active Power	UL1741 SA - SA18	-	X	-	-	-
DC Injection (2022)	IEEE1547.1-2020	-	-	X	-	-
Anti-islanding (Smart Inverters) (2022)	UL1741SB- SB3	-	-	X	-	-
Low and High Voltage Ride-through (2022)	UL1741SB- SB3	-	-	X	-	-
Low and High Frequency Ride-through (2022)	UL1741SB- SB3	-	-	X	-	-
Normal and Soft-Start Ramp Rate (2022)	UL1741SB- SB3	-	-	X	-	-
Specified Power Factor (2022)	UL1741SB- SB3	-	-	X	-	-
Volt/Var Mode (Q(V)) (2022)	UL1741SB- SB3	-	-	X	-	-
Frequency-Watt (2022)	UL1741SB- SB3	-	-	X	-	-
Volt-Watt (2022)	UL1741SB- SB3	-	-	X	-	-
Constant Reactive Power(2022)	UL1741SB- SB3	-	-	X	-	-
Disable Permit Service(2022)	UL1741SB- SB3	-	-	X	-	-
Limit Active Power(2022)	UL1741SB- SB3	-	-	X	-	-
Markings and Instructions(2022)	UL1741SB- SB5	-	-	X	-	-

- (1) References are to section numbers in either UL 1741 and/or UL 1741-Supplement SA (Inverters, Converters and Charge Controllers for Use in Independent Power Systems) or this Rule. References in UL 1741 to "photovoltaics" or "inverter" may have to be adapted to the other technologies by the testing laboratory to appropriately apply in the tests to other technologies.
- (2) Required only if Non-Islanding designation.
- (3) Required only if Non-Export designation is desired.
- (4) Required for Generators that use Distribution Provider power to motor to speed.
- (5) Required for all self-excited induction Generators as well as Inverters that operate as voltage sources when connected to Distribution Provider's Distribution or Transmission System.
- (6) Inverters compliant with Section H.
- (7) Inverters compliant with Section Hh.
- (8) IEEE 1547.1 refers to 2005 revision
- (9)- Smart Inverter which have tested under UL1741SB and IEEE 1547.1-2020
- (10) - Effective January 1, 2022

(Continued)



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Type Test	Reference 1	Inverter (6)	Smart Inverter (7)	Synchronous Generators	Induction Generators
Utility Interaction	UL 1741—39, 40	X	X	X	X
Utility Compatibility (Required testing to 1547 & 1547.1)	UL 1741—46	X	X	X	X
DC Isolation	IEEE 1547.1(8)—5.6	X	X	-	-
Dielectric Voltage Withstand	IEEE 1547.1(8)—5.5.3	X	X	X	X
Harmonic Distortion	IEEE 1547.1(8)—5.11	X	X	X	X
DC Injection	IEEE 1547.1(8)—5.6	X	X	-	-
Distribution Provider Voltage Variation	IEEE 1547.1(8)—5.2	X	-	X	X
Distribution Provider Frequency Variation	IEEE 1547.1(8)—5.3	X	-	X	X
Abnormal Tests	UL 1741—47				
Loss of Control Circuit	UL 1741—47.8	X	X	X	X
Short Circuit	UL 1741—47.3	X	X	X	X
Load Transfer	UL 1741—47.7	X	X	X	X
Surge Withstand Capability	L.3.e	X	X	X	X
Anti-Islanding (non-Smart Inverters)	L.3.b	(2)	-	(2)	(2)
Non-Export	L.3.c	(3)	(3)	(3)	(3)
In-rush Current	L.3.d	-	-	-	(4)
Synchronization	L.3.f	(5)	(5)	X	(5)
Anti-islanding (Smart Inverters)	UL 1741 SA—SA8	-	X	-	-
Low and High Voltage Ride-through (L/H VRT)	UL 1741 SA—SA9	-	X	-	-
Low and High Frequency Ride-through (L/H FRT)	UL 1741 SA—SA10	-	X	-	-
Normal and Soft-Start Ramp Rate (RR)	UL 1741 SA—SA11	-	X	-	-
Specified Power Factor	UL 1741 SA—SA12	-	X	-	-
Volt/Var Mode (Q(V))	UL 1741 SA—SA13	-	X	-	-
Frequency-Watt (FW)—optional	UL 1741 SA—SA14	-	X	-	-
Volt-Watt (VW)—optional	UL 1741 SA—SA15	-	X	-	-
Markings and Instructions	UL 1741 SA6; SA16	-	X	-	-
Table Notes:	(1)—References are to section numbers in either UL 1741 and/or UL 1741-Supplement SA (Inverters, Converters and Charge Controllers for Use in Independent Power Systems) or this Rule. References in UL 1741 to “photovoltaics” or “inverter” may have to be adapted to the other technologies by the testing laboratory to appropriately apply in the tests to other technologies.				
	(2)—Required only if Non-Islanding designation.				
	(3)—Required only if Non-Export designation is desired.				
	(4)—Required for Generators that use Distribution Provider power to motor-to-speed.				
	(5)—Required for all self-excited induction Generators as well as Inverters that operate as voltage sources when connected to Distribution Provider’s Distribution or Transmission System.				
	(6)—Inverters compliant with Section H.				
	(7)—Inverters compliant with Section Hh.				
	(8)—IEEE 1547.1 refers to 2005 revision.				
“X” = Required — “-” = Not Required					

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Sheet 227

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

a. Type Tests and Criteria for Interconnection Equipment Certification (Cont'd.)

Table L.2 Type Tests Sequence for Interconnection Equipment Certification

<u>Test No.</u>	<u>Type Test</u>
1	Distribution Provider Voltage and Frequency Variation
2	Synchronization
3	Surge Withstand Capability
4	Distribution Provider Voltage and Frequency Variation, including ride through
5	Synchronization
6	Other Required and Optional Tests

Tests 1, 2, and 3 must be done first and in the order shown. Tests 4 and on follow in order convenient to the test agency.

b. Anti-Islanding Test

Devices that pass the Anti-Islanding test procedure described in UL 1741 ~~Section 46.3~~ Supplement SB will be considered Non-Islanding for the purposes of these Interconnection requirements. The test is required only for devices for which a Certified Non-Islanding designation is desired.

c. Non-Export Test

Equipment that passes the Non-Export test procedure described in Section L.7.a will be considered Non-Exporting for the purposes of these Interconnection requirements. This test is required only for devices for which a Certified Non-Export designation is desired.

(Continued)



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Sheet 229

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

f. Synchronization Test

This test is applied to synchronous Generators, self-excited induction generators, and inverters capable of operating as voltage-source while connected to Distribution Provider's Distribution or Transmission System. The test is also applied to the resynchronization Function (transition from stand-alone to parallel operation) on equipment that provides such functionality. This test may not need to be performed on both the synchronization and re-synchronization functions if the manufacturers can verify to the satisfaction of the testing organization that monitoring and controls hardware and software are common to both functions. This test is not necessary for induction generators or current-source inverters. Instead, the In-rush Current test Section L.3.d shall be applied to those generators.

This test shall demonstrate that at the moment of the paralleling-device closure, all three synchronization parameters in Table L.3 are within the stated limits. This test shall also demonstrate that if any of the parameters are outside of the limits stated in the table, the paralleling-device shall not close (IEEE 1547-[2018 5.1.2A4.10](#)). The test will start with only one of the three parameters: (1) voltage difference between Generating Facility and Distribution Provider's Distribution or Transmission System; (2) frequency difference; or (3) phase angle outside of the synchronization specification. Verify that the Generating Facility is brought within specification prior to synchronization. Repeat the test five times for each of the three parameters. For manual synchronization with synch check or manual control with auto synchronization, the test must verify that paralleling does not occur until the parameters are brought within specifications.

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GENERATING FACILITY INTERCONNECTIONS**

Sheet 230

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

3. TYPE TESTING (Cont'd.)

f. Synchronization Test (Cont'd.)

**Table L.3
Synchronization Parameter Limits [1]**

Aggregate Rating of Generator Units (kVA)	Frequency Difference (Δf, Hz)	Voltage Difference (ΔV, %)	Phase Angle Difference (ΔΦ, °)
0-500	0.3	10	20
> 500-1,500	0.2	5	15
> 1,500-10,000	0.1	3	10

[1] – IEEE 1547-~~2018, 4.10.45-1.4B~~

g. Paralleling Device Withstand Test

The di-electric voltage withstand test specified in Section L.1 shall be performed on the paralleling device to ensure compliance with those requirements specified in Section H.1.c (IEEE 1547-~~2018 4.11.35-1.3.3~~).

h. Backfeed Test

Non-Export AC/DC Converters must satisfy the requirements in its definition in Section C.

4. PRODUCTION TESTING

At a minimum, each interconnection system shall be subjected to Distribution Provider Voltage and Frequency Variation Test procedure described in UL1741 under Manufacturing and Production Tests, Section 68 and the Synchronization test specified in Section L.3.f. Interconnection systems with adjustable set points shall be tested at a single set of set points as specified by the manufacturer. This test may be performed in the factory or as part of a Commissioning Test (Section L.5).

(Continued)



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GENERATING FACILITY INTERCONNECTIONS

Sheet 246

L. CERTIFICATION AND TESTING CRITERIA (Cont'd.)

7. TYPE TESTING PROCEDURES NOT DEFINED IN OTHER STANDARDS (Cont'd.)

a. Non-Exporting Test Procedures (Cont'd.)

v) Interim Tests for Non-Export AC/DC Converters ("Converter") (Cont'd.)

Step 3: Back-feed Under Fault Conditions – AC Input Shorted: Phase-Ground, Phase-Phase, and 3-Phase

With a battery source or simulated equivalent of a battery source connected to the DC terminals, apply rated conditions of the Converter, then apply a short between any two phases on the grid side of the Converter for 200 milliseconds. After 5 cycles of inducing the short circuit, record the measured peak current at each of the AC terminals of the Converter. These peak currents within this time interval are each required to be less than 0.5% of the Converter's rated RMS AC current. This test is to be repeated for phase-ground and 3-phase shorts. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.

Step 4: Back-feed Under Fault Conditions – Component Faults

Distribution Provider can elect to test for back-feed under the condition of a short circuit across certain components which are internal to the Converter. Potential tests can include inducing a short circuit across different terminals for electronic switches and/or across different terminals for internal transformers. Ultimately, the components used for testing will be chosen on a case-by-case basis and will depend on the Converter's circuit topology. Testing requirements can be modified upon mutual agreement of the Distribution Provider and the Applicant.

Step 5: Harmonics Testing

Under normal loading conditions at 10%, 25%, 50%, 75%, and 100% of the Converter's rated power output, conduct harmonic current distortion measurements on each of the AC terminals. Measurements should be below the maximum harmonic current distortion requirements given in IEEE 1547-~~4.3.3-2018~~ 7.3

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**PG&E Gas and Electric
Advice Submittal List
General Order 96-B, Section IV**

AT&T
Albion Power Company

Alta Power Group, LLC
Anderson & Poole

Atlas ReFuel
BART

Barkovich & Yap, Inc.
California Cotton Ginners & Growers Assn
California Energy Commission

California Hub for Energy Efficiency
Financing

California Alternative Energy and
Advanced Transportation Financing
Authority
California Public Utilities Commission
Calpine

Cameron-Daniel, P.C.
Casner, Steve
Cenergy Power
Center for Biological Diversity

Chevron Pipeline and Power
City of Palo Alto

City of San Jose
Clean Power Research
Coast Economic Consulting
Commercial Energy
Crossborder Energy
Crown Road Energy, LLC
Davis Wright Tremaine LLP
Day Carter Murphy

Dept of General Services
Don Pickett & Associates, Inc.
Douglass & Liddell

East Bay Community Energy Ellison
Schneider & Harris LLP Energy
Management Service
Engineers and Scientists of California

GenOn Energy, Inc.
Goodin, MacBride, Squeri, Schlotz &
Ritchie

Green Power Institute
Hanna & Morton
ICF

IGS Energy
International Power Technology
Intestate Gas Services, Inc.
Kelly Group
Ken Bohn Consulting
Keyes & Fox LLP
Leviton Manufacturing Co., Inc.

Los Angeles County Integrated
Waste Management Task Force
MRW & Associates
Manatt Phelps Phillips
Marin Energy Authority
McKenzie & Associates

Modesto Irrigation District
NLine Energy, Inc.
NRG Solar

Office of Ratepayer Advocates
OnGrid Solar
Pacific Gas and Electric Company
Peninsula Clean Energy

Pioneer Community Energy

Redwood Coast Energy Authority
Regulatory & Cogeneration Service, Inc.
SCD Energy Solutions
San Diego Gas & Electric Company

SPURR
San Francisco Water Power and Sewer
Sempra Utilities

Sierra Telephone Company, Inc.
Southern California Edison Company
Southern California Gas Company
Spark Energy
Sun Light & Power
Sunshine Design
Tecogen, Inc.
TerraVerde Renewable Partners
Tiger Natural Gas, Inc.

TransCanada
Utility Cost Management
Utility Power Solutions
Water and Energy Consulting Wellhead
Electric Company
Western Manufactured Housing
Communities Association (WMA)
Yep Energy