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|  | DISTRIBUTED GENERATION PROTECTION REQUIREMENTS | | 094681 |
| | Asset Type: Electric Transmission and Distribution | Function: Construction and Maintenance | |
| Issued by: Daniel Jantz (DWJ7) | <i>D. Jantz</i> | Date: 2/15/23 | |
| Rev. #01: This document replaces PG&E Document 094681, Rev. #00. For a description of the changes, see Page 12. | | | |

Purpose and Scope

The protection requirements for connecting new Distributed Generation (DG) have been modified to reduce the need for Direct Transfer Trip (DTT) schemes which are costly to employ and difficult to manage.

Distribution Evaluation

1. PG&E at its discretion may still require DTT on any DG system, especially for those that may not trip for end of line faults and has significant fault current contributions.
2. Phase and ground protection are required to detect end-of-line faults. This may be waived for smaller certified units that have aggregated fault current contribution less than 10% and expected to trip due to anti-islanding protection after the feeder breaker tripped.
3. These exemptions do not apply to certified and non-certified Inverters with Stand-Alone capabilities.
4. Transmission DTT requirements are independent and still apply.
5. For a line section with all certified inverters, reclose blocking will not be required if the first reclose can be delayed to 10 seconds.
6. If an existing uncertified DG already has DTT then this uncertified DG would not count towards the 10% limit for the "other machine or uncertified DG is > 10% of project" screen. Other uncertified DG with previously approved protection may still need to be re-studied on a case by case basis.

Certified Inverter:

7. < 40 kW, then
 - DTT and ground fault protection are not required
8. ≥40 kW and < 1000 kW, and
 - A. Line section aggregated DG > 50% of minimum load then
 - 1 DTT and ground fault protection are not required
 - B. Line section aggregated DG > 50% of minimum load, and
 - 1 Aggregate machine or uncertified DG ≤ 40% of the aggregate DG (all types) on a line section, then
 - DTT and ground fault protection are not required
 - 2 Aggregate machine or uncertified DG > 40% of the aggregate DG (all types) on a line section requires:
 - PG&E SCADA equipped recloser or interrupter at machine generation location
9. ≥ 1000 kW, and
 - A. Line section aggregated DG ≤ 50% of minimum load, requires
 - Customer owned Telemetry
 - B. Line section aggregated DG > 50% of minimum load, and
 - 1 Aggregate machine or uncertified DG ≤ 40% of the aggregate DG (all types) on a line section, and
 - (a) Short circuit contribution ratio ≤ 10%, requires

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- Customer owned Telemetry
- (b) Short circuit contribution ratio > 10%, requires
 - Ground Fault Protection and Reclose Blocking
 - PG&E SCADA equipped recloser or interrupter to be installed at Largest Machine generator
- 2 Aggregate machine or uncertified DG > 40% of the aggregate DG (all types) on a line section, requires
 - Ground Fault Protection and Reclose Blocking
 - PG&E SCADA equipped recloser or interrupter to be installed at Largest Machine generator

Machine – Induction or Synchronous includes wind turbine generation:

10. < 40 kW, then DTT and ground fault protection are not required

11. ≥40 kW and < 400 kW, and

A. Line section aggregated DG ≤ 50% of minimum load, and

- 1 Short circuit contribution ratio ≤ 10%, then requires
 - Redundant sets of PG&E approved protective relays
- 2 Short circuit contribution ratio > 10%, then requires
 - Ground Fault Protection and Reclose Blocking
 - Redundant sets of PG&E approved protective relays

B. Line section aggregated DG > 50% of minimum load, then perform Screen Y:

1 Aggregate machine or uncertified DG ≤ 40% of the aggregate DG (all types) on a line section, then

- (a) Short circuit contribution ratio ≤ 10%, then requires
 - Redundant sets of PG&E approved protective relays
- (b) Short circuit contribution ratio > 10%, then requires
 - Ground Fault Protection and Reclose Blocking
 - Redundant sets of PG&E approved protective relays

2 Aggregate machine or uncertified DG > 40% of the aggregate DG (all types) on a line section then the following mitigation is required:

- Ground Fault Protection and Reclose Blocking
- Redundant sets of PG&E approved protective relays
- Perform Screen Y

For a failed RIO study, install PG&E SCADA equipped recloser or interrupter

12. ≥ 400 kW, and

A. Line section aggregated DG ≤ 50% of minimum load, then requires

- Ground Fault Protection and Reclose Blocking
- Redundant sets of PG&E approved protective relays

B. Line section aggregated DG > 50% of minimum load, then perform Screen Y:

1 Aggregate machine or uncertified DG ≤ 40% of the aggregate DG (all types) on a line section, then

- Ground Fault Protection and Reclose Blocking
- Redundant sets of PG&E approved protective relays

2 Aggregate machine or uncertified DG > 40% of the aggregate DG (all types) on a line section then the following mitigation is required:

- Ground Fault Protection and Reclose Blocking

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- Redundant sets of PG&E approved protective relays
- Perform Screen Y,
For a failed RIO study, install PG&E SCADA equipped recloser or interrupter
- Note: When distribution upgrades such as reclose blocking are required additional time is needed before the DG facility is allowed to parallel with the PG&E system.

13. Flow chart – 1 (Distribution Generation Requirements for Distribution Circuits) is appended in reference to the requirements in items 7 thru 13 above.

Transmission and Substation Evaluation:

14. For distributed generation, (i.e., generation connected to non-dedicated distribution circuits), the protection requirements for substation and transmission installations are as follows:
15. PG&E at its discretion may still require DTT on any DG system, especially for those that may not trip for end of line faults and has significant fault current contribution.
16. If an existing uncertified DG already has DTT this uncertified DG would not count towards the 40% limit for machines. This includes existing hardwire CB tripping. Other uncertified DG with previously approved protection may still need to be restudied on a case per case basis.
17. The machine generation shall be fixed P/Q type (fixed power factor).
18. Excess generation on an ungrounded system could lead to temporary phase to ground over voltages during transmission SLG faults, an evaluation will be needed to determine if overvoltage mitigation is required.
19. These exemptions do not apply to certified and non-certified Inverters with Stand-Alone capabilities.

Certified Inverter Substation and Transmission Line Section Review:

20. Substation Transformer

A. Transformer aggregated DG \leq 50% of minimum load then,

- DTT and transformer tripping is not required. End of review.

B. Transformer section aggregated DG $>$ 50% of minimum load

1 If the substation transformer is ungrounded, required

- Evaluation which may include grounding the transformer or installation of an overvoltage tripping scheme to prevent overvoltage of Transmission equipment on the affected line section.

2 If the substation transformer is grounded

(a) Aggregate machine or uncertified DG to total generation ratio \leq 40% of the transformer aggregate DG (all types), then

- No further action is required, continue to substation review.

(b) Aggregate machine or uncertified DG to total generation ratio $>$ 40% of the transformer aggregate DG (all types), Proceed to Screen X:

3 Perform evaluation as per Screen X, determine if ROI study is required

- For a failed ROI study, following mitigation is required:
- Required Mitigation for a failed ROI study: Transformer protection tripping of feeder breakers is required. Tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme would also be required for a single transformer station. Continue to substation review.

21. Substation Review

A. Total Substation aggregated DG \leq 50% of minimum load,

- DTT and transformer tripping are not required. End of review.

B. Total Substation aggregated DG $>$ 50% of minimum load, and

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- 1 Aggregate machine or uncertified DG to total generation \leq 40% of the substation aggregate DG (all types), then
 - No further action is required continue to transmission line review.
- 2 Aggregate machine or uncertified DG to total generation ratio $>$ 40% of the substation aggregate DG (all types), proceed to Screen X
- 3 Perform evaluation as per Screen X, determine if ROI study is required
 - For a failed ROI study, following mitigation is required:
Station tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme is required. Continue to transmission line review.

22. Transmission Line Section Review

A. Total line section aggregated DG \leq 50% of minimum load, then

- DTT from transmission terminals to feeder breakers is not required. End of review.

B. Total Substation aggregated DG $>$ 50% of minimum load, and

- 1 Aggregate machine or uncertified DG to total generation ratio \leq 40% of the line section aggregate DG (all types), then
 - No further action is required. End if review.
- 2 Aggregate machine or uncertified DG to total generation ratio $>$ 40% of the line section aggregate DG (all types), then proceed to Screen X:
- 3 Perform evaluation as per Screen X, determine if ROI study is required.
For a failed ROI study, following mitigation is required:
 - DTT from transmission terminals to feeder breakers is required.
 - Reclose blocking at the transmission terminals is required if not installed.

23. A second flow chart (Flowchart 2 (Figure 2 on Page 8): Certified Inverter Generation DTT Requirements for Transmission Backfeed) is appended in reference to the requirements for items 20 and 22 above.

Machine Based Generation Substation and Transmission Line Section Review:

24. PG&E at its discretion may still require DTT on any DG system, especially for those that may not trip for end of line faults and has significant fault current contribution.
25. If an existing uncertified DG already has DTT this uncertified DG would not count towards the 40% limit for machines or the 10% limit of "Other uncertified DG". This includes existing hardwire CB tripping. Other uncertified DG with previously approved protection may still need to be restudied on a case per case basis. The machine generation shall be fixed P/Q type (fixed power factor).
26. Excess generation on an ungrounded system could lead to temporary phase to ground over voltages during transmission SLG faults. An evaluation will be needed to determine if overvoltage mitigation is required.
27. Phase and ground fault detection for transmission EOL faults is required via 59N, 51N, 51C, 51V or 21 elements. Small generators may not be able to detect all transmission EOL faults, therefore as long as aggregate gen is $<$ 50% of minimum load, EOL fault detection for all transmission faults is not required. For generation with total SCCR $>$ 0.1 EOL fault detection is required for all transmission faults.
28. Substation Transformer
 - A. Transformer aggregated DG \leq 50% of minimum load,
 - DTT and transformer tripping is not required. End of review.
 - B. Transformer section aggregated DG $>$ 50% of minimum load
 - 1 If the substation transformer is ungrounded, required
 - Evaluation which may include grounding the transformer or installation of an overvoltage tripping scheme to prevent overvoltage of Transmission equipment on the affected line section.

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- 2 If the substation transformer is grounded
 - (a) Aggregate machine generation to total generation ratio is $\leq 40\%$ then.
 - (i) Transformer aggregate synchronous machine or uncertified generation $\leq 50\%$ of minimum load then
 - DTT and transformer tripping are not required. Continue to substation review.
 - (ii) Transformer aggregate synchronous machine or uncertified generation $> 50\%$ of minimum load,
 - Transformer protection tripping of feeder breakers is required. Tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme would also be required for a single transformer station. Continue to substation review.
- 3 Aggregate machine generation to total generation ratio is $> 40\%$, proceed to Screen Y

For a failed ROI study, following mitigation is required:

 - Transformer protection tripping of feeder breakers is required. Tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme would also be required for a single transformer station. Continue to substation review.

29. Substation Review

- A. Total Substation aggregated DG $\leq 50\%$ of station minimum load,
 - DTT and transformer tripping are not required. End of review.
- B. Total Substation aggregated DG $> 50\%$ of station minimum load, and
 - 1 Aggregate machine generation to total generation ratio is $\leq 40\%$ then,
 - (a) Station Aggregate Synchronous machine or uncertified generation $\leq 50\%$ of minimum load,
 - Station tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme is not required.
 - (b) Station Aggregate Synchronous machine or uncertified generation $> 50\%$ of minimum load,
 - Station tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme is required. Continue to transmission line review.
 - 2 Aggregate machine generation to total generation ratio is $> 40\%$, then proceed to Screen Y
 - Perform Screen Y evaluation to determine if ROI study is required. If ROI study fails, then following mitigation is necessary:

Station tripping via the HV Bus Differential or Total Overcurrent (TOC) scheme is required. Continue to transmission line review.

30. Transmission Line Section Review

- A. Total line section aggregated DG $\leq 50\%$ of minimum line section load
 - DTT from transmission terminals to feeder breakers is not required. End of review.
- B. Total Substation aggregated DG $> 50\%$ of minimum line section load, and
 - 1 Aggregate machine generation to total generation ratio is $\leq 40\%$ of the aggregate DG (all types), then,
 - (a) Line Section aggregate synchronous machine generation $\leq 50\%$ of minimum load,
 - DTT from transmission terminals to feeder breakers is not required.
 - (b) Line Section Aggregate synchronous machine or uncertified generation $> 50\%$ of minimum load
 - DTT from transmission terminals to feeder breakers is not required. End of review.
 - 2 Aggregate machine generation to total generation ratio is $> 40\%$, then proceed to Screen Y.
 - 3 Perform Screen Y evaluation to determine if ROI study is required.

If ROI study fails, then following mitigation is necessary:

 - DTT from transmission terminals to feeder breakers is required.

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- Reclose blocking at the transmission terminals is required, if not installed.

31. A third flow chart (Flowchart 3 (Figure 3 on Page 9): Machine Based Generation DTT Requirements for > 40kW Transmission Backfeed) is appended in reference to the requirements in items 24 thru 30 above.

Definitions

Certified Inverter: For the purposes of this document, it is an inverter that has been “Certified” per UL 1741 or UL 1741SA, or UL1741SB to trip in 2 seconds or less after the formation of an unintended island.

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

Line Section: Defines the zone of protection for the DG in which it is expected to detect and trip for faults and is bounded by a 3 phase fault interrupting device. A given line section or sections could include multiple zones of protection.

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

Uncertified Generation: Generation that does not have active anti-islanding capability.

Note: Generation may have a UL 1741 SA or SB certification and not have active-islanding capability.

| References | Location | Document |
|---|-------------------------------|--------------------------|
| Distributed Generation Protection Requirements | DIH | 094681 |
| Functionally Equivalent Non-Import Configuration Testing Requirements | DIH | 094682 |
| Mitigating Substation Power Transformer Overloads Due to PV and BESS | DIH | 094685 |
| Distribution Interconnection Handbook | DIH | TD-2306M |
| Transmission Interconnection Handbook | TIH | TD-1013M |

Distributed Generation Protection Requirements

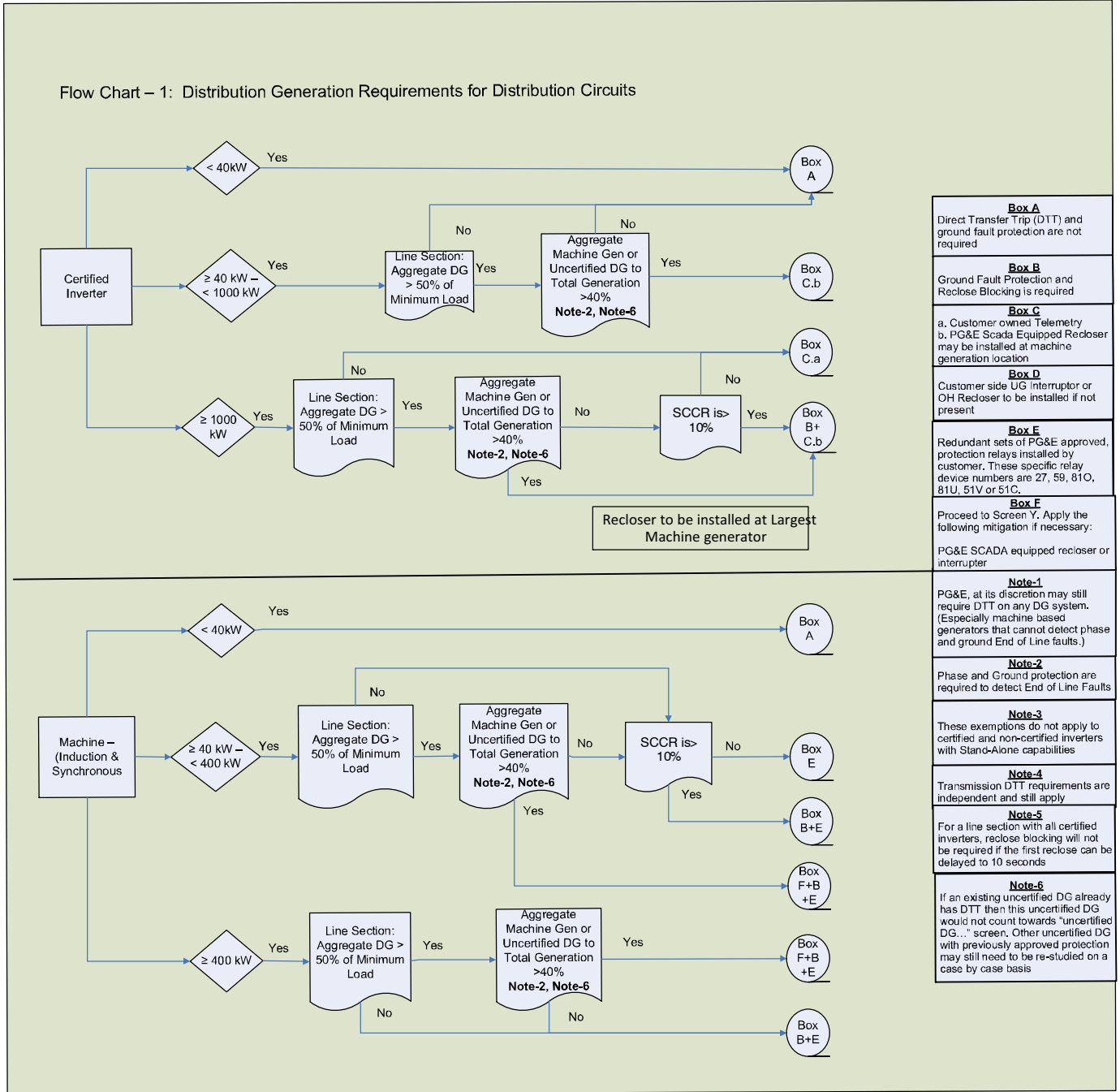


Figure 1
Flow Chart 1 – Distributed Generation Requirements for Distribution Circuits

Distributed Generation Protection Requirements

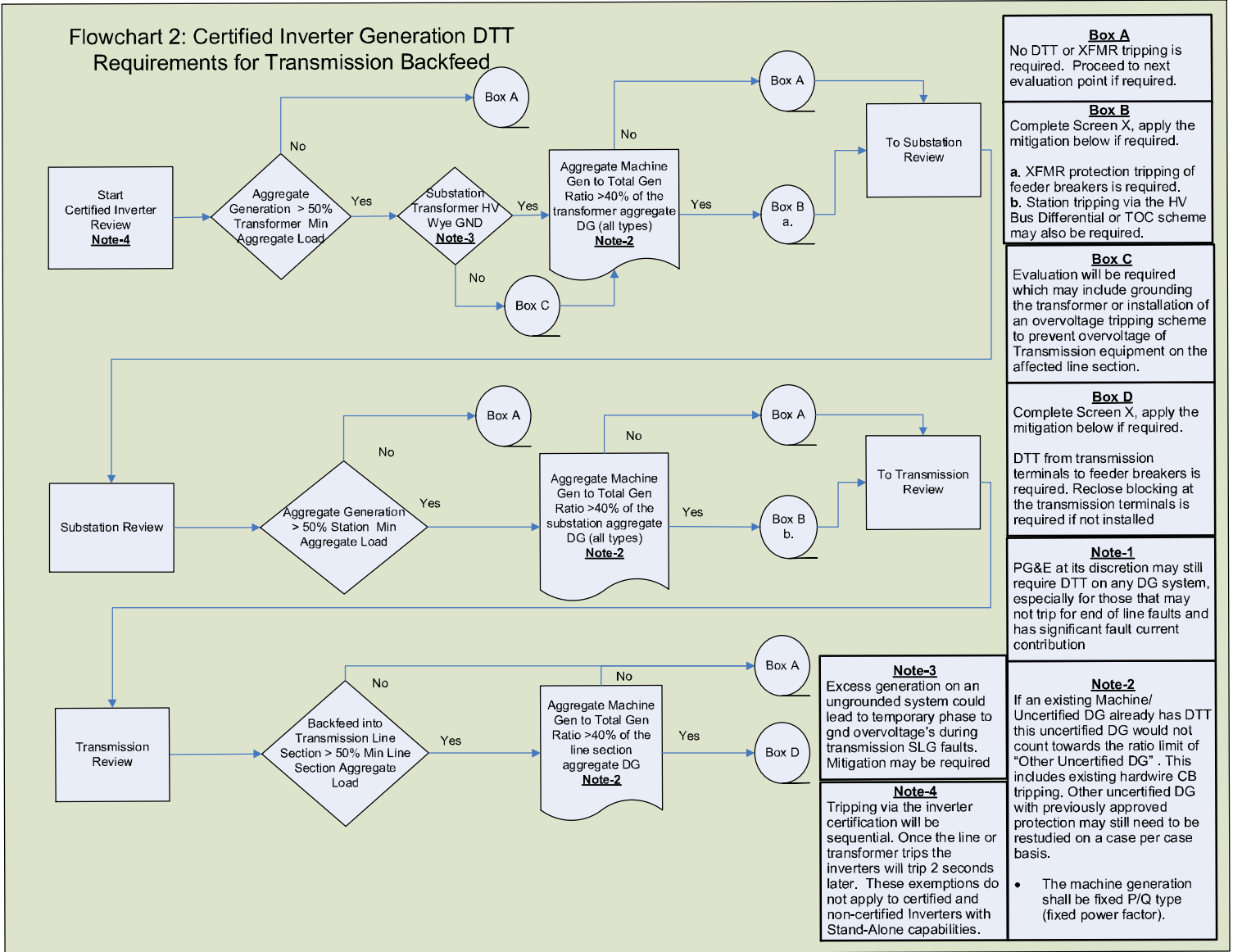
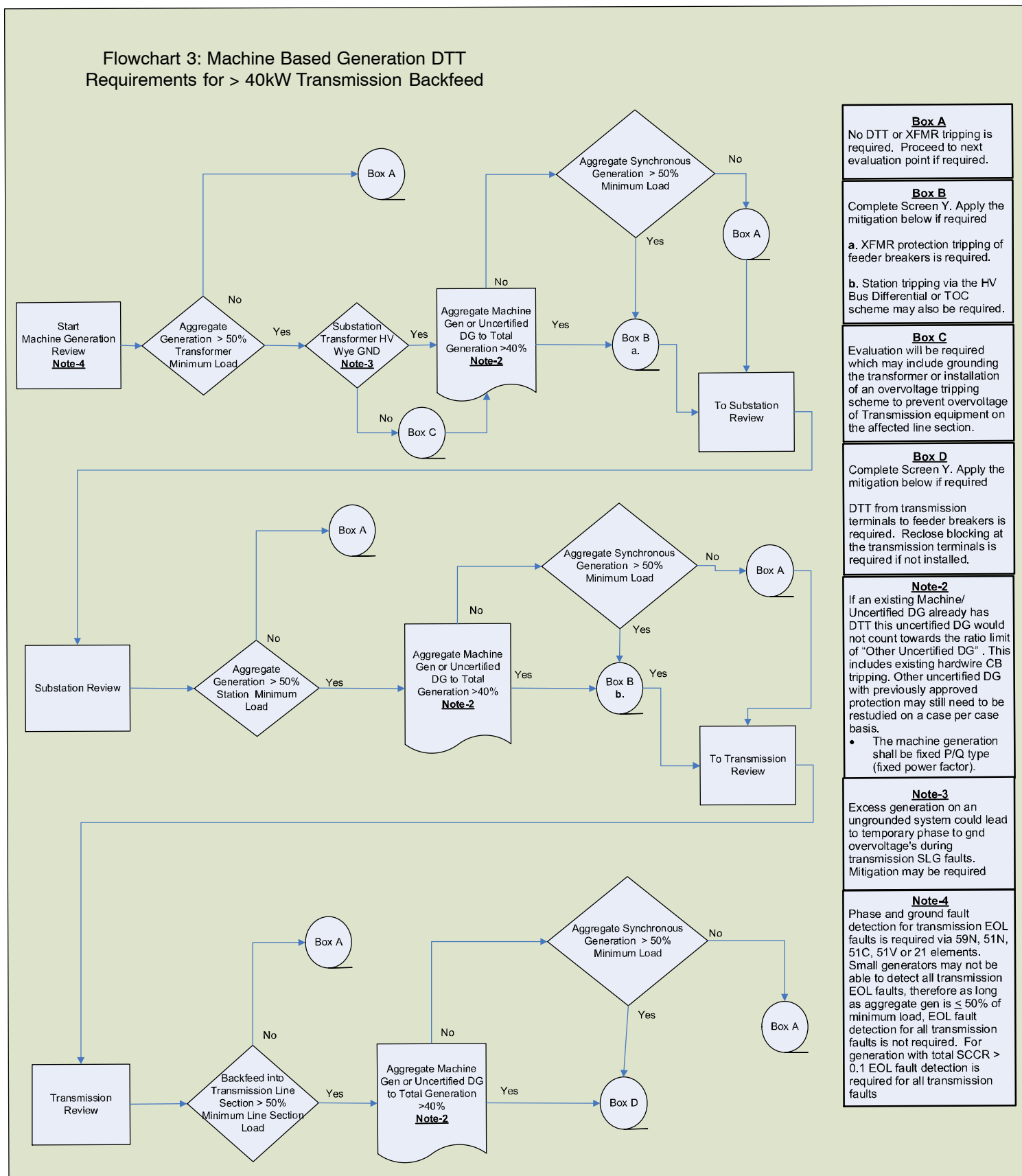


Figure 2
Flow Chart 2 – Certified Inverter Generation Requirements for Transmission Backfeed

Distributed Generation Protection Requirements



**Figure 3
Flow Chart 3 – Machine Based Generation DTT Requirements for > 40kW Transmission Backfeed**

Distributed Generation Protection Requirements

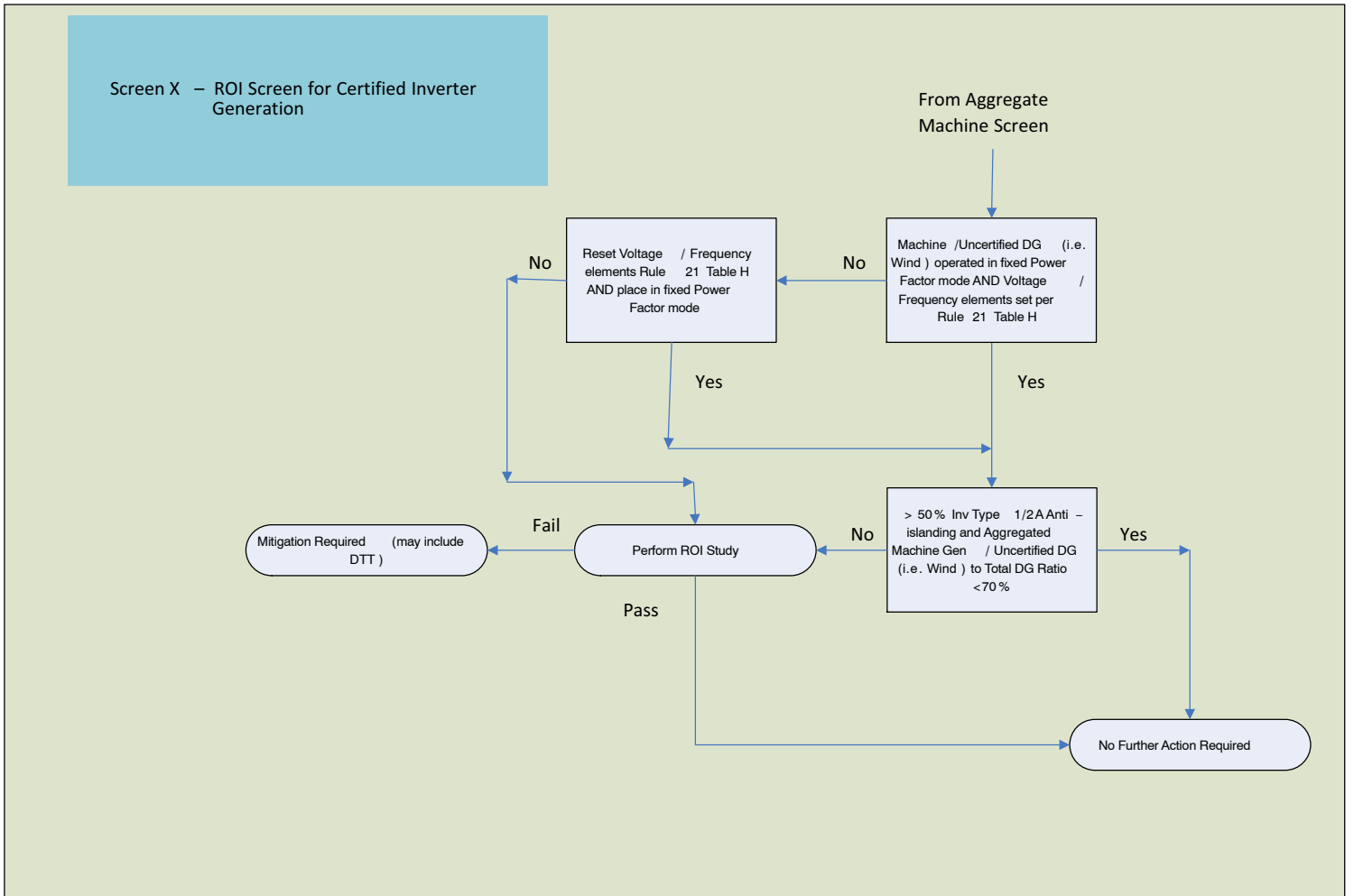


Figure 4
Screen X – ROI Screen for Certified Inverter Generation

Distributed Generation Protection Requirements

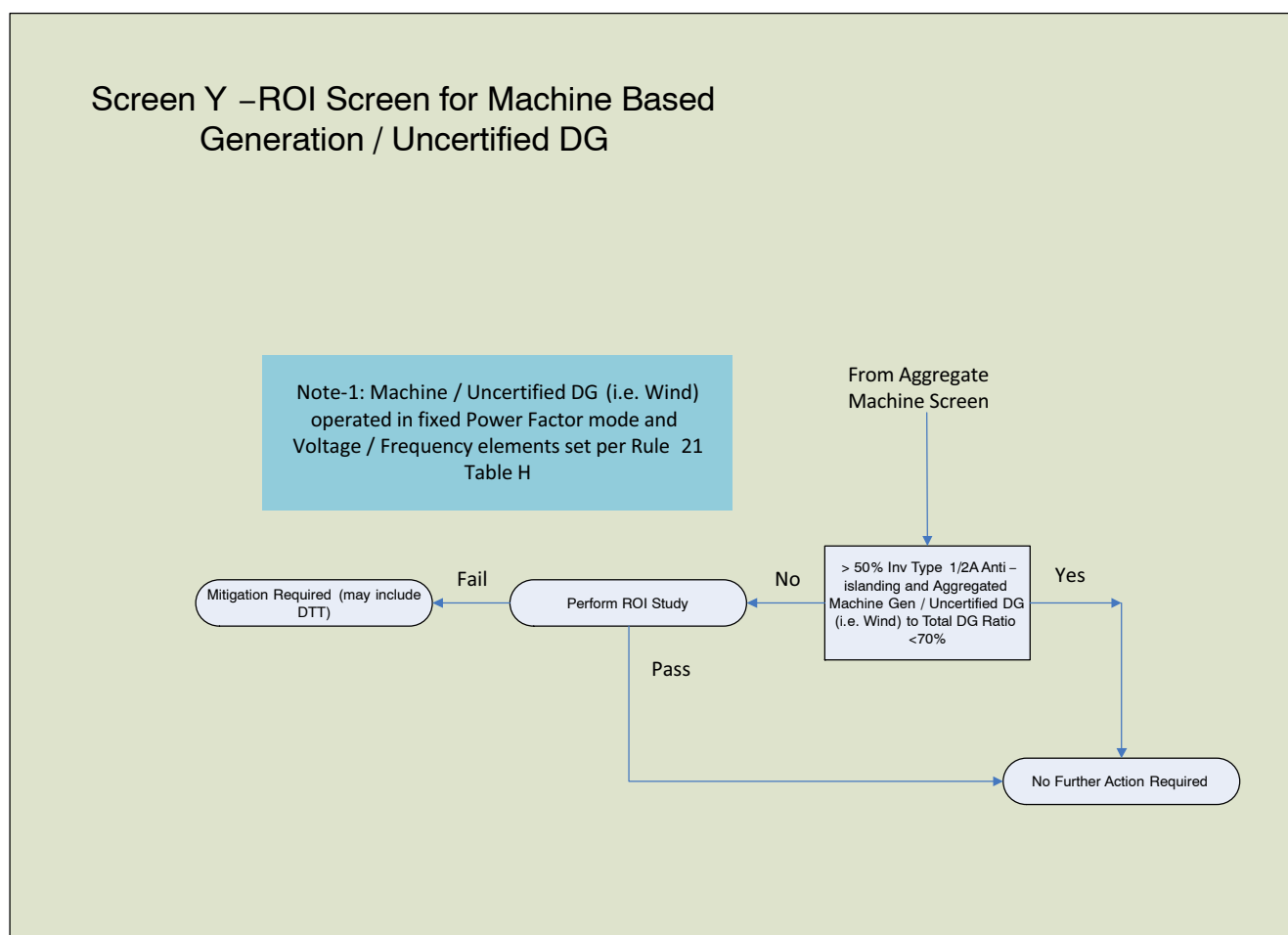


Figure 5
Screen Y – ROI Screen for Machine Based Generation / Uncertified DG

Revision Notes

Revision 01 has the following changes:

1. Corrected document Title typo.
2. Corrected Note 8, Note 8.1, Note 8.2 on Page 1.
3. Removed Bullet 8.2 “Ground Fault Protection and Reclose Blocking”, on Page 1.
4. Edited Bullet 8.2 “PG&E SCADA equipped recloser or interrupter at machine generation location” on Page 1.
5. Edited Bullet 9.A on Page 1.
6. Edited Note 9.B.1 on Page 1.
7. Edited Bullet 9.B.1.(a) on Page 1.
8. Edited 2nd Bullet 9.B.1.(b) on Page 2.
9. Edited Note 9.B.2 on Page 2.
10. Deleted “Uncertified Inverter” Note 10 on Page 2. Renumbered Notes.
11. Added Note 11.B on Page 2.
12. Added Note 12.B.2 on Page 2.
13. Edited Note 13 on Page 3. Deleted Note 14 on Page 3. Renumbered Notes.
14. Added Note 15 on Page 3. Renumbered Notes.
15. Edited Note 16 on Page 3.
16. Edited Note 20.2 on Page 3.
17. Edited Note 21.B on Pages 3 and 4.
18. Edited Note 22.B on Page 4.
19. Added new evaluation Screen X and Screen Y and revised the requirements according to CPUC Working Group 4 Proposal 18e.