Jack E. Jirak
Associate General Counsel

Mailing Address:
NCRH 20 / P.O. Box 1551
Raleigh, NC 27602

o: 919.546.3257
f: 919.546.2694

jack.jirak@duke-energy.com

March 29, 2021

VIA ELECTRONIC FILING

Ms. Kimberley A. Campbell, Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4300

RE: Duke Energy Carolinas, LLC's and Duke Energy Progress, LLC's Comments in Support of Inspections for Legacy Solar Generating Facilities
Docket No. E-100, Sub 101

Dear Ms. Campbell:

Please find enclosed Duke Energy Carolinas LLC's and Duke Energy Progress, LLC's Comments in Support of Inspections for Legacy Solar Generating Facilities in the above-referenced proceeding.

If you have any questions, please do not hesitate to contact me. Thank you for your assistance with this matter.

Sincerely,

Jack E. Jirak

Enclosure

cc: Parties of Record

CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Carolinas LLC's and Duke Energy Progress, LLC's Comments in Support of Inspections for Legacy Solar Generating Facilities, in Docket No. E-100, Sub 101, has been served by electronic mail, hand delivery or by depositing a copy in the United States mail, postage prepaid to parties of record.

This the 29th day of March, 2021.

Jack E. Jirak
Associate General Counsel
Duke Energy Corporation
P.O. Box 1551/NCRH 20
Raleigh, North Carolina 27602
(919) 546-3257
Jack.jirak@duke-energy.com

STATE OF NORTH CAROLINA
UTILITIES COMMISSION
RALEIGH

DOCKET NO. E-100, SUB 101

BEFORE THE NORTH CAROLINA UTILITIES COMMISSION

In the Matter of Petition for Approval of Revisions to Generator Interconnection Standards	)))))	COMMENTS OF DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC IN SUPPORT OF INSPECTIONS FOR LEGACY SOLAR GENERATING FACILITIES

NOW COME Duke Energy Carolinas, LLC ("DEC") and Duke Energy Progress, LLC ("DEP" and together with DEC, the "Companies"), pursuant to the North Carolina Utilities Commission's ("Commission") March 9, 2021 *Order Seeking Comments Regarding Generator Inspection Provisions of the North Carolina Generator Interconnection Standards* (the "Order Seeking Comments") and March 16, 2021 *Order Granting Extension of Time* issued in the above-captioned docket, and hereby submit these Comments for the Commission's consideration.

I. INTRODUCTION

The need for rigorous inspection of the medium voltage AC side of interconnected Generating Facilities has been a topic of much discussion before the Commission. Beginning in 2016, to address experienced power quality events that originated on certain Interconnection Customers' medium voltage facilities at the point of interconnection, the Companies partnered with Advanced Energy Corporation ("Advanced Energy") to establish a more robust inspection and commissioning program for all new utility-scale solar Interconnection Customers. Comprehensive inspections for both new and existing

Generating Facilities were discussed during the Advanced Energy-led interconnection stakeholder process that took place in 2017 and were again addressed in comments filed with the Commission in early 2018. On June 14, 2019, following an evidentiary proceeding and hearing on proposed amendments to the North Carolina Interconnection Procedures ("NCIP"), the Commission issued its *Order Approving Revised Interconnection Standard and Requiring Reports and Testimony* (the "2019 NCIP Order") which, in part, established certain requirements related to post-commercial operation inspections of interconnected facilities. In particular, the Commission found that "[i]t is critical that the Utilities be in a position to ensure the safety and integrity of the grid"[1] and approved the addition of Sections 6.5.2, 6.5.3, and 6.5.4 to the NCIP, which authorize the Companies to inspect the medium voltage AC side of both new and operating facilities and to invoice the applicable Interconnection Customer for the costs of such inspections.

The inspection process established in Section 6.5.2 specifically addresses Generating Facilities that were interconnected prior to the Companies' implementation of an inspection process and thus were "not inspected prior to commencing parallel operation"[2] (the "Uninspected Facilities"). There are approximately 300 utility-scale Uninspected Facilities interconnected to the Companies' distribution systems totaling over 1,000 MW. Even before the 2019 NCIP Order, the Companies contracted with Advanced Energy to conduct a pilot inspection of a select group of Uninspected Facilities. Advanced Energy inspected four Uninspected Facilities in 2018[3] and five in 2019. Carolinas Clean Energy Business Association ("CCEBA") and other stakeholders raised concerns

[1] 2019 NCIP Order at 21.
[2] NCIP § 6.5.2.
[3] The Companies did not bill Interconnection Customers for inspections conducted in 2018 because those inspections took place *before* the final 2019 NCIP Order was entered.

regarding the costs of the pilot inspections as Section 6.5.2 mandates that such costs are to be borne by the Interconnection Customer. To address these concerns, the Companies temporarily postponed planned inspections of other Uninspected Facilities and engaged in collaborative discussions with CCEBA and other interested stakeholders to develop a flexible, efficient, and potentially lower-cost approach to inspecting the remaining Uninspected Facilities whereby Interconnection Customers could conduct self-inspections subject to standards and guidelines developed by the Companies.

After working with stakeholders to arrive at a mutually acceptable alternative inspection procedure for more than a year, CCEBA has now asserted on behalf of its members, by letter dated February 11, 2021, that the Companies do not have the right to inspect any Uninspected Facility that had a fully executed Interconnection Agreement prior to the 2019 NCIP's June 14, 2019 effective date. The basis for this position—which CCEBA has never before asserted and which applies to the approximately 300 Uninspected Facilities—is that NCIP Section 1.1.3 states that the 2019 revisions are inapplicable to Generating Facilities that had a fully executed Interconnection agreement dated before June 14, 2019.[4]

The Companies reported this development to the Commission in their March 1, 2021 Interconnection Fee-Related Work and Post-Commercial Operation Inspection Report, which prompted the Commission to issue its March 9, 2021 Order Seeking Comments, asking the parties to submit comments detailing their concerns regarding inspection of the Uninspected Facilities.

[4] *Id.* § 1.1.3.

For the reasons described below, the Companies believe CCEBA's position conflicts with intent of the 2019 NCIP Order by rendering Sections 6.5.2 moot in its entirety and removing the Companies' ability to ensure the safety and integrity of the grid with respect to the 295 remaining Uninspected Facilities.

II. COMMENTS

A. <u>Inspection of Uninspected Facilities is Necessary to Ensure the Safe and Reliable Parallel Operation of those Facilities</u>

The fundamental purpose of the NCIP is to facilitate interconnection of generating facilities within the jurisdiction of the Commission and to ensure generating facilities safely and reliably operate in parallel with utility systems in North Carolina.[5] Consistent with their position in the recent 2017-2019 NCIP stakeholder process and proceedings, the Companies believe it is critical to inspect all Uninspected Facilities to ensure that they have been constructed consistent with the Companies' generally-applicable construction and design standards and will operate in a safe and reliable manner in compliance with terms of the Interconnection Agreement.

The pilot inspections Advanced Energy conducted on behalf of the Companies in 2018 and 2019 identified a number of safety and reliability issues related to the quality of the medium voltage construction and inverter settings.[6] Some of the most critical issues identified as part of the pilot inspections were as follows:

(1) Grounding issues outside the security fence, including missing, damaged, and/or insufficient grounding at overhead or pad-mounted equipment, which present a safety risk to the general public;

[5] See generally NC Interconnection Agreement, at 1.6.
[6] A copy of Advanced Energy's 2018/2019 Periodic Inspection Pilot Findings is attached hereto as Exhibit A.

(2) Grounding issues inside the security fence, including missing, damaged, and/or insufficient grounding at overhead or pad-mounted equipment, which present a safety risk to staff working inside the facility;

(3) Unguarded and uninsulated medium voltage ("MV") component, including gang operated air break ("GOAB") control rod insulator located too close to grade level, which presents a safety risk;

(4) Clearance issues, including insufficient conductor clearance between energized parts or between an energized part and grounded part, which presents a safety issue for switch operators and a reliability risk when coupled with wind or wild animal disruption;

(5) Incorrect MV cable terminations and bending radius at overhead riser pole and pad-mounted equipment, which presents a reliability risk as the cable may fail prematurely;

(6) Under-rated equipment, which presents a safety risk of failure during lineman operation and a reliability risk as the device may have a shorter than expected life;

(7) Undersized wire or cable, which presents a reliability risk as the conductor may have a heating issue and fail prematurely. In extreme cases, undersized conductors may cause fire, presenting a safety risk;

(8) Loose connection on MV or LV side, which presents a reliability risk;

(9) Vegetation management, which presents a reliability risk as overgrown vegetation may encroach on the energized component and prevent quick access for site maintenance;

(10) Unexpected equipment installed, which presents safety and reliability risks when the equipment was not studied as part of the Companies' interconnection process; and

(11) Inconsistent device settings, which presents a reliability risk where device settings do not follow the Companies' specifications.

Advanced Energy conducted similar inspection studies in 2014 and 2015, revealing similar safety and reliability issues.[7] In all three inspection studies (2014, 2015, and 2018/2019), installation of unstudied and unapproved equipment was of particular concern

[7] A copy of Advanced Energy's PV Interconnection Inspections Conducted for Duke Energy (June 17, 2015) is attached hereto as Exhibit B; a copy of Advanced Energy's Update on Advanced Energy's Solar PV Interconnection Assessments (June 22, 2016) is attached as Exhibit C.

to the Companies. By way of example, inverter manufacturers invariably specify the types of transformers that can be used with their inverters. When an incorrect transformer is used, Advanced Energy found that inverters do not always detect a loss of single-phase power on the three-phase utility distribution line. This creates a potential safety risk for the Companies' employees as well as others that may have a need to enter the premises.

In short, since at least 2014, the Companies have documented compliance issues with the Interconnection Request and Interconnection Agreement compliance and construction safety and reliability issues related to the Uninspected Facilities. Throughout this time period, the Companies have also consistently worked with industry stakeholders to determine the best way to accommodate inspections on a going forward basis.

Most recently, the Companies engaged with stakeholders in 2020 to develop the self-inspection plan through the Technical Standards Review Group ("TSRG") to achieve the twofold goals of (1) verifying the equipment installed in the field as compared to the equipment approved through the Interconnection Study process; and (2) ensuring the inverters and protective device settings match the Companies' specifications. Confirming this information through utility inspections or a reasonably developed self-inspection program is necessary to ensure safe and reliable parallel operation of generating facilities in a manner consistent with Companies' standards for operating and maintaining its own distribution system equipment and interconnected facilities.

B. <u>The Commission Should Clarify the Current Ambiguity in the 2019 NCIP</u>

In the Companies' view, it is clear from the face of Sections 6.5.2, 6.5.3, and 6.5.4 that the Commission intended to require both new *and already operating facilities* to submit to regular inspections to ensure utilities are "in a position to ensure the safety and integrity of the grid."[8] CCEBA's reading of the 2019 NCIP would render Section 6.5.2 meaningless as there are no "Generating Facilit[ies] that [were] not inspected prior to commencing parallel operation" and also did not have a fully executed Interconnection Agreement prior to June 14, 2019.[9] CCEBA's position would also significantly limit the periodic inspections provided for in Section 6.5.3 to only recently-connected generating facilities. CCEBA's position would also seemingly limit the Companies from inspecting pre-2019 interconnected generating facilities under Section 6.5.4 where "the Utility identifies or becomes aware of any condition that (1) has the potential to either cause disruption or deterioration of service to other customers served from the same electric system or cause damage to the Utility's System or Affected Systems, or (2) is imminently likely to endanger life or property or cause a material adverse effect on the security of, or damage to the Utility's System, the Utility's Interconnection Facilities or the systems of others to which the Utility's System is directly connected."

As highlighted above, the Companies believe the record and the Commission's intentions in approving the inspection requirements in the 2019 NCIP Order are clear based on its finding that "[i]t is critical that the Utilities be in a position to ensure the safety and integrity of the grid."[10] CCEBA's position on these issues impedes the Companies from meeting the Commission's directive by raising doubt whether these inspection requirements apply to Uninspected Facilities.

To preserve the intent of these sections, the Companies respectfully request that the Commission take action to clarify its 2019 NCIP order either by (1) entering an order

---

[8] 2019 NCIP Order at 21.
[9] *See* NCIP §§ 1.1.3, 6.5.2.
[10] 2019 NCIP Order at 21.

explicitly stating that the exclusionary language in Section 1.1.3—i.e., that the 2019 NCIP revisions do not apply to Generating Facilities with a fully executed Interconnection Agreement as of June 14, 2019—does not apply to Section 6.5.2; or (2) adopting the following minor revisions to Sections 1.1.3 and 6.5.2:

> 1.1.3 **Except as otherwise provided herein,** the 2019 revisions to this interconnection Standard shall not apply to Generating Facilities having a fully executed Interconnection Agreement as of the effective date of the 2019 revisions to this Standard, unless the Interconnection Customer proposes a Material Modification, transfers ownership of the Generating Facility, or supplication of the 2019 revisions to the Commission's interconnection standard are agreed to in writing by the Utility and the Interconnection Customer.
>
> 6.5.2 **Notwithstanding Section 1.1.3,** in the case of any Generating Facility that was not inspected prior to commencing parallel operation, the Utility shall be authorized to conduct an inspection of the medium voltage AC side of each Generating Facility (including assessing that the anti-islanding process is operational). The Interconnection Customer shall pay the actual cost of such inspection within 30 Business Days after the Utility provides a written invoice for such costs.
>
> 6.5.3 **Notwithstanding Section 1.1.3, t**he Utility shall also be entitled, on a periodic basis, to inspect the medium voltage AC side of each Interconnected Generating Facility on a reasonable schedule determined by the Utility in accordance with the inspection cycles applicable to its own distribution system. The Interconnection Customer shall pay the actual cost of such inspection within 30 Business Days after the Utility provides a written invoice for such costs.
>
> 6.5.4 **Notwithstanding Section 1.1.3,** The Utility shall also be entitled to inspect the medium voltage AC side of an Interconnected Generating Facility in the event that the Utility identifies or becomes aware of any condition that (1) has the potential to either cause

> disruption or deterioration of service to other customers served from the same electric system or cause damage to the Utility's System or Affected Systems, or (2) is imminently likely to endanger life or property or cause a material adverse effect on the security of, or damage to the Utility's System, the Utility's Interconnection Facilities or the systems of others to which the Utility's System is directly connected. The Interconnection Customer shall pay the actual cost of such inspection within 30 Business Days after the Utility provides a written invoice for such costs.

Finally, the Companies also highlight that Section 1.1.3 provides that the Utility and the Interconnection Customer may agree to the applicability of these new standards in writing.[11] Based on CCEBA's recent actions and positions, regulatory action by the Commission seems necessary to ensure the Commission's intent in enacting these provisions is achieved. However, the Companies continue to be willing to engage with CCEBA and other stakeholders to discuss how to accomplish the inspections provided for in these sections in a reasonable manner that minimizes costs for Interconnection Customers while ensuring the Companies can meet their obligations to ensure the safety and integrity of the grid.

III. CONCLUSION

There is overwhelming evidence demonstrating that inspection of the Uninspected Facilities is necessary to ensuring the safety and reliability of those facilities and the integrity of the Companies' grid. CCEBA's position fails to account for the Commission's intent in adopting these provisions and does not match the robust discussion regarding

[11] NCIP § 1.1.3 (provides that the updated NCIP may become applicable to operating facilities where the Interconnection Customer proposes a Material Modification, transfers ownership of the Generating Facility, or application of the current standard are agreed to in writing by the Utility and the Interconnection Customer).

inspection of post-commissioned facilities that has taken place over the course of many years in this docket as well as in the TSRG. Accordingly, the Companies respectfully request that the Commission provide clarification that will allow the Companies and stakeholders to proceed with the self-inspection pilot program they have jointly developed with TSRG over the past year.

Respectfully submitted, this 29th day of March, 2021.

Jack E. Jirak
Associate General Counsel
Duke Energy Corporation
P.O. Box 1551/NCRH 20
Raleigh, North Carolina 27602
Telephone: (919) 546-3257
Jack.Jirak@duke-energy.com

E. Brett Breitschwerdt
McGuireWoods LLP
501 Fayetteville Street, Suite 500
PO Box 27507 (27611)
Raleigh, North Carolina 27601
Telephone: (919) 755-6563
bbreitschwerdt@mcguirewoods.com

Counsel for Duke Energy Carolinas, LLC and Duke Energy Progress, LLC

EXHIBIT A

advanced energy

2018/2019 Periodic Inspection Pilot Findings

Advanced Energy

February 11, 2021

EXHIBIT A

Advanced Energy

Advanced Energy is a nonprofit energy consulting firm. We work with electric utilities, government and a wide variety of private organizations in the residential, commercial and industrial, solar, motors and drives and electric vehicle markets. Our customized services include research, testing, training, consulting and program design.

advanced energy

Periodic Inspection History

- June 2016 – Duke Energy implemented an interconnection commissioning process for all new distribution connected solar PV sites > 1 MW
- Approx. 300 sites interconnected prior to June 2016 had limited or no commissioning conducted
- 2018/2019 – Duke Energy conducted a periodic inspection pilot of some older sites to inform the development of a periodic inspection program
- 2020/2021 – Duke Energy developing a self-inspection program for previously uninspected generating facilities. Self-inspection pilot beginning in early 2021.

Training Purpose

- Present the technical findings from the nine sites in the 2018/2019 periodic inspection pilot
- Provide examples of safety, reliability and power quality issues to look for in a self-inspection
- Not a comprehensive list of all items that could be found in a self-inspection
- Not a training on the self-inspection program details. The self-inspection program is still under development through the 2021 pilot process.

2018/2019 Periodic Inspection Pilot

- Pilot inspections were conducted in 2018 (4 sites) and 2019 (5 sites)
- Pilot sites ranged in capacity from 2 to 5 MW and entered service in 2012 to 2015
- All sites were inspected from the AC side of the inverters to the point of interconnection (POI)
- Pilot inspection scope:
  - Interconnection construction quality
  - Inverter settings
  - Expected vs. installed interconnection equipment

EXHIBIT A

Construction Quality Categories

- **Immediate safety issues** – Construction quality problems that violate industry codes and standards, and are imminently likely to endanger life or property or damage either the utility's system or customer's generating facilities.
- **Potential reliability or power quality issues** – Construction quality problems that may develop over time into something with the potential to either cause disruption or deterioration of service to other customers.

advanced energy

EXHIBIT A

Construction Quality Issues

- Construction quality issues are based on non-conformance with:
  - National Electrical Safety Code (NESC)
  - National Electrical Code (NEC)
  - Good Utility Practice *(defined by the North Carolina Interconnection Procedures, Forms, and Agreements for State-Jurisdictional Generator Interconnections)*
    - Examples:
      - Duke Energy distribution construction standards
      - USDA Rural Utilities Service (RUS) bulletins
      - IEEE standards and recommended practices

advanced energy

EXHIBIT A

Overview of Periodic Inspection Pilot Findings

Interconnection Construction Quality

- ☒ 8 of 9 sites had immediate safety issues
- ☒ All sites had potential reliability or power quality issues

Inverter Settings

- ☑ 1 site had correct settings
- ☒ 8 sites had incorrect settings

Equipment Agreement with Utility Documentation

- ☑ 5 sites agreed
- ☒ 4 sites disagreed

advanced energy

EXHIBIT A

Overview of Periodic Inspection Pilot Findings

Site #	# Immediate Safety Issues	# Potential Reliability or Power Quality Issues
1	0	4
2	3	3
3	3	5
4	2	11
5	3	9
6	1	7
7	2	2
8	2	10
9	2	12
Avg	**2**	**7**

advanced energy

EXHIBIT A

Overhead Line Construction and Equipment Installation

advanced energy

EXHIBIT A

GOAB Pole

Immediate Safety Issues

Immediate Safety Issues – GOAB Pole

Insufficiently Grounded GOAB

- Gang Operated Air Break (GOAB) switch pole ground cut just above grade
- GOAB switch is unsafe to operate, so site cannot be safely de-energized by O&M personnel

NESC 123A and 215C1; NEC 250.190(A); Duke 08.10-37; RUS 1728F-803 drawings H3.1 and H4.1

advanced energy

EXHIBIT A

Immediate Safety Issues – GOAB Pole

Control Rod Insulator

The GOAB control rod insulator is located too close to grade level, creating a hazard for the switch operator.

NESC 123A and 215C1; NEC 110.3(B) and 250.190(A); RUS 1728F-803 drawing VS2.32

Immediate Safety Issues – GOAB Pole

Control Rod Attachment

All GOAB handle and control rod brackets are very loose due to pole drying/shrinkage, lack of maintenance and lack of locking hardware, making the switch unsafe for operation.

NESC 012C, 120A and 121A; NEC 90.1(B), 110.3(B), 110.12 and 110.13; RUS 1728F-803 locknuts; Duke 03.00-100D lockwashers

advanced energy

EXHIBIT A

GOAB Pole

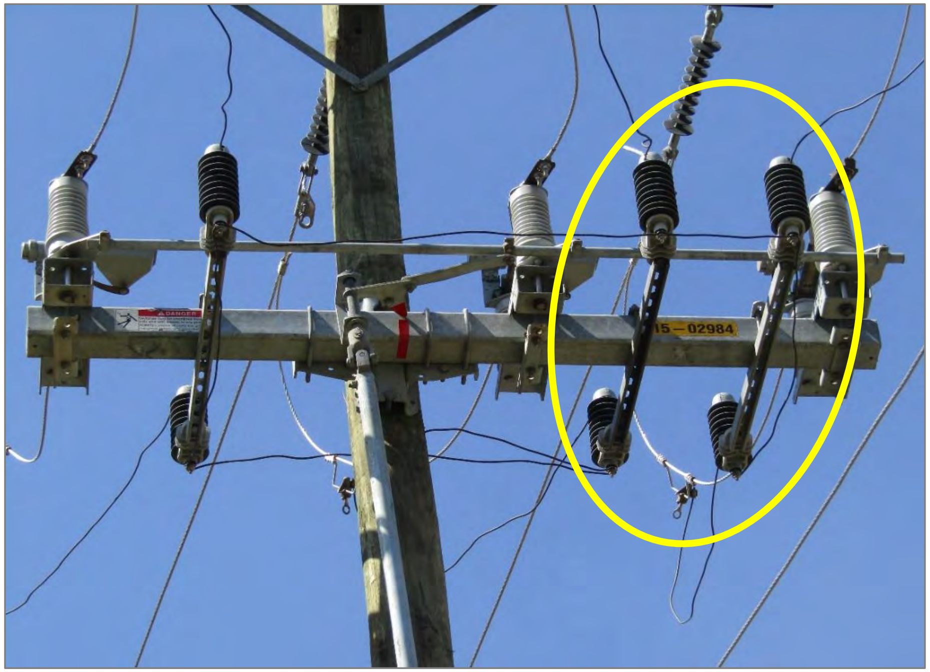
Potential Reliability and Power Quality Issues

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Insufficient Conductor Clearances

- Incorrect arrester mounting brackets and mounting locations cause insufficient phase-to-phase and phase-to-ground clearances
- 12 inches phase-to-phase and phase-to-ground clearance where NESC requires 18 inches minimum
- Arresters are unnecessary for normally closed GOAB switches on solar facilities



NESC Tables 235-1 and 235-5

advanced energy

EXHIBIT A

NESC Tables 235-1 and 235-5 Minimum Conductor Clearances

Nominal Voltage Phase-to-Phase (kV)	Horizontal Phase-to-Phase (in.)	Horizontal Phase-to-Ground (in.)	Vertical Phase-to-Phase (in.)	Vertical Phase-to-Ground (in.)
12.5	14	12	18	16
23	18	14	22	18

advanced energy

Duke Energy Minimum Conductor Clearances

Nominal Voltage Phase-to-Phase (kV)	Phase-to-Phase (in.)	Phase-to-Ground (in.)
Bare Energized Parts and Conductors		
12.5	24	24
23	24	24
Covered Energized Parts and Conductors		
12.5	18	18
23	18	18

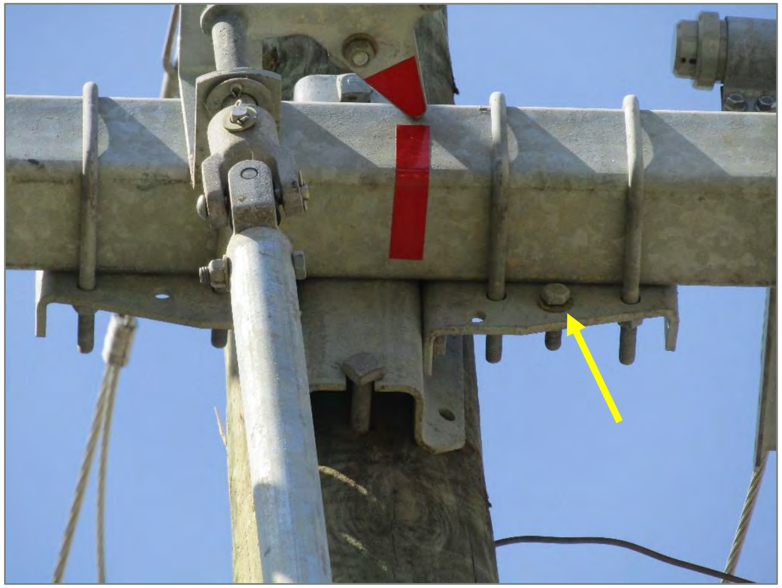
These clearances are required for facilities commissioned after June 2016. They are not applicable to the nine facilities in this pilot because they were built before 2016.

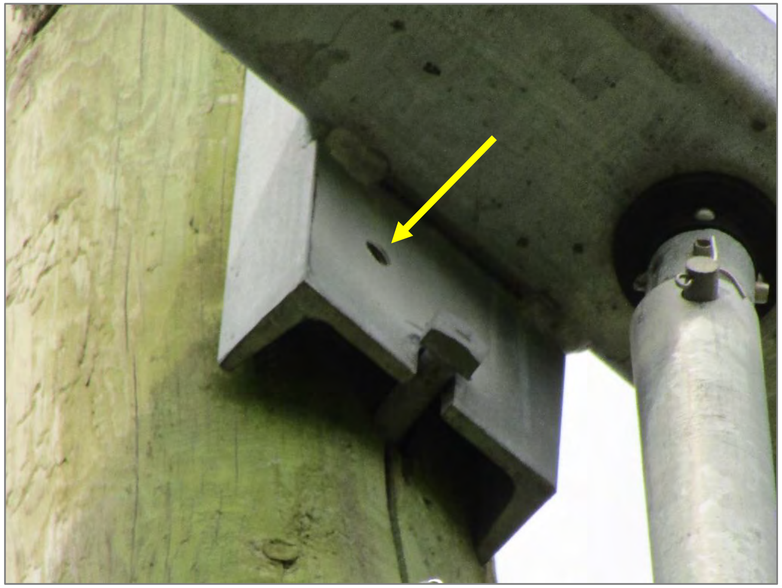
DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; Duke 06.00-120

Reliability & Power Quality Issues – GOAB Pole

Ungrounded GOAB Switch Frame

- Missing GOAB frame ground lug
- Missing 2 AWG solid copper jumper from GOAB frame to system neutral





NESC 123A and 215C1; NEC 250.190(A); Duke 08.10-37

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Missing GOAB Switch Ground Grid

Control rod operated GOAB switches must have a ground grid equivalent to **one** of the following:

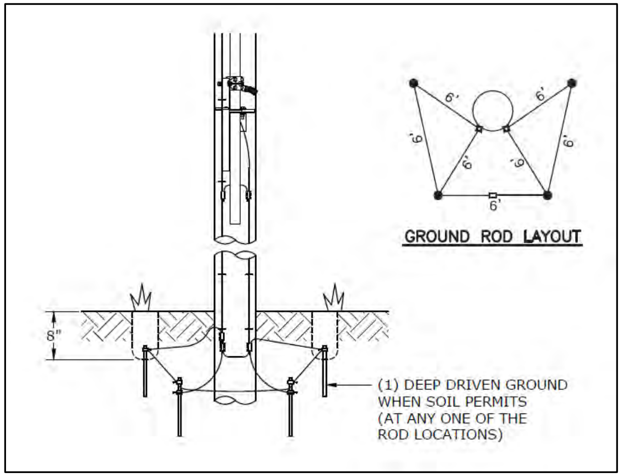
- Duke Energy (FMO) standard 08.10-37
- RUS Bulletin 1728F-804 drawing H3.1
- RUS Bulletin 1728F-804 drawing H4.1

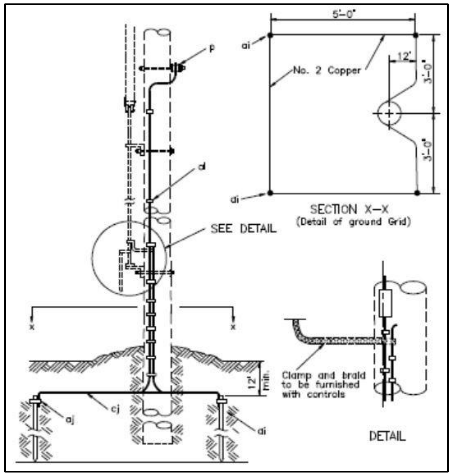
Duke Energy GOAB ground grid with 2 AWG bare solid copper wire grid loop and four ground rods

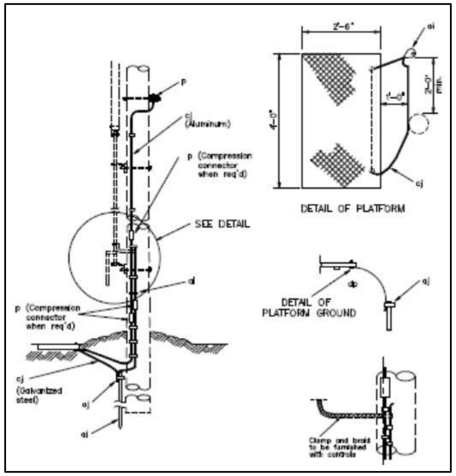
NESC 123A and 215C1; NEC 250.190(A); Duke 08.10-37; RUS 1728F-803 drawings H3.1 and H4.1

Reliability & Power Quality Issues – GOAB Pole

GOAB Switch Ground Grid Options







Duke Energy std. 08.10-37 four rods and 2 AWG solid copper wire grid loop. One 20 ft. deep driven rod required. Other three rods 8 ft. minimum

RUS Bulletin 1728F-804 drawing H3.1 four rods and 2 AWG solid copper wire loop

RUS Bulletin 1728F-804 drawing H4.1 galvanized steel platform, one rod and 2 AWG solid copper loop

NESC 123A and 215C1; NEC 250.190(A); Duke 08.10-37; RUS 1728F-803 drawings H3.1 and H4.1

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Inadequate GOAB Platform Ground

- An undersized 4 AWG solid copper pole ground is installed where 2 AWG solid copper is required
- An undersized 6 AWG bare stranded copper switch platform ground wire is installed where 2 AWG bare solid copper is required
- The platform has a single connection to the pole ground where it is required to have a looped connection from the pole ground, to the ground rod, to two connections on opposite sides of the platform, back to the pole ground

Duke 08.10-37; RUS 1728F-803 drawings H3.1 and H4.1

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Missing GOAB Ground Grid

Single 2 AWG bare stranded copper pole ground goes below grade to a ground rod instead of a looped ground grid.

Duke 08.10-37; RUS 1728F-803 drawings H3.1 and H4.1

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Pole Ground Splice

- Pole ground splice made with a mechanical connector
- 3 wires connected with a split-bolt connector rated for 2 wires
- Compression connectors are required

NEC 110.3(B); Duke 02.03-102B; RUS 1728F-803 Construction Specifications for Grounding and drawings H3.1 and H4.1

advanced energy

Reliability & Power Quality Issues – GOAB Pole

Pole Ground Connection to Neutral

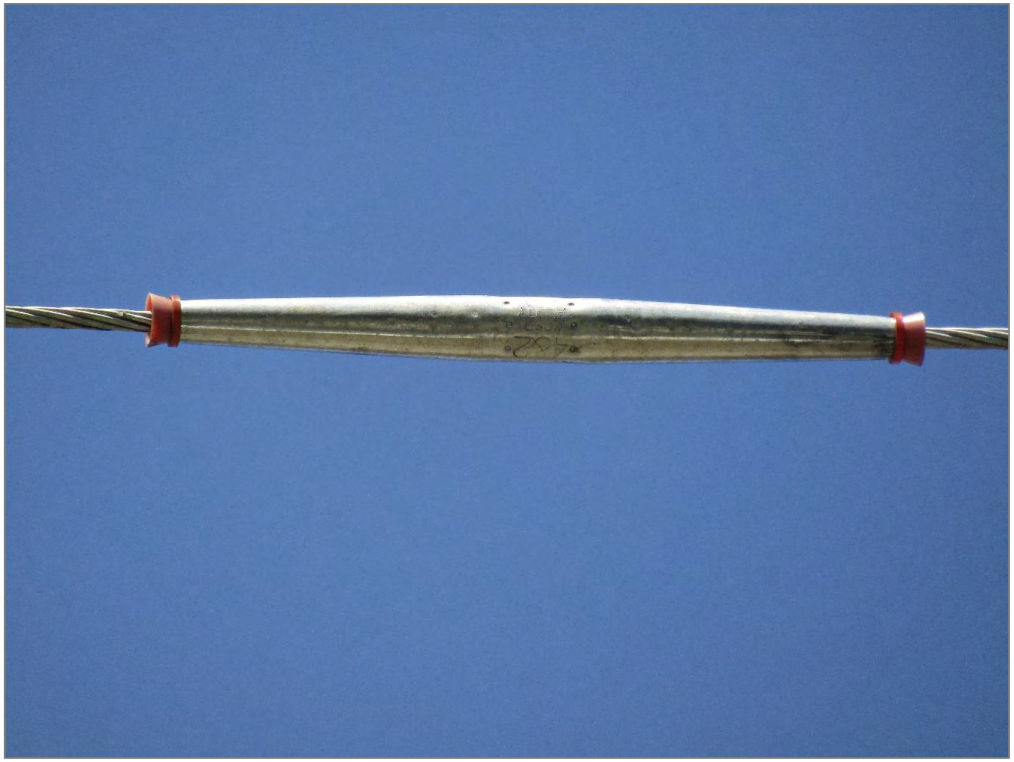
- Pole ground connection to system neutral using a mechanical connector
- A compression connector is required

Duke 02.03-102B; RUS 1728F-803 Construction Specifications for Grounding and drawings H3.1 and H4.1

Reliability & Power Quality Issues – GOAB Pole

Automatic Splice in Slack Span

- Automatic splice used in slack spans between GOAB and Duke meter pole
- Compression slice required
- Automatic splices are prohibited in slack spans because they require tension and can vibrate loose



NEC 110.3(B); Duke 04.02-102 and 04.09-120

EXHIBIT A

Reliability & Power Quality Issues – GOAB Pole

Vegetation Management

- Overgrown vegetation makes safe operation of the GOAB control rod difficult
- Overgrowth at this site concealed a cut GOAB pole ground conductor, making operation of the GOAB switch unsafe
- Overgrown deep ruts and large groundhog holes, making navigation at the point of interconnection dangerous

NESC 012, 120A, 121A and 218A1; DE Legacy Carolinas Dist. Manuals, Line Clearance, 1.8 - Brush Cutting

advanced energy

EXHIBIT A

GOAB/Riser Pole

Immediate Safety Issues

advanced energy

Immediate Safety Issues – GOAB/Riser Pole

Ungrounded Guy Wires

- The guy wires at the riser pole are not grounded
- The upper guy wire is installed above energized parts but does not have a guy insulator stick
- The guy wires are located outside the facility fence, creating a risk to the public

NESC 092C2 and 215C2a; Duke 02.04-100; RUS 1728F-803 Construction Specifications for Grounding and drawing E5.1G

EXHIBIT A

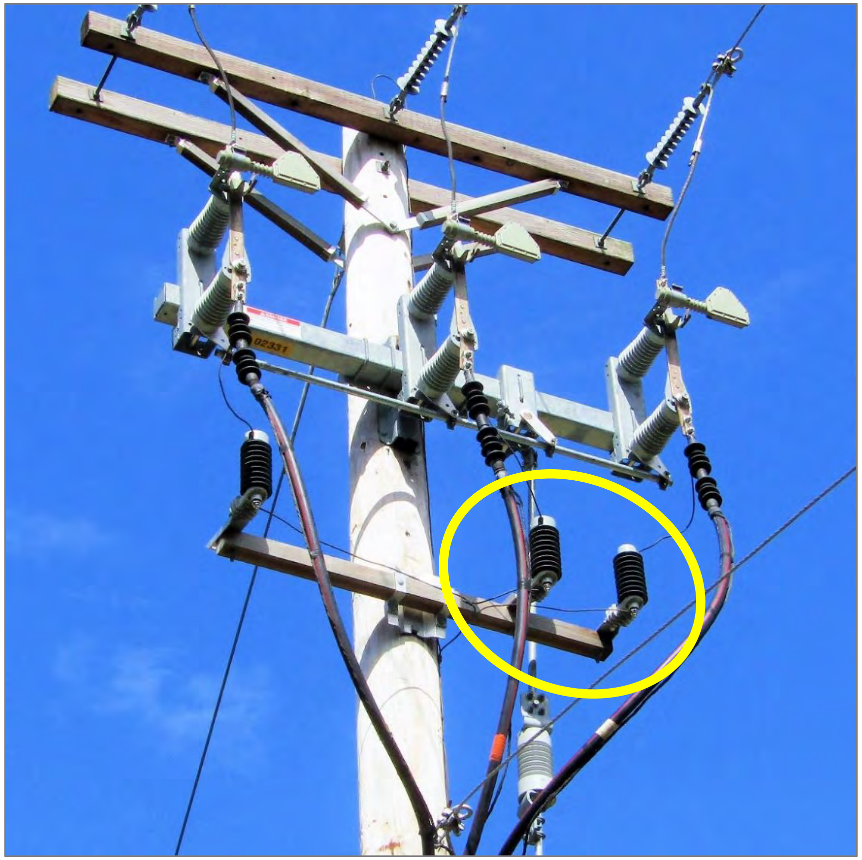
GOAB/Riser Pole

Potential Reliability and Power Quality Issues

Reliability & Power Quality Issues – GOAB/Riser Pole

Insufficient Clearance

12 inches of phase-to-phase clearance between lightning arrester primary terminals where NESC requires 18 inches minimum



NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; Duke 06.00-120

advanced energy

EXHIBIT A

Meter Pole

Immediate Safety Issues

advanced energy

Immediate Safety Issues – Meter Pole

Ungrounded Guy Wires

- The guy wires are not grounded
- The lower guy wire connects to the pole above the system neutral less than 24 inches below energized primary parts and does not have a guy insulator installed
- The guy wires are located outside the facility fence, creating a risk to the public

NESC 092C2 and 215C2a; Duke 02.04-100; RUS 1728F-803 Construction Specifications for Grounding and drawing E5.1G

advanced energy

EXHIBIT A

Meter Pole

Potential Reliability and Power Quality Issues

advanced energy

Reliability & Power Quality Issues – Meter Pole

Vegetation Management

Overgrown vegetation at the customer meter pole was cut by O&M staff during inspection visit, revealing hazardous deep ruts and large groundhog holes.

NESC 012, 120A, 121A and 218A1; DE Legacy Carolinas Dist. Manuals, Line Clearance, 1.8 - Brush Cutting

EXHIBIT A

OFFICIAL COPY

Mar 29 2021

Reliability & Power Quality Issues – Meter Pole

Insufficient Clearances

- 12 inches vertical phase-to-ground clearance where NESC requires 18 inches minimum
- System neutral and meter frame too close to crossarm results in congested meter pole framing with insufficient clearances

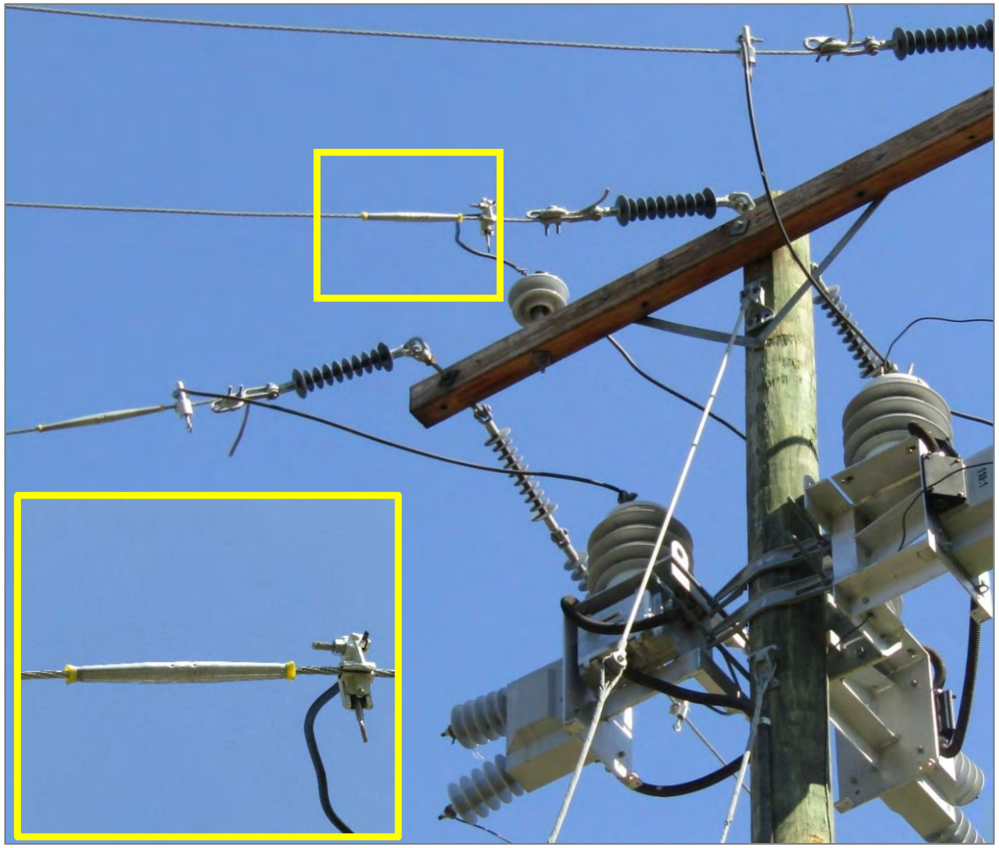
NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; Duke 06.00-120

advanced energy

Reliability & Power Quality Issues – Meter Pole

Automatic Splices in Slack Span

- Automatic splices in slack span instead of compression splices
- Splices within 1 ft of pole line hardware
- Splices must be min.10 ft from hardware on new construction and min. 2 ft for repair work



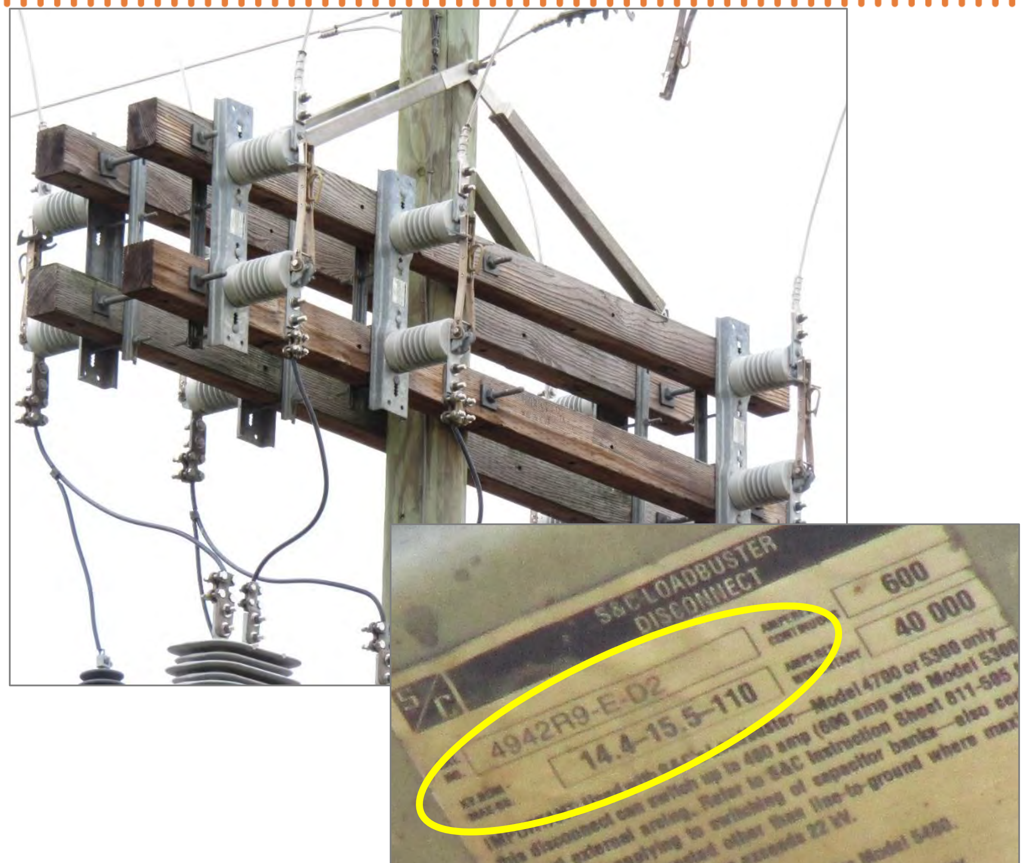
NEC 110.3(B); Duke 04.02-102 and 04.09-120; RUS 1728F-803 Conductor Installation Specifications

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Meter Pole

Insufficient Switch Voltage Rating



- 14.4 kV switches used where 27 kV switches are required for 23 kV nominal voltage
- 14.4 kV switches only have 110 kV BIL
- 125 BIL required for 23 kV system

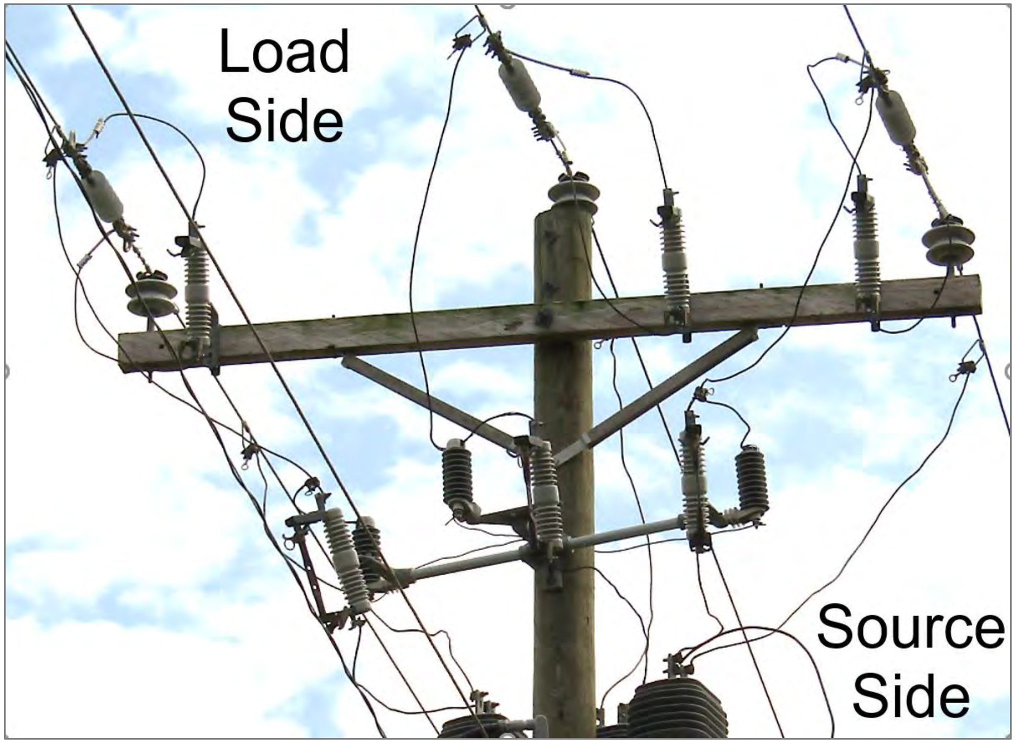
NESC 173A; NEC 110.3(B), 110.4 and 490.21(C)(4); RUS 1728F-803 drawings VS2.01 and VQ4.1; Duke 08.02-110B

advanced energy

Reliability & Power Quality Issues – Meter Pole

Backwards Framed Meter Pole

- Pole is built backwards so cutouts cannot be opened safely without first de-energizing the site
- Meter and bypass cutouts are reverse fed, with utility source connected to the bottom, causing the blades to remain energized when the switches are opened



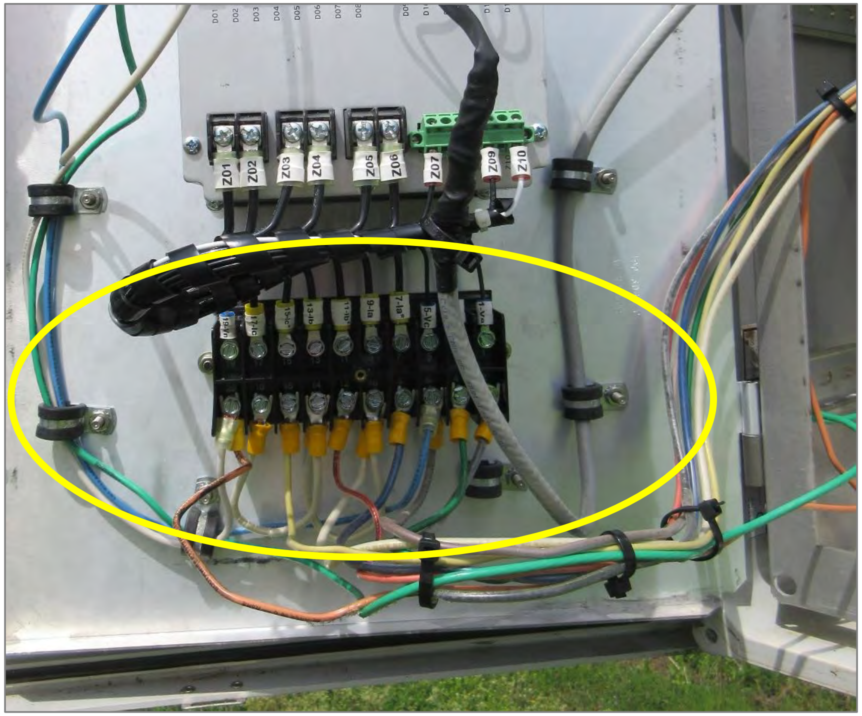
DEC-DEM Distribution Standards Manual-Part 1 – 88420DUK; Duke 11.01-09; RUS 1728F-803 drawings VS1.01

EXHIBIT A

Reliability & Power Quality Issues – Meter Pole

Meter Field Wiring

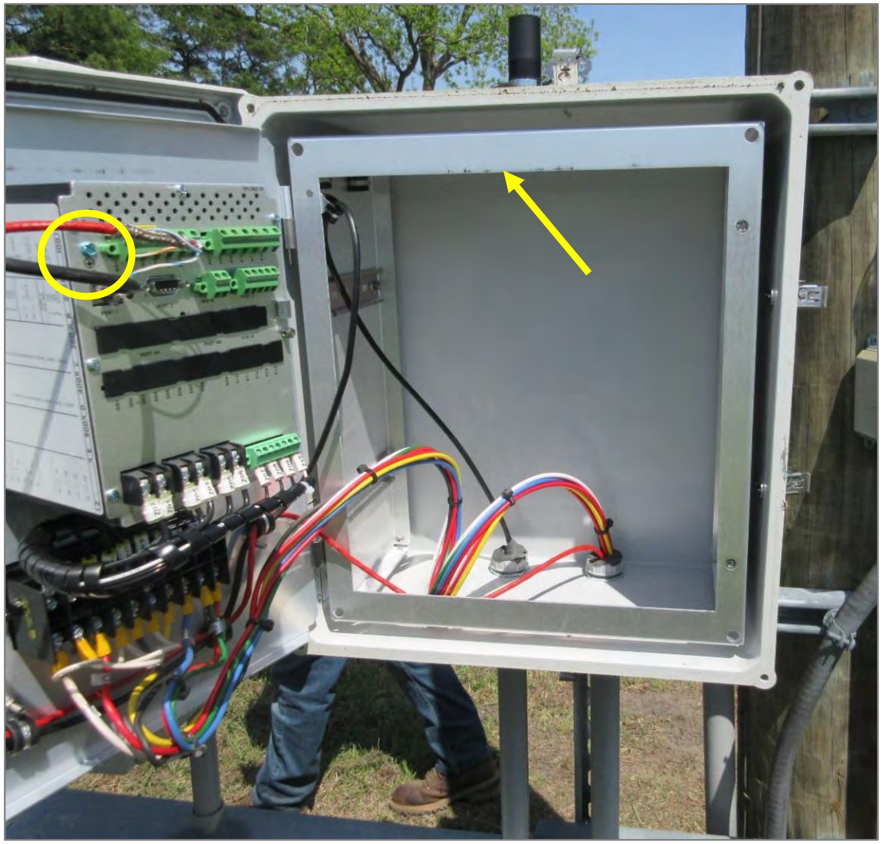
- 12 AWG solid copper field wiring used on hinged door mounted meter test switch
- All crimp-on fork terminals were loose on field installed solid wiring
- Crimp terminals are only listed for stranded wiring
- Several terminals came loose when door was opened due to stiff wire and loose connections
- Stranded wire is required for flex hinged door wiring



Reliability & Power Quality Issues – Meter Pole

Meter Grounding

- Pole mounted aluminum meter enclosure not bonded to pole ground
- Meter chassis not grounded at green marked grounding screw



NESC 123A and 215C1; NEC 110.3(B), 250.4(A)(2) and 250.190; Duke 11.00-01, 02.03-110 and 20.04-143; RUS 1728F-803 Construction Specifications for Grounding

advanced energy

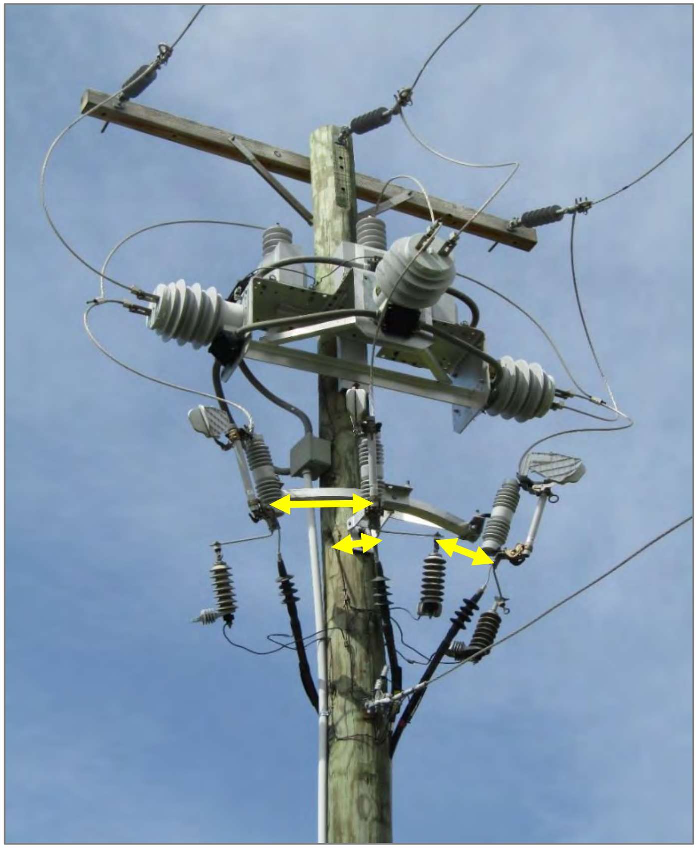
EXHIBIT A

Meter/Riser Pole

Potential Reliability and Power Quality Issues

Reliability & Power Quality Issues – Meter/Riser Pole

Insufficient Clearances



- Meter/riser pole with undersized 12 kV COLA bracket where 23 kV bracket is required
- Insufficient phase-to-ground clearance of 8 inches where NESC requires 14 inches min
- Insufficient phase-to-phase clearance of 12 inches where NESC requires 18 inches min

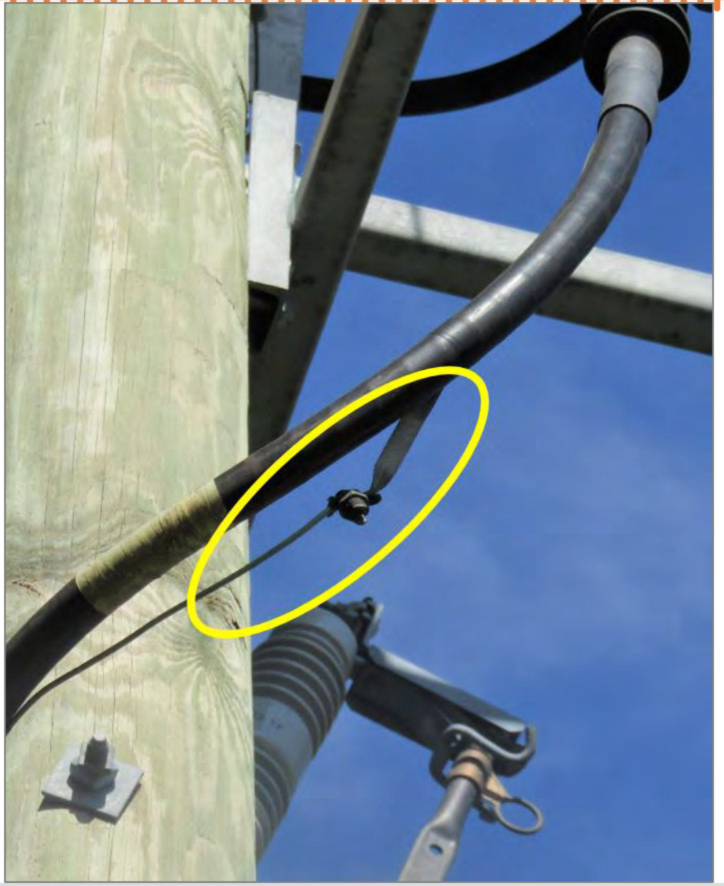
NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK

EXHIBIT A

Reliability & Power Quality Issues – Meter/Riser Pole

Undersized Terminator Braid Jumpers

- The 10 AWG insulated copper ground jumper is undersized for the 6 AWG copper terminator ground braid
- The conductor must be equivalent in circular mils to the ground braid to be sufficient to carry neutral current



NEC 110.3(B) and 250.190(C); IEEE 576 section 14.2(h)

EXHIBIT A

Riser Pole

Immediate Safety Issues

advanced energy

EXHIBIT A

OFFICIAL COPY

Mar 29 2021

Immediate Safety Issues – Riser Pole

Undersized MV Cable

- Summer riser ampacity of 1/0 AWG AL MV cable is 160 Amps
- Facility rated current is 232 Amps

NESC 160; NEC Table 310.60(C)(74); Duke 23.01-109

advanced energy

Immediate Safety Issues – Riser Pole

Unsafe Disconnect Switches

- 6 inches phase-to-phase clearance when opening switch
- 9 inches phase-to-ground clearance when opening switch
- NESC requires 14 inches phase-to-phase and 12 inches phase-to-ground minimum on 12 kV system

NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; Duke 21.05-100

advanced energy

EXHIBIT A

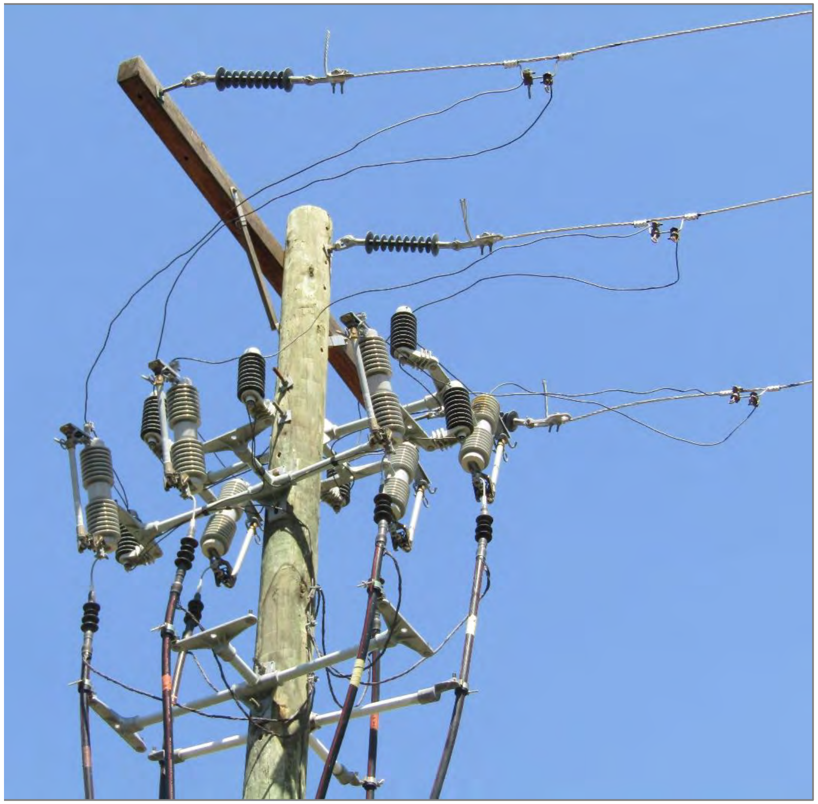
Riser Pole

Potential Reliability and Power Quality Issues

advanced energy

Reliability & Power Quality Issues – Riser Pole

Insufficient Clearances



- Non-standard and incorrect framing of double-riser pole causes clearance problems
- Many instances of insufficient phase-to-ground clearances less than NESC horizontal and vertical requirements of 14 and 18 inches respectively
- Incorrect positioning of arresters above energized parts will result in phase-to-ground faults if arresters blow
- Bare copper jumpers and missing animal guards exacerbates the problems

NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; Duke 21.03-105

advanced energy

Reliability & Power Quality Issues – Riser Pole

Insufficient Clearances

- Arrester ground leads too close to MV cable terminations of opposite phase
- 8 inches of phase-to-ground clearance where NESC requires 14 inches minimum

NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; DEP Legacy (2007) 21.02-01; Duke 21.03-110

advanced energy

EXHIBIT A

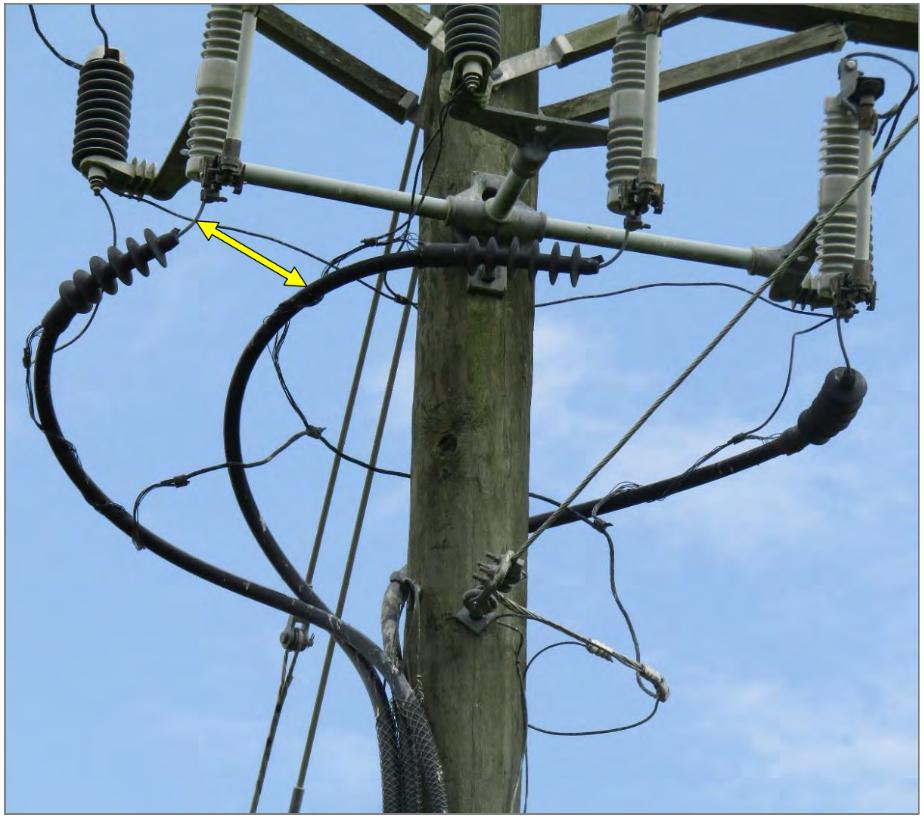
OFFICIAL COPY

Mar 29 2021

Reliability & Power Quality Issues – Riser Pole

Incorrect Terminator Orientation

- Terminators installed horizontally instead of vertically
- Insufficient phase-to-ground clearance between termination and concentric neutral of opposite phases
- Orientation results in buildup of pollution on the terminators, leading to premature failure



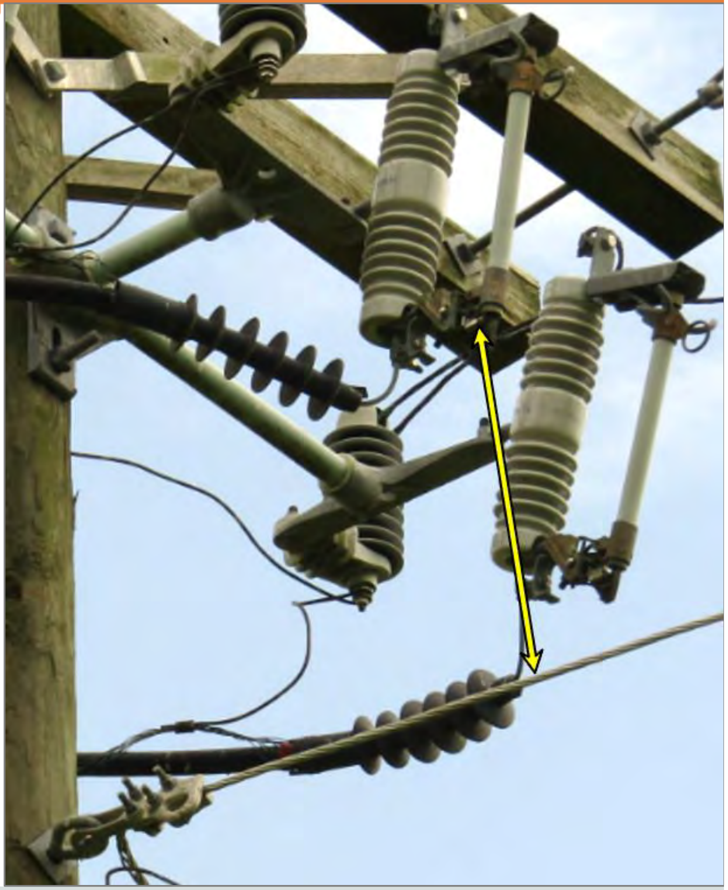
NESC Tables 235-1 and 235-5; NEC 110.3(B); DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; DEP Legacy (2007) 21.02-01; Duke 21.03-110

advanced energy

Reliability & Power Quality Issues – Riser Pole

System Neutral Elevation

- System neutral installed too high
- Results in insufficient phase-to-ground clearance when cutout is opened
- Likely to cause a flashover when the middle phase cutout is open
- Requires terminators to be incorrectly installed horizontally



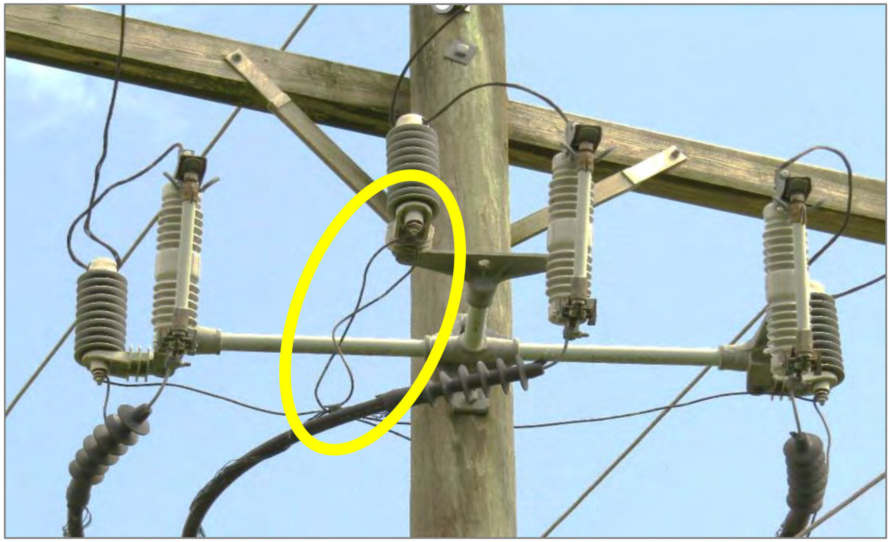
NESC Tables 235-1 and 235-5; DEC-DEM Distribution Standards Manual-Part 1 – 10003DUK and 88420DUK; DEP Legacy (2007) 21.02-01; Duke 21.03-110

advanced energy

EXHIBIT A

Incorrect Arrester Grounding

The lightning arrester ground leads are incorrectly connected to both the neutral bus and to the MV cable concentric neutrals. If an arrester fails it is likely to cause a phase-to-ground fault.



Reliability & Power Quality Issues – Riser Pole

Undersized Equipment Jumpers

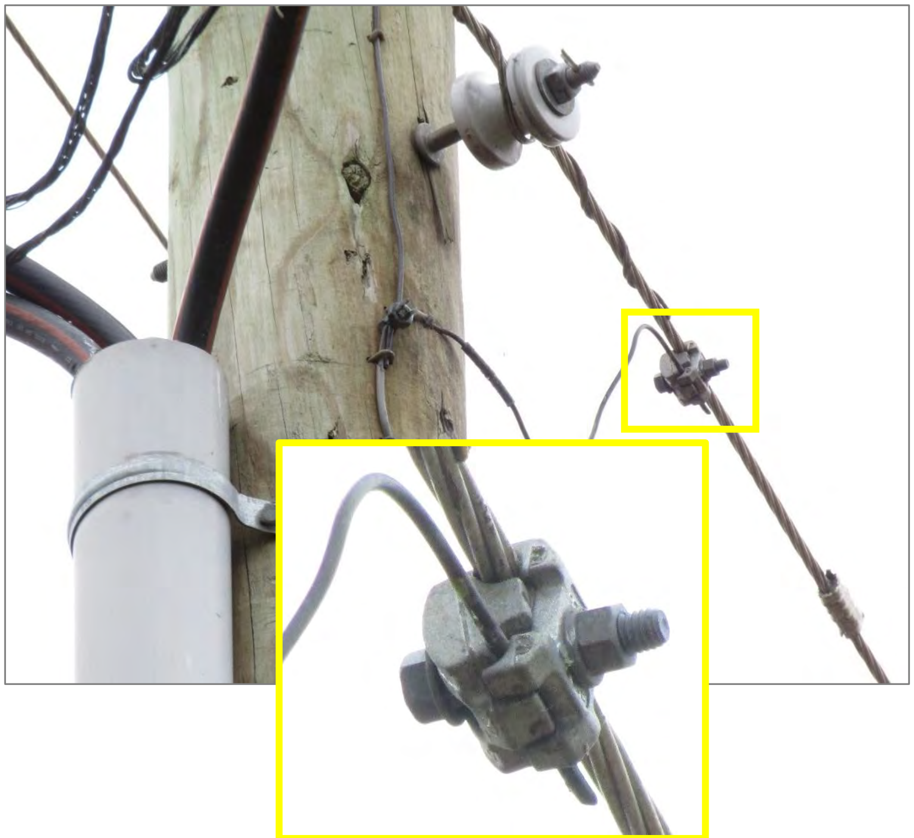
- 2 AWG stranded bare copper equipment jumpers are undersized for 232 Amp site rated current
- Minimum 1/0 AWG covered copper jumpers are required for rated current and wildlife protection

NESC 160; NEC Table 310.15(B)(21); Duke 05.01-105

EXHIBIT A

Reliability & Power Quality Issues – Riser Pole

Pole Ground Connection to Neutral



- Pole ground connection to system neutral using a mechanical connector
- A compression connector is required

Duke 02.03-102B; RUS 1728F-803 Construction Specifications for Grounding

EXHIBIT A

Pad-Mounted Equipment Installation

advanced energy

EXHIBIT A

Junction Enclosures

Immediate Safety Issues

advanced energy

EXHIBIT A

Immediate Safety Issues – Junction Enclosures

Ungrounded Junction Plates

- Missing ground lugs and ungrounded junction plates in MV junction enclosure
- Results in a buildup of static charge on semi-conductive junction bodies, which presents a safety hazard to personnel
- May cause premature failure of junction due to corona discharge

NESC 314B; NEC 110.3(B) and 250.190(A); RUS 1728F-806 section 13 and drawing UH3.1

advanced energy

EXHIBIT A

Junction Enclosures

Potential Reliability and Power Quality Issues

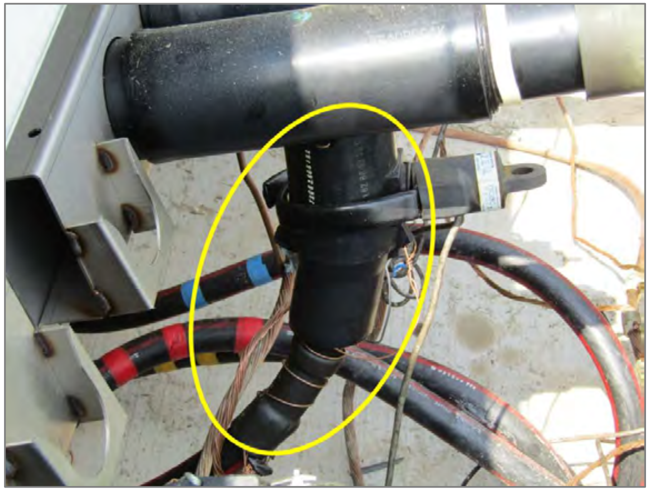
advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Junction Enclosures

MV Cable Bending Radius

Excess cable length results in insufficient bending radius and deformation of the T-bodies. This can lead to premature cable and elbow failure.



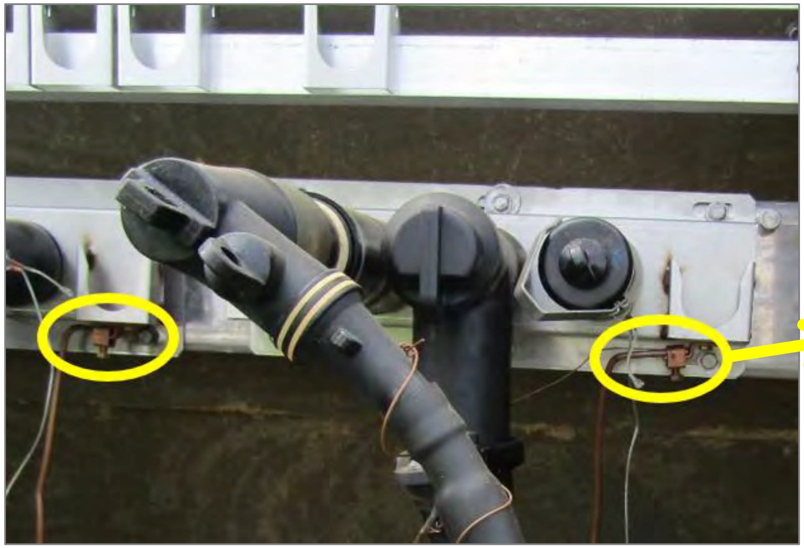
NESC 351A2; NEC 110.3(B) and 300.34; Duke 23.01-105; RUS 1728F-806 section 9

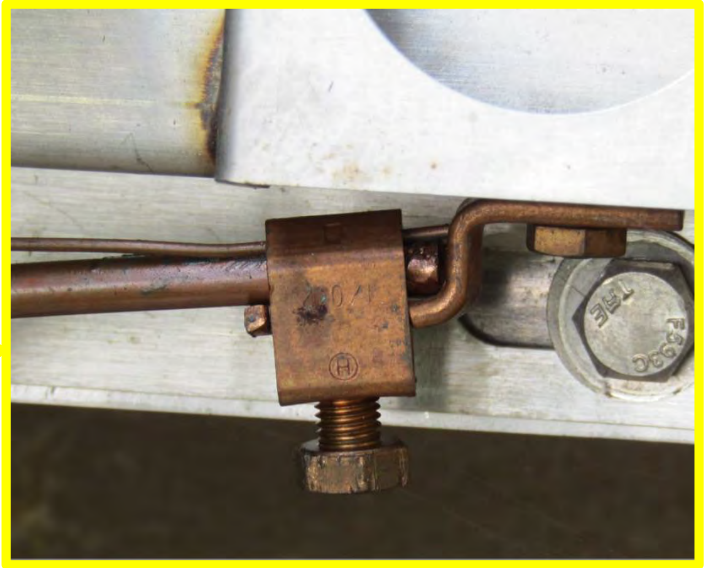
advanced energy

Reliability & Power Quality Issues – Junction Enclosures

Improper Grounding

Two wires are installed in a lug that is only designed to accept one wire, so neither wire is ensured to maintain a good connection.





NEC 110.3(B) and 110.14(A)

advanced energy

EXHIBIT A

Transformers

Immediate Safety Issues

advanced energy

Immediate Safety Issues – Transformers

H0 Bushing Grounding

- H0 bushing not directly connected to transformer ground loop
- H0 bushing only grounded through the transformer tank
- Requires neutral current to flow through steel tank to return to MV cable neutrals

NEC 200.2(B); Duke 27.04-124

Immediate Safety Issues – Transformers

Blown Lightning Arrester

- Blown lightning arrester in MV transformer
- Interior of blown arrester body remains energized and is open, resulting in an uninsulated accessory
- Open arrester body is subjected to moisture and is prone to carbon tracking
- Creates a safety hazard for O&M personnel

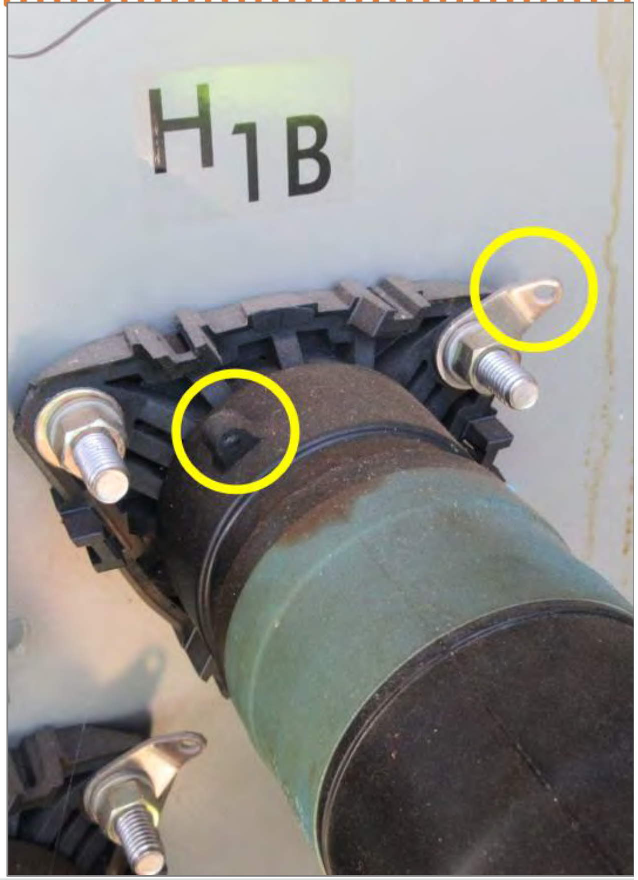
NESC 012C, 120A and 121A; NEC 90.1(B) and 110.12(B); Duke 01.06-100

advanced energy

Immediate Safety Issues – Transformers

Missing Elbow and Bushing Drains

- Missing electrostatic drain ground wires on transformer bushing inserts, cable elbows and elbow arresters
- Results in a buildup of static charge on bushing accessories, which presents a safety hazard to personnel
- May cause premature failure of accessories due to corona discharge
- Electrostatic drain wires must be 14 AWG bare solid copper



NESC 374A; NEC 110.3(B); Duke 27.04-124; RUS 1728F-806 section 13

EXHIBIT A

Immediate Safety Issues – Transformers

Unlatched MV Elbows

- The colored latch indicator ring is visible on MV cable elbows and arresters that are not fully seated on the bushings
- Loose elbows allow moisture and dust intrusion and carbon tracking, creating the risk of a flashover
- A full maintenance check is required on these elbows to clean and seal the bushings with silicone grease

NEC 110.3(B); Duke 26.02-141G

advanced energy

EXHIBIT A

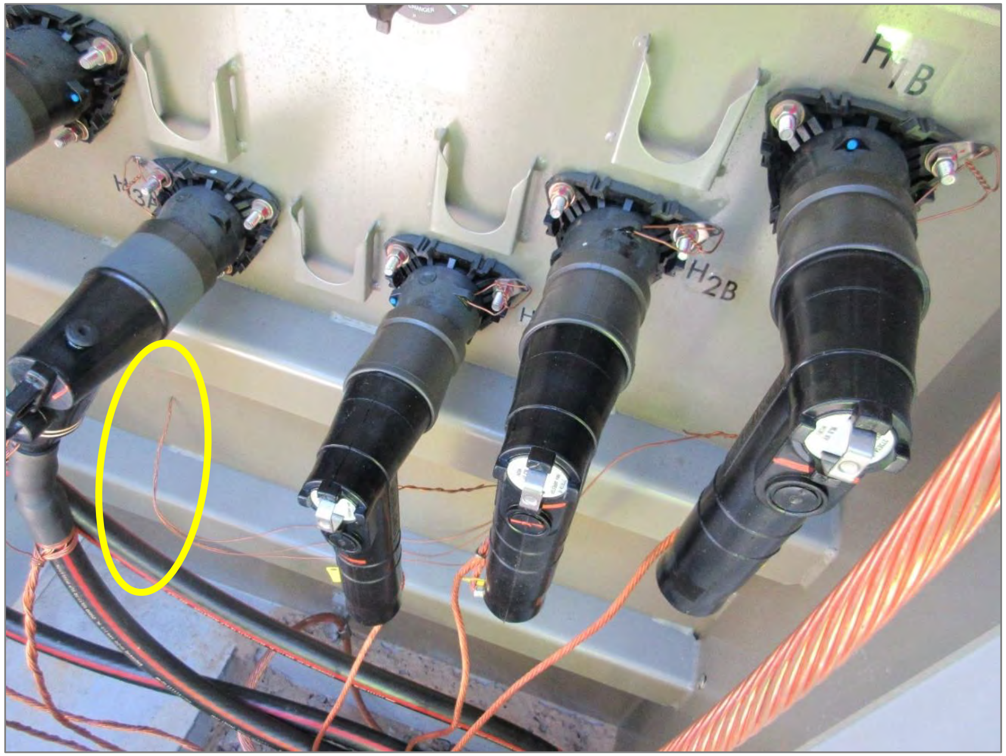
OFFICIAL COPY

Mar 29 2021

Immediate Safety Issues – Transformers

Disconnected Electrostatic Drains

The electrostatic drain wires for the transformer lightning arresters are twisted together but not connected to ground, creating a shock hazard for O&M personnel.



NESC 374A; NEC 110.3(B); Duke 27.04-168; RUS 1728F-806 section 13

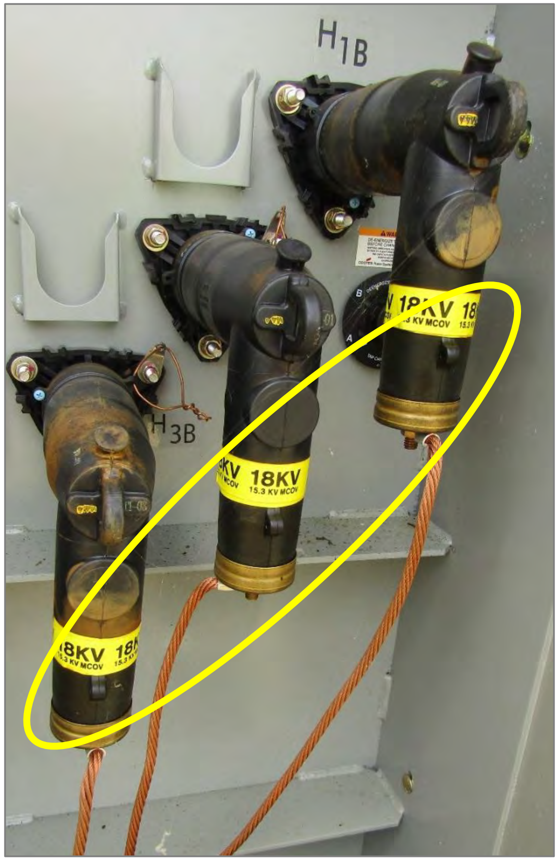
advanced energy

EXHIBIT A

Immediate Safety Issues – Transformers

Missing Arrester Drains

- Missing electrostatic drain ground wires on lightning arresters grounding eyelets
- Results in a buildup of static charge on bushing accessories, which presents a safety hazard to personnel
- May cause premature failure of accessories due to corona discharge
- Electrostatic drain wires must be 14 AWG bare solid copper



NESC 374A; NEC 110.3(B); Duke 27.04-168; RUS 1728F-806 section 13

advanced energy

EXHIBIT A

Immediate Safety Issues – Transformers

Electrostatic Drain Routing

- The 14 AWG arrester electrostatic drain wires are wrapped around the full length of the 2 AWG ground lead
- When an elbow blows, the high velocity ejection of the MOV blocks and brass ground lead cap will likely tear the drain wire away from the elbow eyelets, leaving the elbow ungrounded
- This creates a shock hazard for O&M personnel

NESC 374A; NEC 110.3(B); Duke 27.04-168; RUS 1728F-806 section 13

advanced energy

EXHIBIT A

Transformers

Potential Reliability and Power Quality Issues

advanced energy

Reliability & Power Quality Issues – Transformers

Incorrect Tap Setting

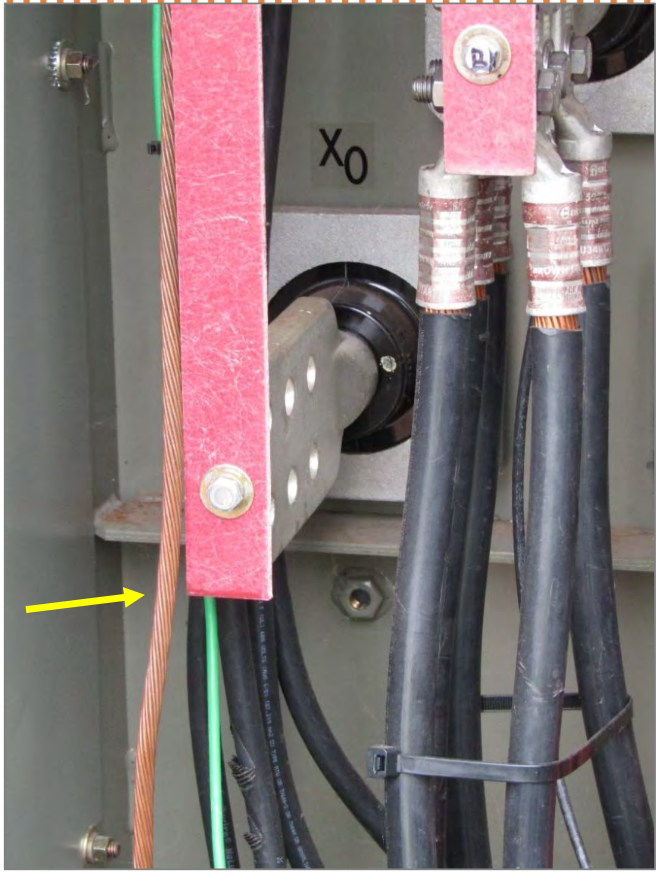
Transformer tap changer not set to nominal voltage tap C. Causes inverter settings to be out of compliance with the site Interconnection Agreement and IEEE 1547.

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Ungrounded X0 Bushing Clearance

- The 4/0 AWG bare copper GS bushing ground jumper is not secured away from the intentionally ungrounded X0 bushing
- The bare copper jumper may inadvertently contact the X0 bushing, causing improper inverter operation and possible inverter damage



NEC 110.3(B)

advanced energy

EXHIBIT A

Oil Containment

- Under-oil arrester switch with a leaking seal
- Oil leak must be monitored and repaired as necessary to prevent soil contamination and transformer damage

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Incorrect Arrester Voltage Rating

- 21 kV (17 kV MCOV) arresters installed on 23 kV transformer
- 18 kV (15.3 kV MCOV) arresters are required for adequate system protection

NEC 110.3(B); Duke 26.18-101; RUS 1728F-803 drawing VP1.3; RUS 1728F-806 section 27

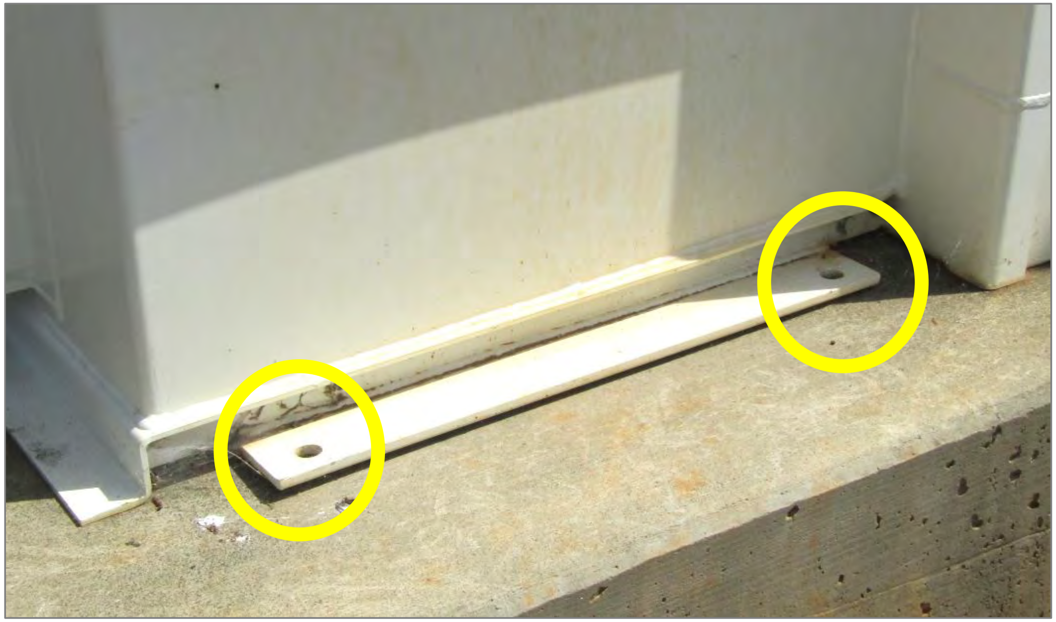
advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Transformer Not Secured to Pad

Transformers must be secured to resist movement during seismic activity, flooding, physical impacts and electrical faults.



NEC 110.3(B) and 110.13(A); Duke 27.00-109; RUS 1728F-806 drawings UF1.PC and UF3.BC

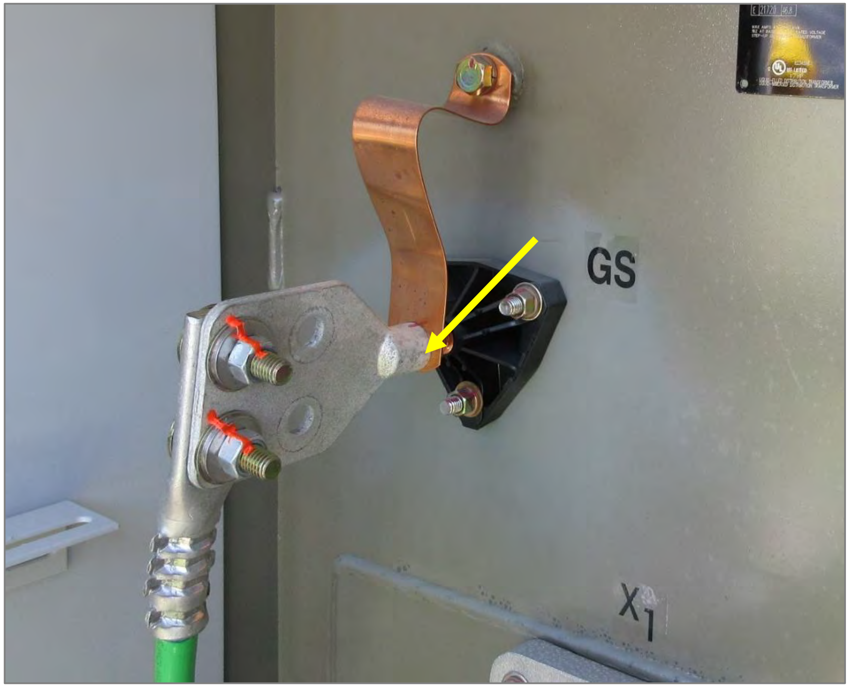
advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Loose Transformer Spade

Loose ground shield (GS) bushing jam nut and spade



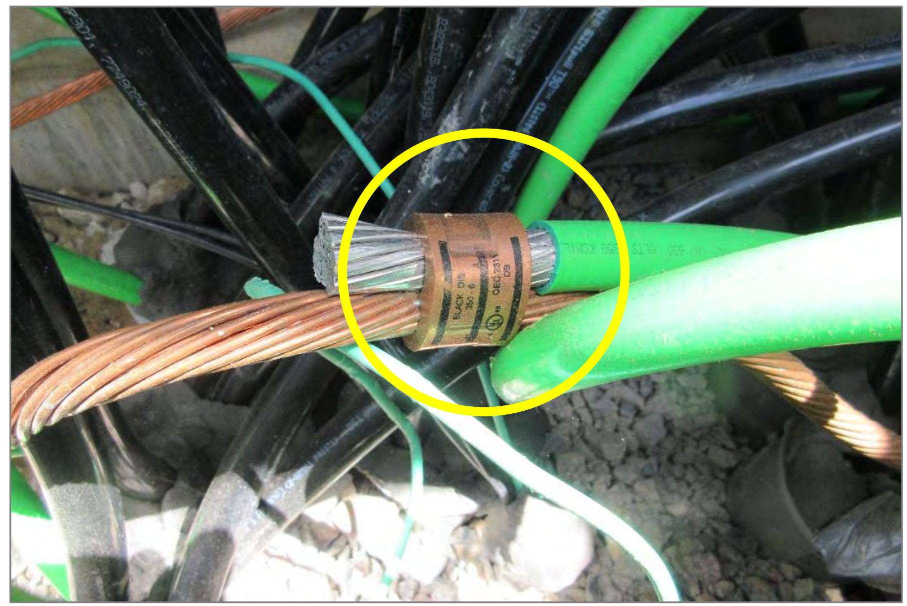
NEC 110.3(B) and 110.14(D); Duke 27.02-112

advanced energy

Reliability & Power Quality Issues – Transformers

Incompatible Connector

- Copper connector used on aluminum wire
- Aluminum wire and aluminum-to-copper wire connections require tin-plated aluminum connectors



NEC 110.3(B) and 110.14; Duke 04.00-102; IEEE 576 section 15.5

advanced energy

Reliability & Power Quality Issues – Transformers

Incorrect Ground Hardware

- 3/8-inch zinc-plated steel hardware is undersized and has insufficient corrosion protection
- Transformer ground pads are threaded for 1/2-inch bolts
- 1/2-inch bronze tank ground lugs, 1/2-inch silicon bronze bolts or 1/2-inch stainless steel bolts are required for transformer grounding due to highly corrosive conditions of condensation, flooding and soil contact (e.g. fire ant mounds)

NESC 093A and 093B; NEC 110.3(B), 110.11 and 300.6; IEEE 576 section 15.4; Duke 04.07-100

advanced energy

Reliability & Power Quality Issues – Transformers

Insufficient MV Cable Bending Radius

- MV cable bending radius as little as 4 times cable diameter
- Minimum bending radius is required to be 12 times cable diameter
- Tight bend can lead to premature cable failure due to insulation damage and separation of shield layers within the cable
- Cables like the ones shown at right may have irreversible damage due to having been bent so tightly

NESC 351A2; NEC 110.3(B) and 300.34; Duke 23.01-105; RUS 1728F-806 section 9

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Incorrect MV Cable Terminations

- In addition to insufficient bending radius, these poorly terminated MV cables have an excessive length of cable jacket and concentric neutral removed
- In a fault condition, large neutral currents may flow on cable semiconducting shield layer, causing a cable fire

NEC 110.3(B); Duke 26.02-141; RUS 1728F-806 section 13; IEEE 576 section 13.1

advanced energy

Reliability & Power Quality Issues – Transformers

Inferior Blown Elbow Repair

A blown elbow repair had the following deficiencies:

- Residual soot and debris not cleaned can damage components from carbon tracking
- Burned paint not repaired, allowing the steel enclosure to rust
- Soot covered safety labels not cleaned
- The 15 kV replacement elbow is sufficient for the 12 kV system but does not match the other 25 kV class elbows on site

NEC 110.12, 110.12(B) and 328.14; RUS 1728F-803 General Construction Specifications; RUS 1728F-806 section 1(b)

advanced energy

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Secondary Connection Lugs

- Compression lugs have an insufficient number of crimps
- Lugs only have 2 crimps but 4 crimps are required
- 4 brown color bands indicate 4 crimps are required with the standard crimping die used for these connectors

NEC 110.3(B); Duke 04.00-104

advanced energy

Reliability & Power Quality Issues – Transformers

Missing Lightning Arresters

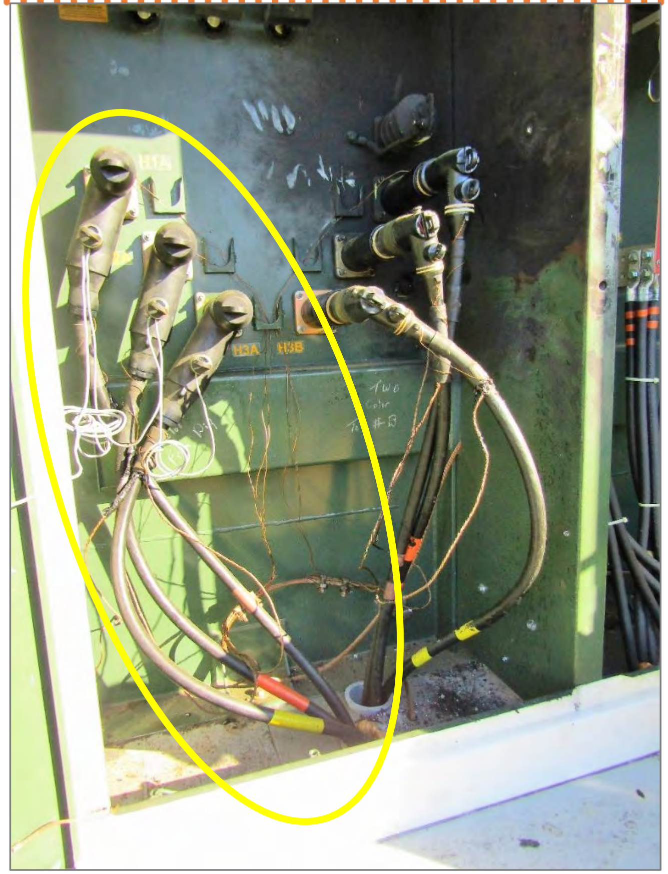
- The transformer at the end of the line in the underground feeder does not have lightning arresters installed on the live front primary bushings
- Switching and lightning voltage surges will double and reflect back up the line on the MV cable
- This increases potential for overvoltage and equipment damage

EXHIBIT A

Reliability & Power Quality Issues – Transformers

Undersized MV Cable Sizing

- 1/0 AWG AL MV cables are directly buried and have an ampacity of only 222 Amps
- Facility rated current is 232 Amps
- The cables are frequently overloaded for many hours per day and may fail prematurely



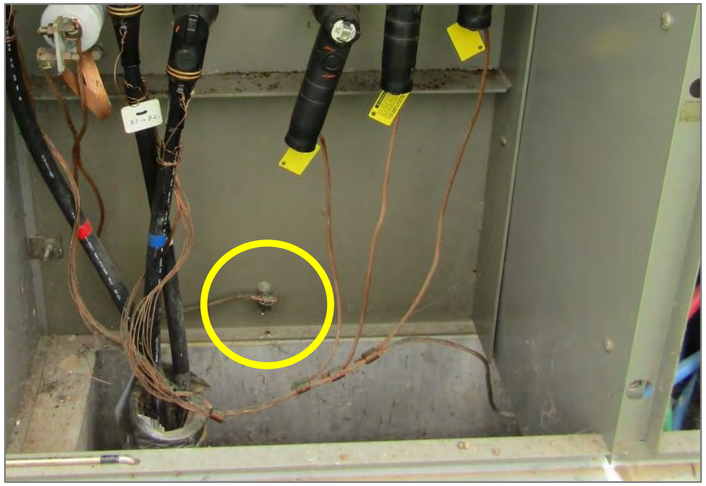
NESC 160; NEC 110.3(B) and Table 310.60(C)(82); Duke 23.01-109

advanced energy

EXHIBIT A

Missing Ground Connection

- Ground bus only connects to ground pad in primary compartment
- Ground bus is not connected to ground pad in secondary compartment



Duke 20.04-143 and 27.04-126; RUS 1728F-806 section 24(b) and drawing UG3.2

advanced energy

EXHIBIT A

Inverters

Immediate Safety Issues

advanced energy

EXHIBIT A

Immediate Safety Issues – Inverters

Missing NRTL Listing Mark

The nameplate is missing the NRTL listing mark showing the inverters are listed to UL standard 1741

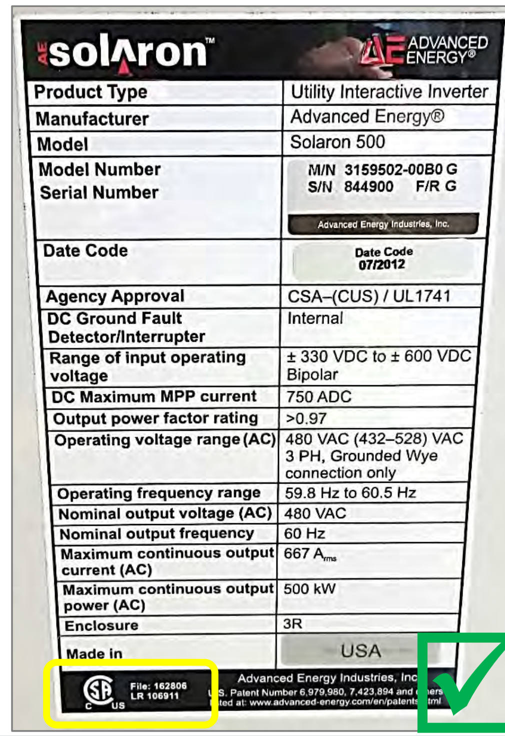
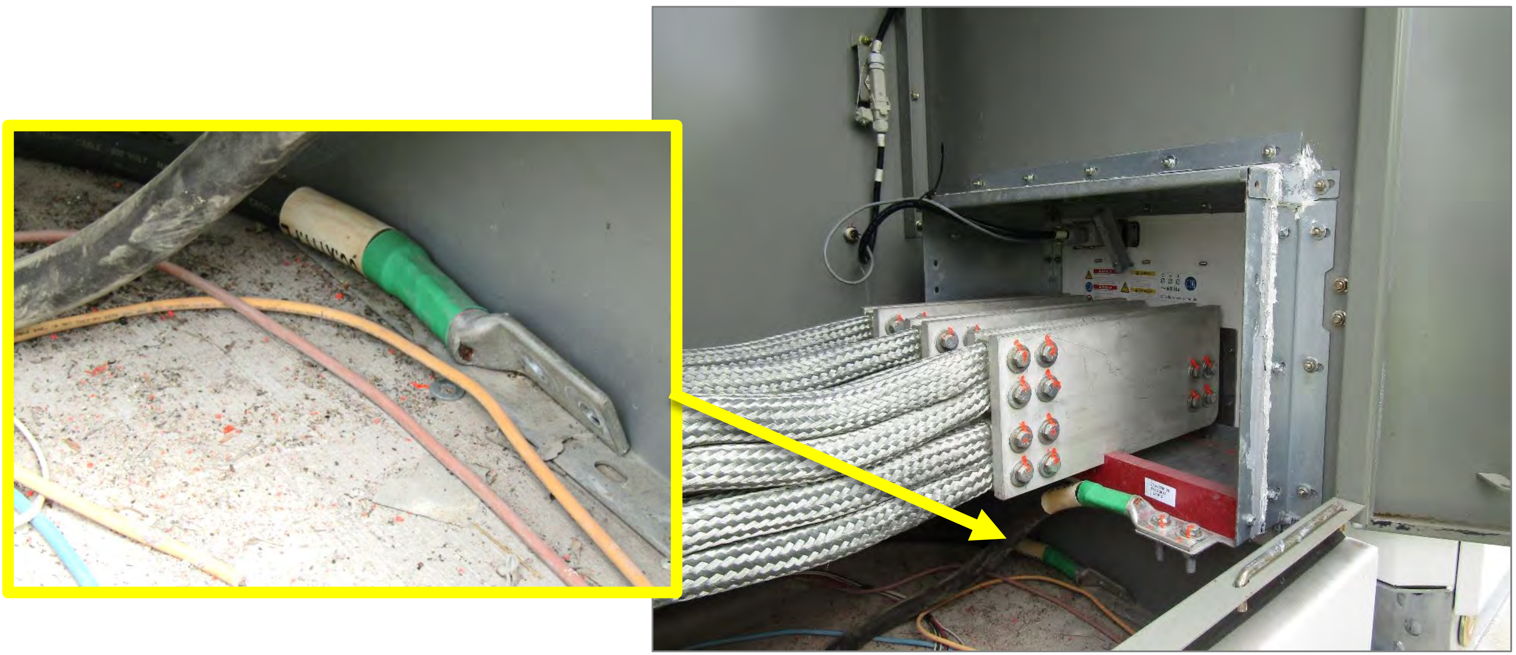


EXHIBIT A

Immediate Safety Issues – Inverters

Disconnected Inverter Ground

The 500 kcmil flexible copper ground cable between the inverter and transformer was not connected to the inverter ground bus bar in the throat connection cabinet.



NESC 123A and 215C1; NEC 110.3(B); Duke 20.04-143

EXHIBIT A

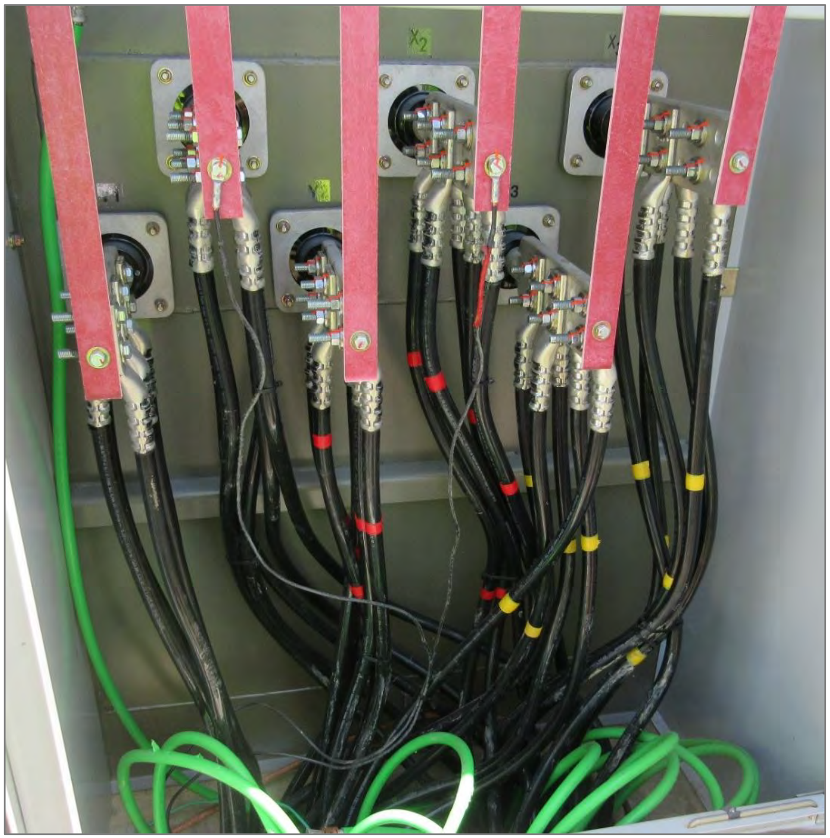
Inverters

Potential Reliability and Power Quality Issues

advanced energy

Reliability & Power Quality Issues – Inverters

Insufficient Secondary Conductor Voltage Rating



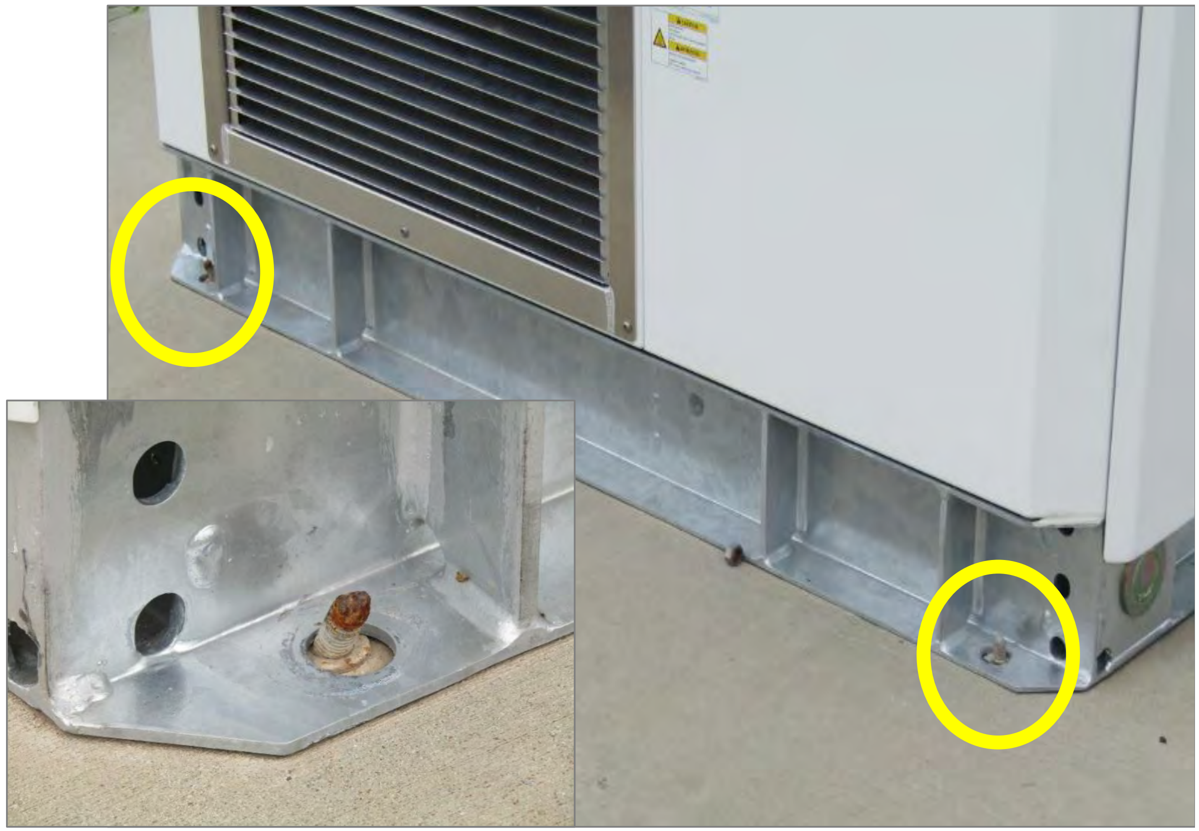
- 600-Volt conductors (THWN-2) have insufficient insulation
- Inverter RMS voltage to ground is 800 Volts and peak pulsed voltage to ground is 1450 Volts

NEC 110.3(B)

Reliability & Power Quality Issues – Inverters

Inverter Not Secured to Pad

Replacement inverter not secured to pad after flooding destroyed two previous units.



NESC 180A1; NEC 110.3(B) and 110.13(A)

advanced energy

EXHIBIT A

Inverters

Inverter Settings

advanced energy

Inverter Settings

Summary

- 1 of the 9 sites had all inverter settings correct
- Four general types of inverter settings were verified

# Sites with Correct Settings	Inverter Setting
1	Grid voltage and frequency protection
8	Power factor
6	Maximum power export
6	Grid reconnection timer

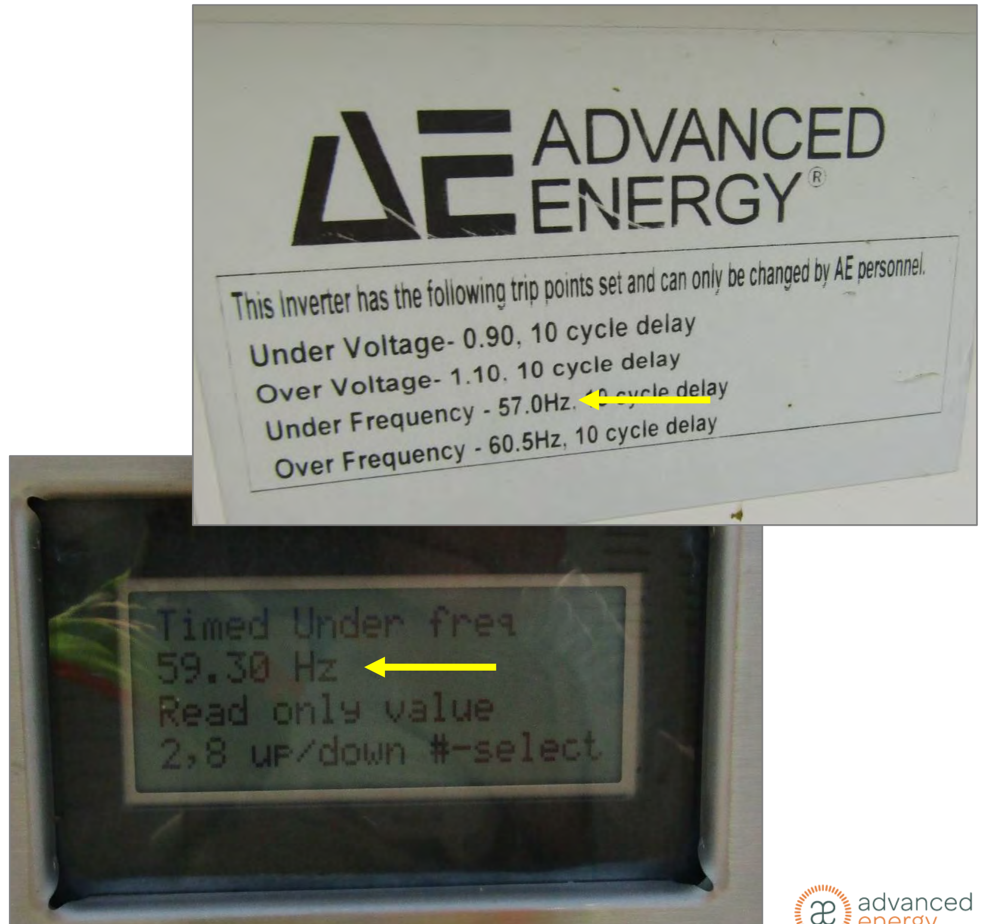
advanced energy

EXHIBIT A

Inverter Settings

Example DEP Site

- Settings programmed into inverter do not agree with factory applied label
- Voltage and frequency settings set to default IEEE-1547 settings instead of Interconnection Agreement (IA) required settings



advanced energy

Inverter Settings

Example DEP Site

- Site has 10 inverters with inconsistency in settings across the site
- All inverters had setting multiple incorrect settings
- Values in red do not agree with the Duke Energy Progress (DEP) required settings

Parameter	Expected Per IA		Inverters A1/A2/B1/B3		Inverter B2		Inverter C2		Inverters C1/C3/D1/D2	
	Value	Time (sec)	Value	Time (sec)	Value	Time (sec)	Value	Time (sec)	Value	Time (sec)
Under Voltage 1	0.90 per unit	0.167	0.90	0.167	0.90	0.167	0.88	2	0.88	2
Under Voltage 2	0.90 per unit	0.167	0.90	0.167	0.90	0.167	0.60	1	0.60	1
Over Voltage 1	1.10 per unit	0.167	1.10	0.167	1.10	0.167	1.10	1	1.10	1
Over Voltage 2	1.10 per unit	0.167	1.10	0.167	1.10	0.167	1.20	0.160	1.20	0.160
Under Frequency 1	57 Hz	0.167	57	0.167	57	0.167	59.5	2	59.5	2
Under Frequency 2	not required		57	0.160	57	0.160	57	0.160	57	0.160
Over Frequency 1	60.5 Hz	0.167	60.5	0.167	60.5	0.167	60.5	2	60.5	2
Over Frequency 2	not required		62	0.160	62	0.160	62	0.160	62	0.160
Power Factor	1.0	--	1.0	--	1.0	--	1.0	--	1.0	--
Grid Reconnect Timer	--	300	--	300	--	30	--	30	--	300

Inverter Settings

Example DEC Site

- Inverter programmed settings don't agree with Duke Energy Carolinas (DEC) required settings
- Values in red are incorrect across all inverters on site

Parameter	Expected Per IA		All Inverters	
	Value	Time (sec)	Value	Time (sec)
Under Voltage 1	0.88	2.0	0.90	4
Under Voltage 2	0.50	0.16	0.50	3.55
Over Voltage 1	1.10	1.0	1.10	1.5
Over Voltage 2	1.20	0.16	1.20	1.05
Under Frequency 1	59.3	0.16	59.3	0.1
Under Frequency 2	not required		56	0.08
Over Frequency 1	60.5	0.16	60.5	0.1
Over Frequency 2	not required		65	0.08
Power Factor	1.0	--	1.0	
Grid Reconnect Timer	--	300		300

advanced energy

EXHIBIT A

Inverter Settings

Example DEP Site

- Inverter programmed settings don't agree with DEP required settings
- Values in red are incorrect across all inverters on site

Parameter	Expected Per IA		All Inverters	
	Value	Time (sec)	Value	Time (sec)
Under Voltage 1	0.90 per unit	0.167	0.88	0.8
Under Voltage 2	0.90 per unit	0.167	0.50	0.1
Over Voltage 1	1.10 per unit	0.167	1.10	0.8
Over Voltage 2	1.10 per unit	0.167	1.20	0.1
Under Frequency 1	57 Hz	0.167	59.3	0.03
Under Frequency 2	not required		57	0.03
Over Frequency	60.5 Hz	0.167	60.5	0.03
Power Factor	1.0	--	1.0	--
Grid Reconnect Timer	--	300	--	300

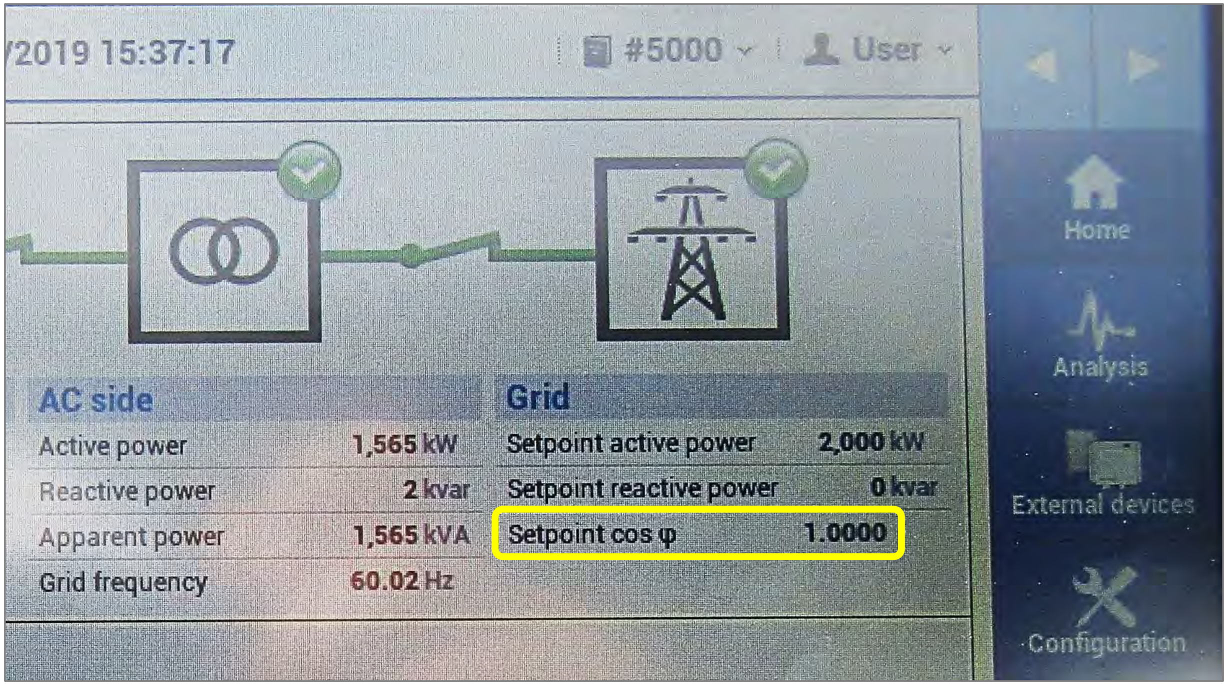
advanced energy

EXHIBIT A

Inverter Settings

Power Factor

- IA requires 0.98 power factor
- One inverter set to 1.0 with other set to 0.98



advanced energy

Inverter Settings

Maximum Power

- Maximum power of all six inverters set to 833 kW instead of 829 kW
- Facility maximum power is 4.998 MW and exceeds IA maximum of 4.975 MW

64	P-W	0	880	833	kW
65	P-WGra	1	100	40	%/Hz
66	P-WMod			WCnst	
67	P-WNom	0	100	100	%

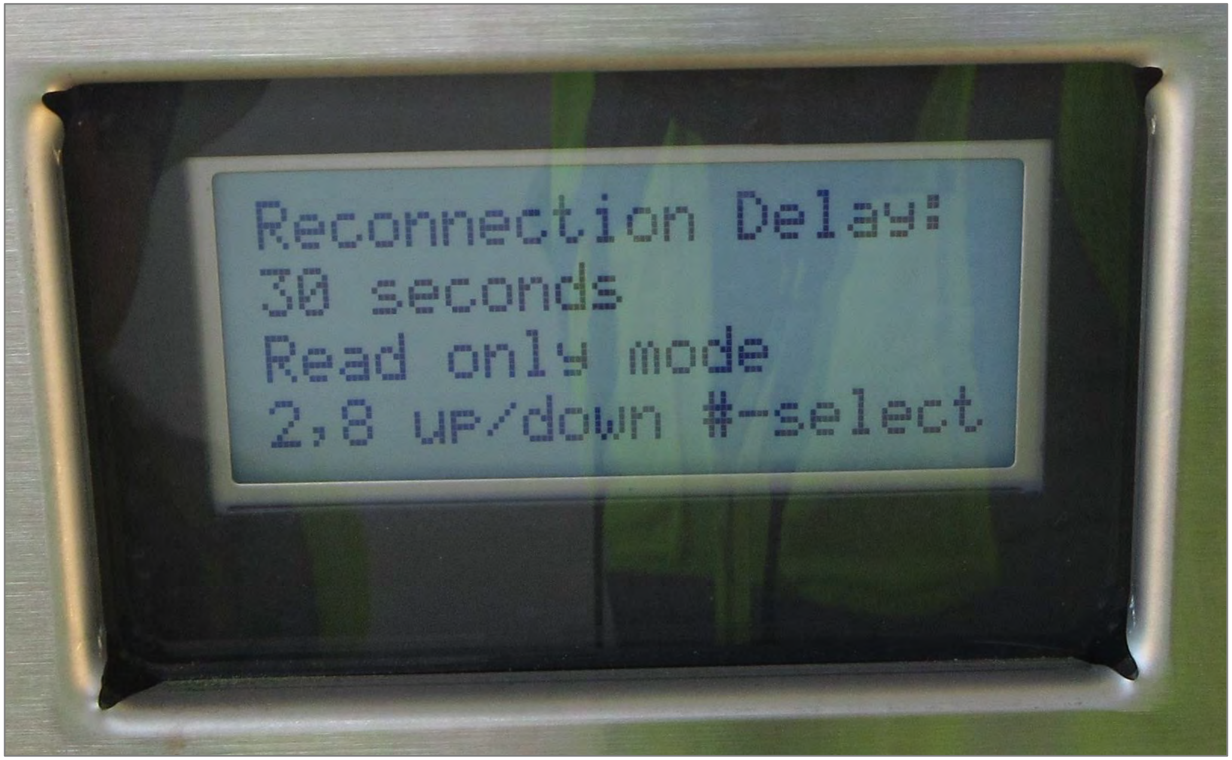
advanced energy

EXHIBIT A

Inverter Settings

Grid Reconnect Timer

Reconnect timer set to 30 seconds instead of required 300 seconds.



advanced energy

EXHIBIT A

Major Equipment

Unexpected Equipment – Inverters and Transformers

advanced energy

EXHIBIT A

Unexpected Equipment – Inverters and Transformers

Number of Inverters and Transformers

- 3 MW facility expected but 2.5 MW installed
- (6) AE Solaron 500 inverters expected but only (5) were installed
- (3) 1000 kVA transformers expected but (2) 1000 kVA and (1) 500 kVA installed

advanced energy

EXHIBIT A

Unexpected Equipment – Inverters and Transformers

Number and Type of Inverters and Transformers

- (5) AE 1000NX inverters expected but (6) SMA SC800CP installed
- (5) 1000 kVA YG/yg transformers expected but (3) 1760 kVA YG/y/y installed

advanced energy

EXHIBIT A

For questions about this presentation, contact Advanced Energy at: solarcommissioning@advancedenergy.org

For questions about the Self-Inspection Program, contact Duke Energy at: DER-TechnicalStandards@duke-energy.com

EXHIBIT B

PV Interconnection Inspections Conducted for Duke Energy

Shawn Fitzpatrick, P.E.

Advanced Energy

June 17, 2015

Inspection Background

- Conducted as part of Advanced Energy's 2014 ratepayer funded service account projects
- Half-day interconnection inspections and performance evaluations in Duke Energy Progress (DEP) NC territory
- 15 customer owned PV plants, 0.5 MW – 3.3 MW
- Inspections conducted Sept – Dec 2014

Inspection Scope

1. Transformer compliance with inverter requirements
2. Inverter and transformer compliance with interconnection documentation on file with DEP
3. Interconnection protection settings
4. Electrical code compliance at AC equipment pads
5. High-level system performance evaluation

Transformers and Inverters

- Customer owned transformers convert PV plant low voltage (<1 kV) power to utility distribution level voltage (12-23 kV)
- Inverters convert PV array DC power to utility compatible AC

EXHIBIT B


SUNNY CENTRAL 750CP-US
UTILITY
GRADE
PHOTOVOLTAIC SYSTEM
AC DISCONNECT

Key Findings

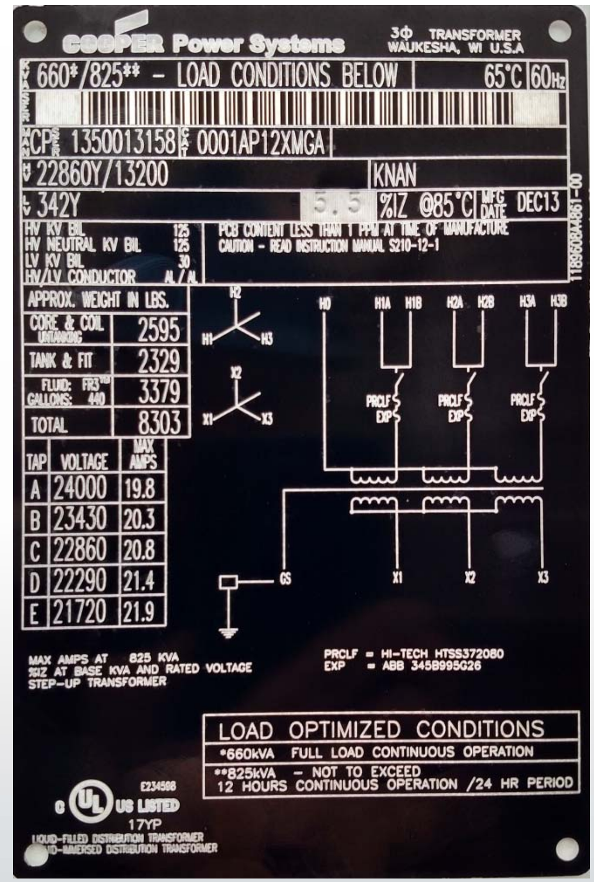
- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Key Findings

- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Transformer Requirements

- Inverter manufacturers specify the types of transformers that can be used with their inverters
- Advanced Energy (AE) found that with some transformer types, inverters do not always detect a loss of single phase power on the three phase utility distribution line
- 4 of the 15 sites inspected have a transformer type that desensitizes the inverter's ability to detect a loss of single phase power on a three phase line
- This is a potential safety concern and Duke Energy has taken measures to address the issue



advanced energy

Key Findings

- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Interconnection Documentation

- DEP has a customer interconnect requests (IR) and interconnection agreements (IA) on file for each site
- The as-built site configuration for 9 of the 15 sites did not agree with the interconnection documentation filed by site owner

Site No.	Parameter Differing from Interconnection Documentation			
	AC Rating (kW)	Inverter Type	Transformer Size	Transformer Type
Site 3				X
Site 8		X		X
Site 9			X	X
Site 10	X	X		
Site 11				X
Site 12	X	X	X	X
Site 13				X
Site 14		X		X
Site 15	X			

Key Findings

- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Interconnection Protection Settings

- Inverter interconnection protection settings prevent PV plants from energizing utility lines during an outage
- DEP requires inverter interconnection protection settings for voltage and frequency to be adjusted from factory default

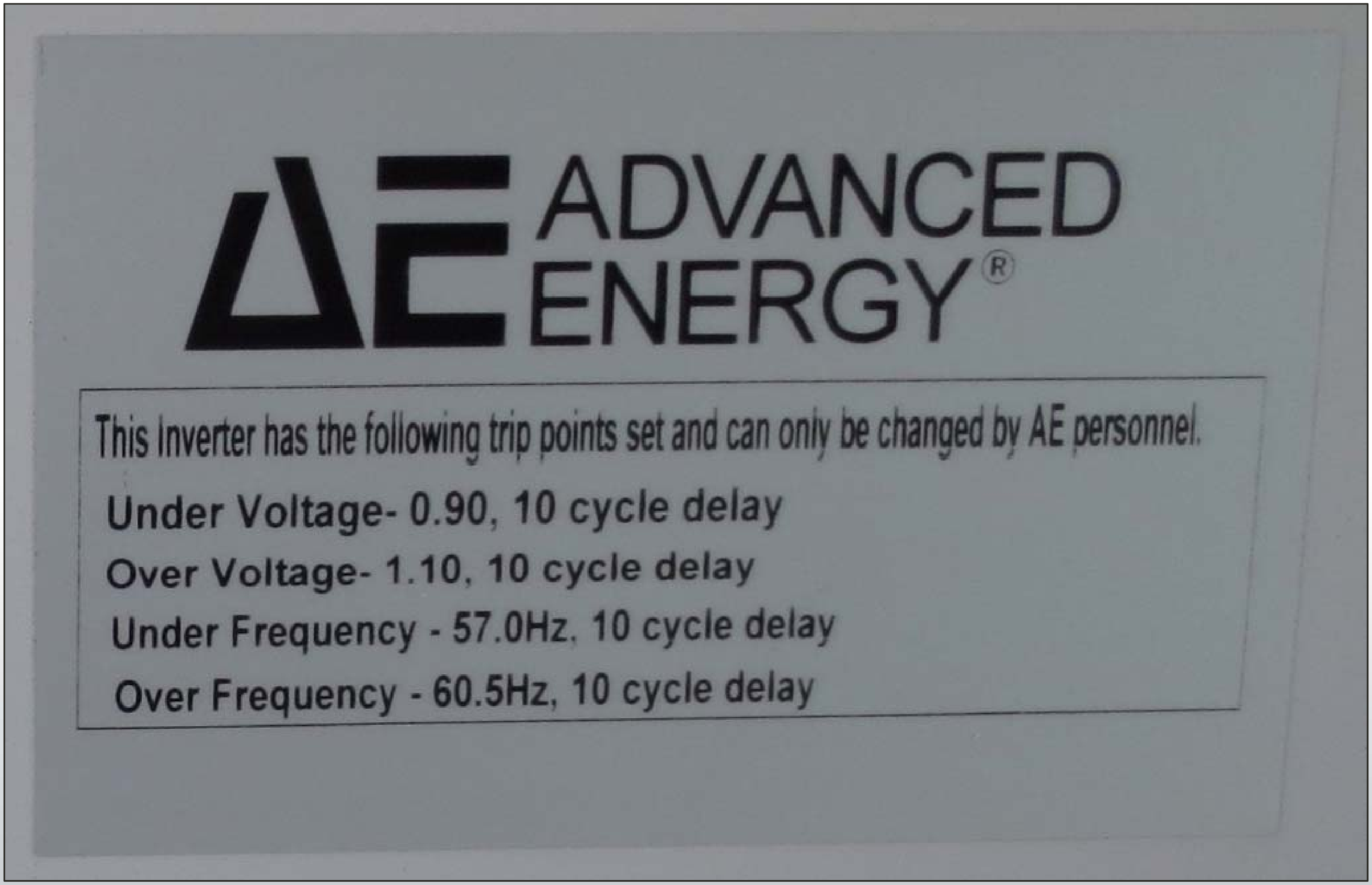
Utility Required Interconnection Protection Settings		
Parameter	**Setpoint**	**Time Delay (sec)**
Under voltage #1 (27-1)	0.90 per unit	0.16
Under voltage #2 (27-2)	0.90 per unit	0.16
Over voltage #1 (59-1)	1.10 per unit	0.16
Over voltage #2 (59-2)	1.10 per unit	0.16
Under frequency (81U)	57.0 Hz	0.16
Over frequency (81O)	60.5 Hz	0.16

advanced energy

Interconnection Protection Settings

- No sites fully comply with the utility's required interconnection protection settings
- Under Frequency
  - All sites will trip offline due to under frequency before desired by the utility
- Under Voltage and Over Voltage
  - All sites will take longer to trip offline due to abnormal voltage than desired by the utility

Interconnection Protection Settings



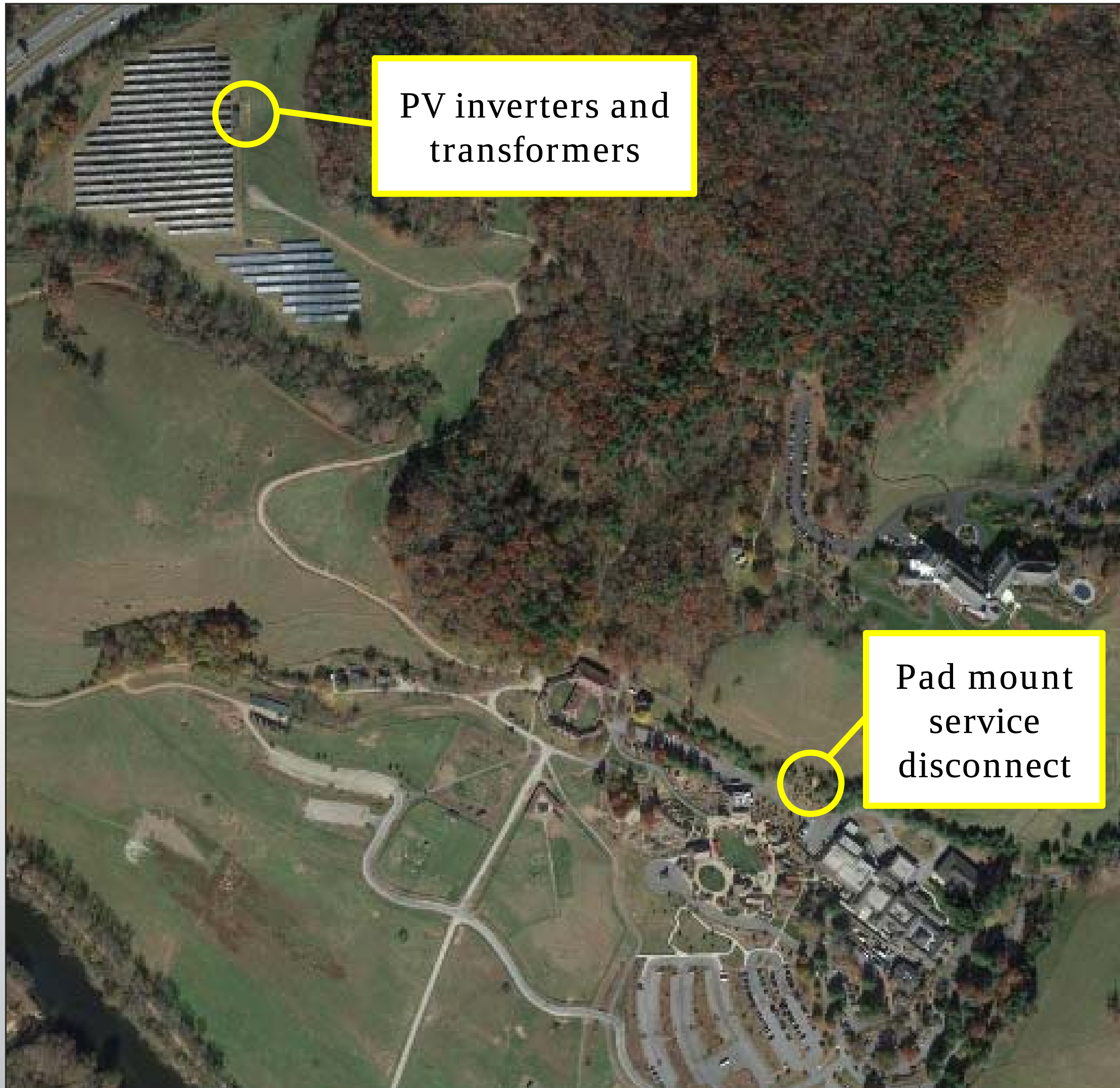
Key Findings

- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Electrical Code Violations

Missing Service Disconnect

- 2 of the 15 sites do not have a customer owned service disconnect located at the PV site, creating unsafe situations
- 1 of these 2 does have a customer owned service disconnect, but it is located ½ mile away at a poorly marked pad-mount disconnect switch


PV inverters and transformers
Pad mount service disconnect

Electrical Code Violations

Missing AC Ground Detectors

- 8 of the 15 sites do not have the required AC ground detectors on ungrounded AC inverter feeders

Key Findings

- Transformer requirements
- Interconnection documentation vs. actual installation
- Interconnection protection settings
- Electrical code violations
- Performance evaluations

Performance Evaluations

- Site performance is given in terms of performance factor (PF):

  PF = measured kW ÷ expected kW

- At the time of inspection, weather conditions were acceptable for testing at 10 of the 15 sites

Performance Evaluations

Site No.	AC Rated Capacity (MW)	Performance Factor (PF)	Notes
Site 1	1	80.2%	8% of array was out of service
Site 2	0.50	94.0%	
Site 3	0.55	93.1%	
Site 4	2	79.8%	
Site 7	1	92.5%	
Site 8	2	98.7%	
Site 9	2	85.9%	Substantial vegetation shading
Site 10	0.52	85.5%	
Site 13	1	86.2%	4.4% of array was out of service
Site 14	2	91.8%	
Total	**12.57**	--	
Weighted PF	--	**88.6%**	

Performance Evaluations

Solar/tree farm – 85.9% performance factor

Another Interesting Finding

- At one site, owner and contractor were not aware they owned the transformers
- They didn't have keys to open the transformers
- It took two hours, three trips to a hardware store, a broken bolt cutter and a battery powered angle grinder to open the transformers
- When they did get the transformers open…

EXHIBIT B

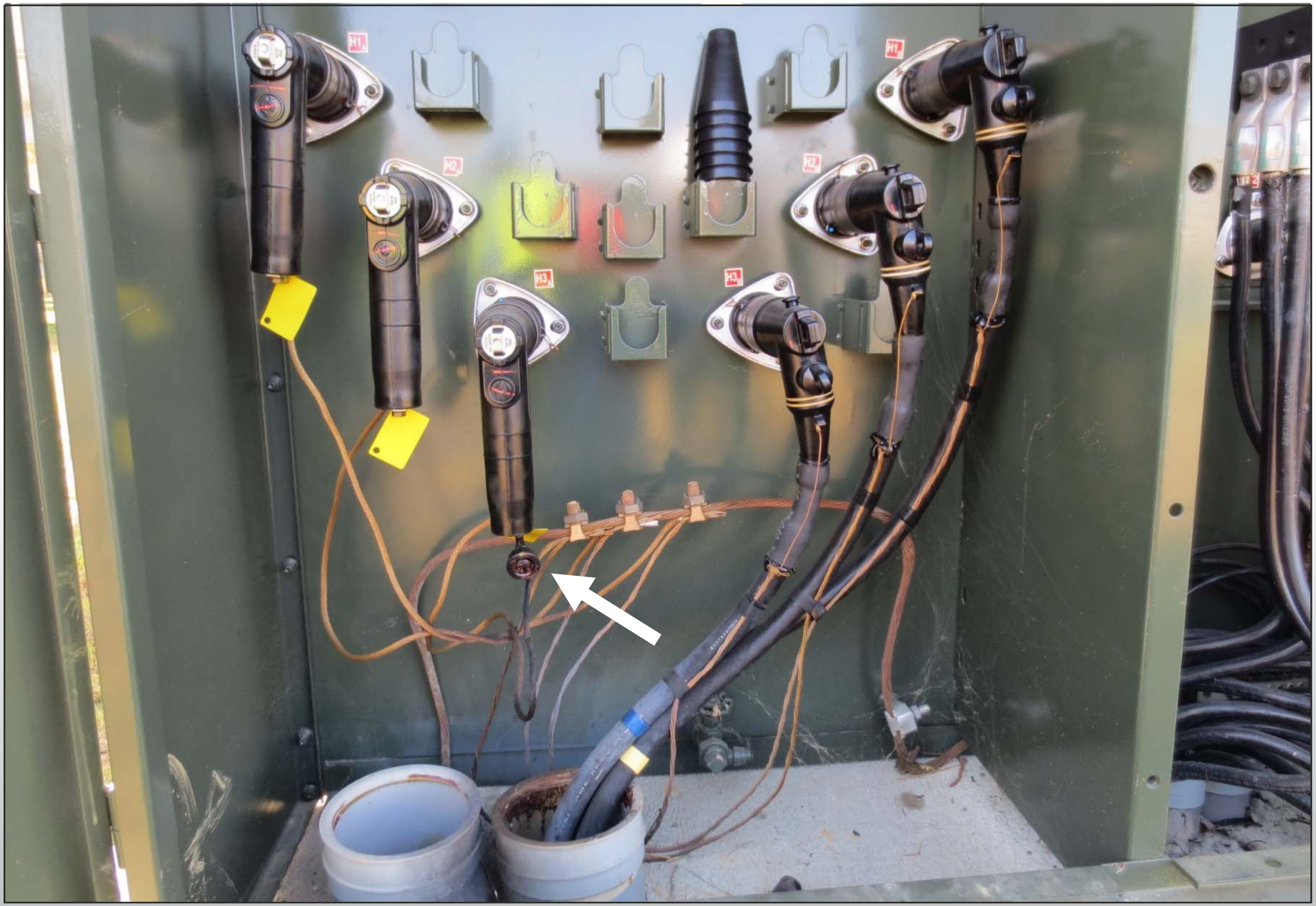
Another Interesting Finding

- Insulation was burned off the secondary conductors within one transformer

EXHIBIT B

Another Interesting Finding

- One surge arrestor was blown out



Mar 29 2021 OFFICIAL COPY

Inspections Summary

- 27% of sites have a transformer type that may create an open phase safety problem
- As-built configuration at 60% of sites does not comply with interconnection documentation on file with the utility
- No sites fully comply with the utility's required interconnection protection settings
- 53% of sites have obvious electrical code violations
- Weighted avg. performance factor = 89%

Inspection Follow Up

- AE shared these findings during two meetings with DEC/DEP staff and a meeting with the Public Staff in 2015
- AE presented these findings at the Utility Solar Conference in San Diego in April 2015
- Duke Energy is requiring PV plant owners to make changes to the interconnection protection settings
- Duke Energy has implemented extra safety measures for sites with open phase concerns
- In 2015 Advanced Energy is conducting interconnection inspections at 42 additional sites in DEP and DEC territories in NC

EXHIBIT B

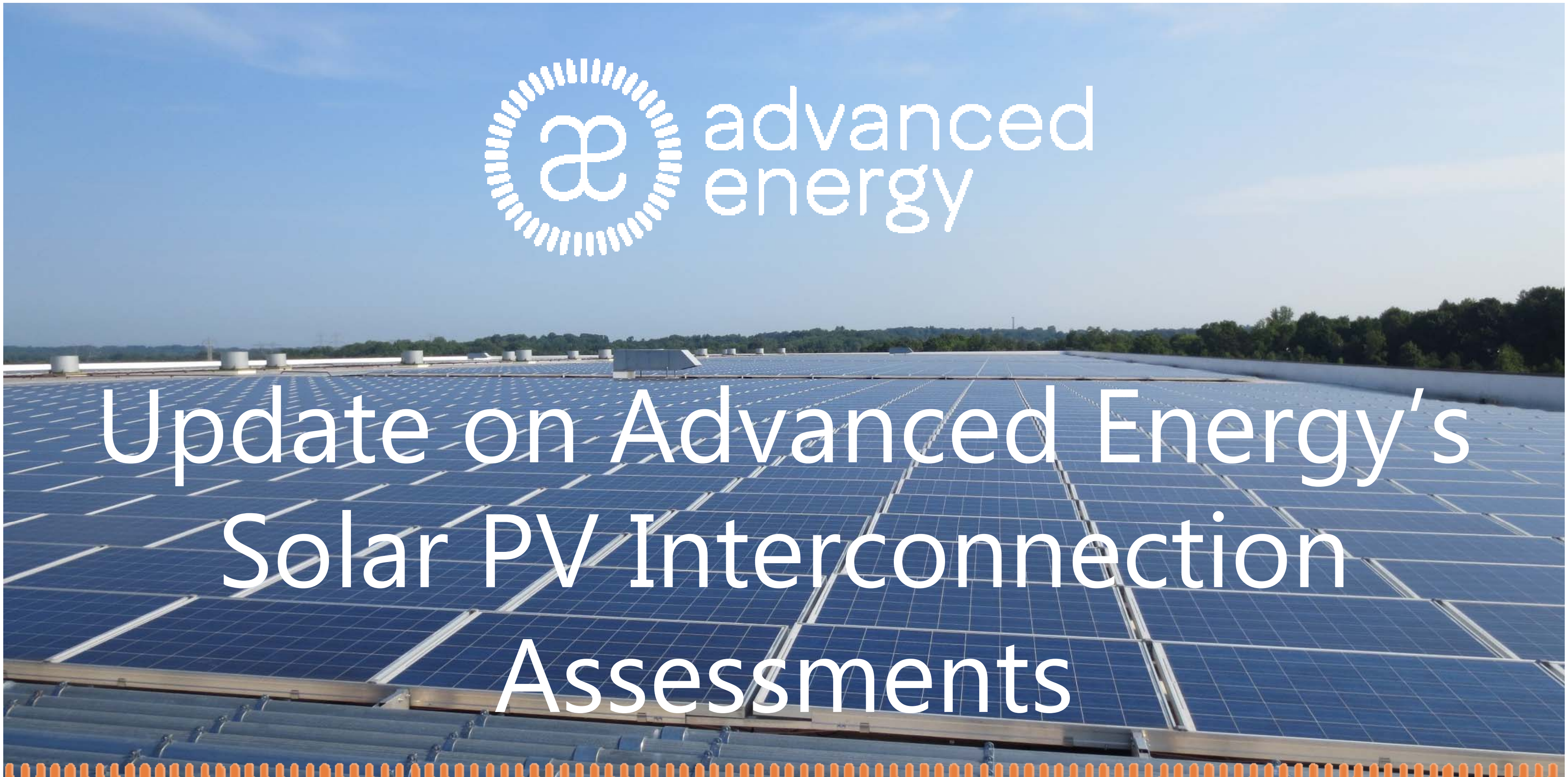
Thank You

Shawn Fitzpatrick, P.E.

sfitzpatrick@advancedenergy.org

919-857-9000

EXHIBIT C



Update on Advanced Energy’s Solar PV Interconnection Assessments

Shawn Fitzpatrick, P.E.

June 22, 2016

2015 Interconnection Assessments

Duke Energy engaged Advanced Energy to perform AC interconnection assessments on recently built solar facilities not owned by the utility

↓

Duke Energy selected PV sites for assessment in both Duke Energy Progress (DEP) and Duke Energy Carolinas (DEC) territories

↓

Similar to 2014 assessments of 15 large PV facilities in DEP territory

EXHIBIT C

2015 Interconnection Assessments

- Assessed 41 PV facilities already in operation
  - Sites were completed in last 5 years
  - 29 sites were completed in last 3 years
  - 19 sites were completed in last 2 years
- Size range: 260 kW – 6.24 MW AC
  - 30 sites were 2 MW or larger
- Sites built by 17 different EPCs
- Assessments conducted July – Nov 2015

ASSESSMENT SCOPE

advanced energy

- 2 to 4 hour on-site assessment
- PV System Owner or O&M representative was present
- Determine whether inverters, transformers and interconnection equipment installed agreed with documentation on file with Duke Energy
- Determine whether interconnection protection settings agreed with documentation on file with Duke Energy

ASSESSMENT SCOPE *(cont.)*

- Determine whether transformer vector group and grounding comply with inverter manufacturer recommendations

- Document obvious or significant National Electrical Code (NEC) violations at inverter and interconnection equipment locations

advanced energy

EXHIBIT C

1 Duke Energy documentation vs. actual installation

2 Open phase detection problem

KEY FINDINGS

advanced energy

1 **Duke Energy documentation vs. actual installation**

2 Open phase detection problem

KEY FINDINGS

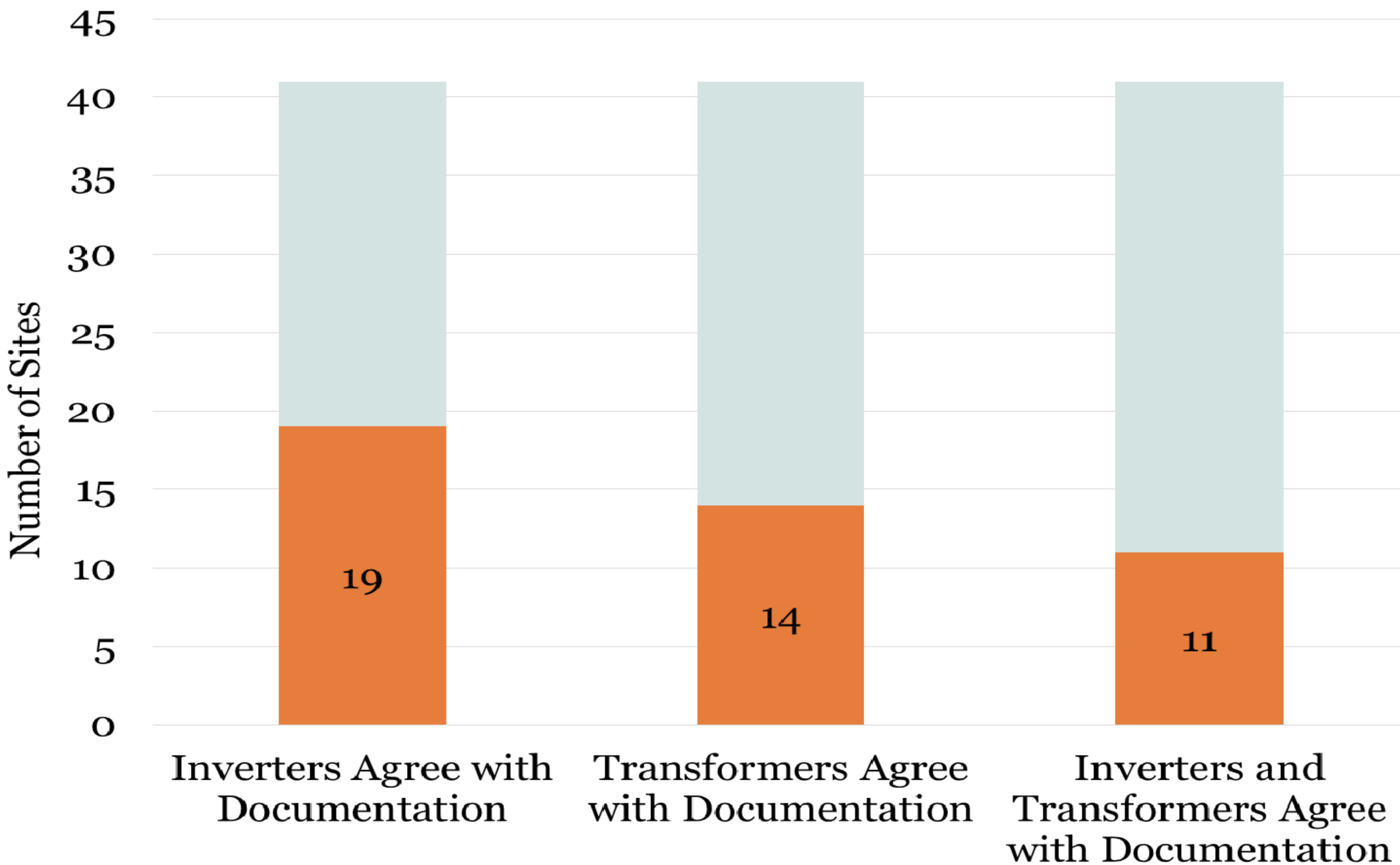
Duke Energy Documentation

For each site, Duke Energy had one or more of the following documents on file:

1. Interconnection Request (IR)
2. Interconnection Single-Line Diagram (SLD)
3. Interconnection Agreement (IA)

EXHIBIT C

As-Built Hardware Agreement



Max. Adjusted Inverter Export Capability

- The IA defines the maximum physical export capability in MW
  - Inverter nameplate rating may be higher
  - Inverter settings may be adjusted to limit output to the IA max. export capability
- Site owner is responsible for ensuring the settings comply with the IA
- 40 of 41 sites were in compliance with IA max. MW capability
  - **The one site that was out of compliance was approved for 5 MW but was found to be adjusted to generate 6.24 MW**
  - **In April 2016 Duke Energy witnessed the site overgenerating by 25% at 6.24 MW**

Interconnection Protection Settings

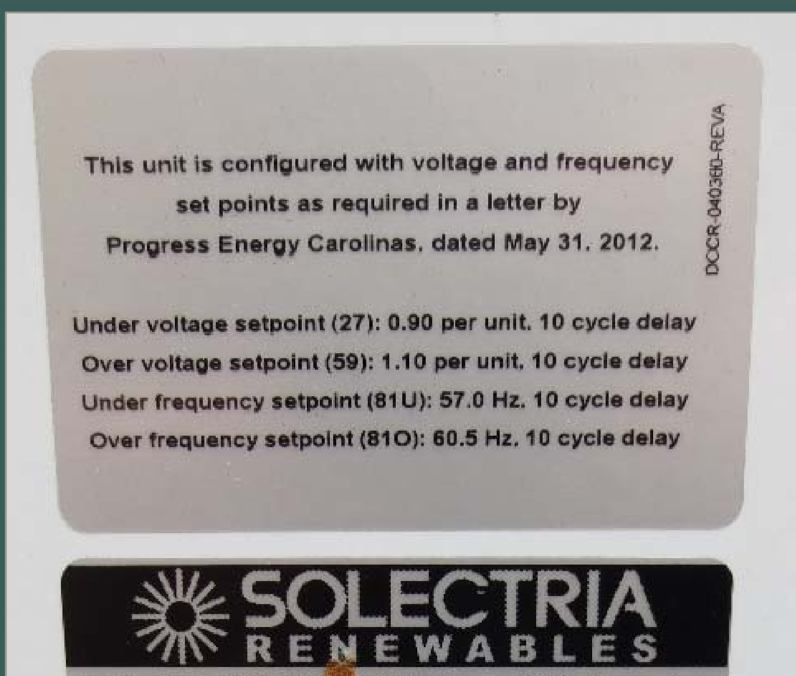
- The IA defines the inverter interconnection protection settings to be either:
  - IEEE 1547 default
  - Other utility specified settings
- **Only 9 of 41 sites were in compliance with IA settings**

Sample DEP Interconnection Protection Settings		
Parameter	**Setpoint**	**Time Delay (sec)**
Under voltage #1 (27-1)	0.90 per unit	0.16
Under voltage #2 (27-2)	0.90 per unit	0.16
Over voltage #1 (59-1)	1.10 per unit	0.16
Over voltage #2 (59-2)	1.10 per unit	0.16
Under frequency (81U)	57.0 Hz	0.16
Over frequency (81O)	60.5 Hz	0.16

Interconnection Protection Settings

Inverters at 4 sites labels installed on the inverters indicating interconnection protection settings had been adjusted at the factory to utility specified values

However, we found the actual inverter internal settings did not agree with those specified on the labels



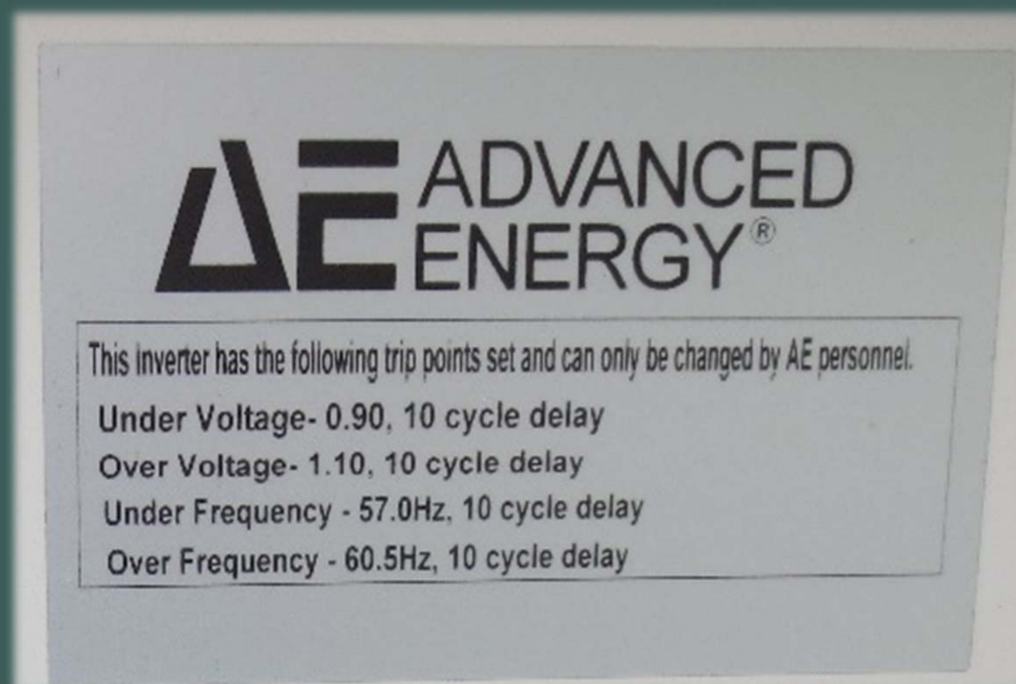
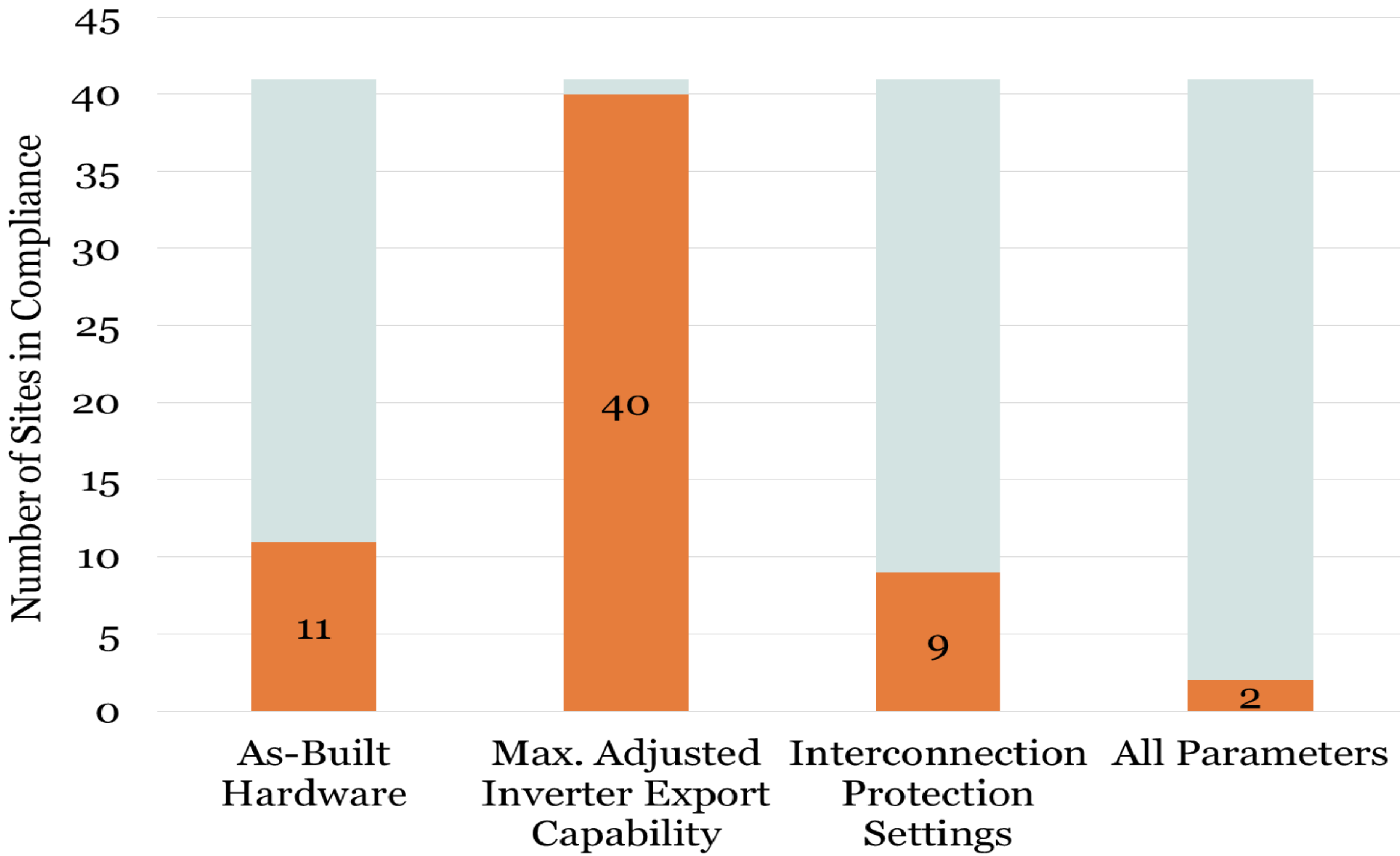


EXHIBIT C

Documentation Compliance Summary



1 Duke Energy documentation vs. actual installation

2 **Open phase detection problem**

KEY FINDINGS

Open Phase Detection Problem

- Some inverter manufacturers have documentation cautioning that certain transformer vector groups desensitize the inverter's ability to detect a single open phase condition on the utility distribution feeder
- Grounded Wye/delta (YNd) transformers with delta on the inverter side are known to cause single open phase detection problems for inverters
- SMA cautions Grounded Wye/ungrounded wye (YNy) transformers desensitize the Sunny Central HE and CP inverters to single open phase detection at low power level

OPEN PHASE DETECTION PROBLEM

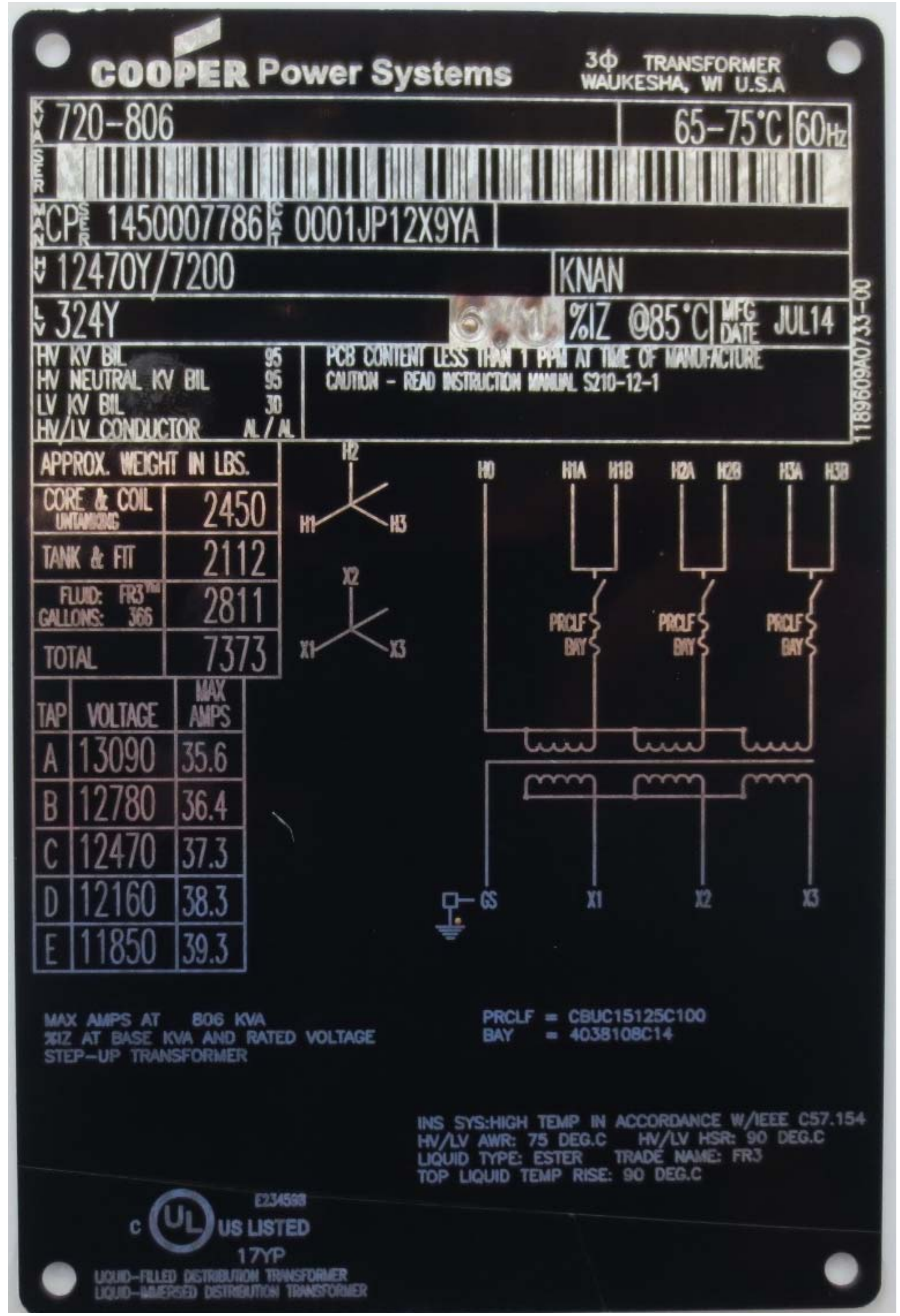
One site has a grounded YNd transformer (delta on the inverter side), creating an open phase detection problem

advanced energy

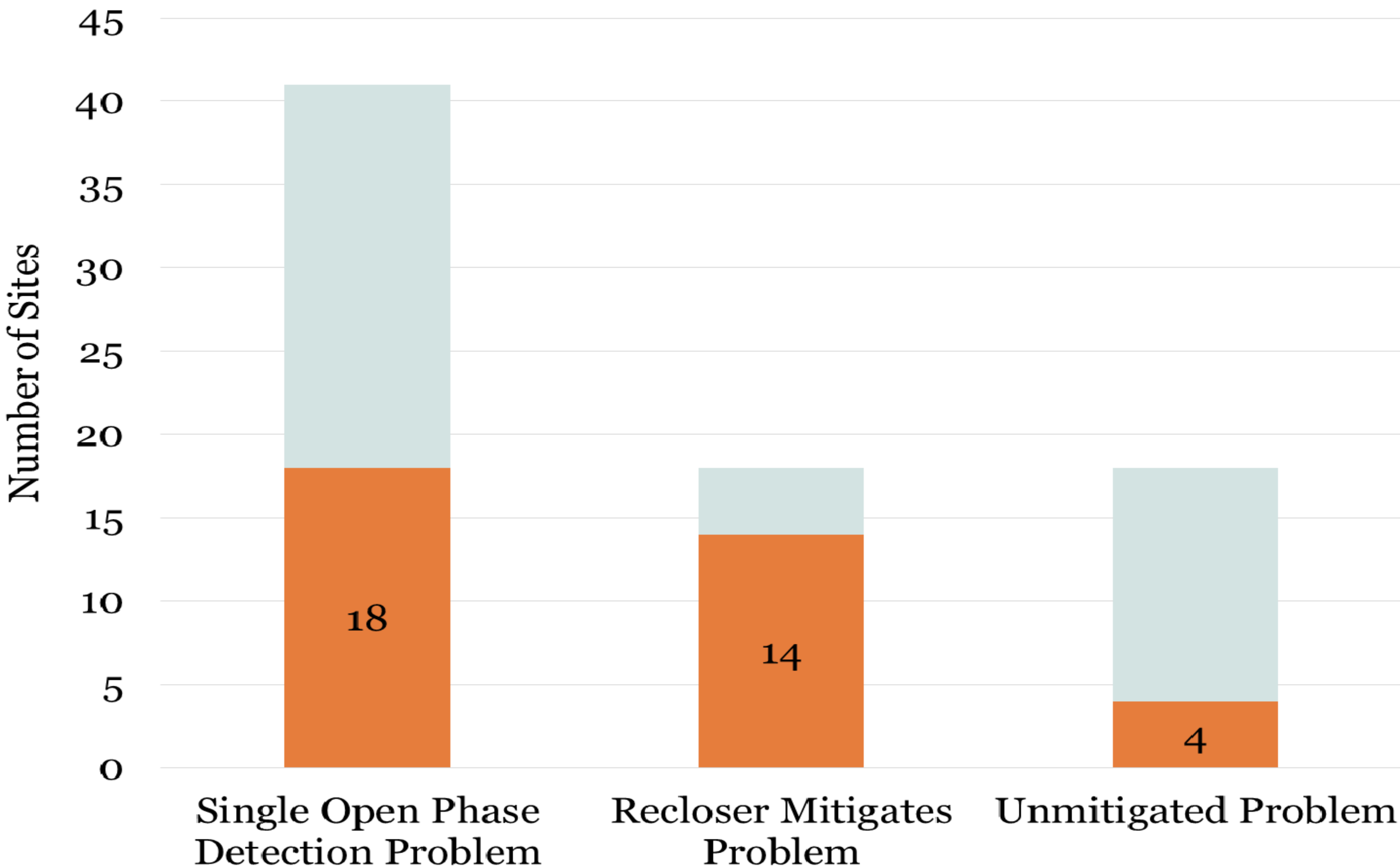
OPEN PHASE DETECTION PROBLEM

- 17 sites have SMA HE or CP inverters with grounded YNy transformers (grounded on utility side), leading to a single open phase detection problem
- Duke Energy recloser mitigates the problem at most sites

advanced energy



Open Phase Detection Problem



Example Outcomes of Key Assessment Findings

25% Overgeneration at the 6.24 MW Site

– Duke Energy study and distribution system upgrades were completed for the approved 5 MW site, not 6.24 MW

– Overloaded PV facility-owned and utility-owned medium voltage circuits and equipment may lead to premature failure and power quality issues on the utility distribution circuit, affecting other customers

Example Outcomes of Key Assessment Findings

Incorrect Interconnection Protection Settings

- Solar farms will not disconnect from the grid quickly enough in response to abnormal grid conditions, possibly tripping other customers offline due to poor power quality and increasing damage due to faults
- Solar farms may disconnect from the grid prematurely in response to low grid frequency conditions, impacting grid stability

Example Outcomes of Key Assessment Findings

Desensitized Open Phase Detection

- Loss of a single phase in a three phase utility distribution system is a common occurrence
- Desensitized open phase detection may allow the PV facility to energize an otherwise deenergized phase, resulting in:
  - Reduced power quality for other customers
  - Damage to utility and other customer property
  - Life threatening conditions for the general public and utility personnel

NC Solar Industry Follow Up

- Dec. 2015 – AE presented assessment results to Duke Energy
- Feb. 2016 – At the request of NCSEA, AE also presented assessment results to the NC solar industry
- NCSEA / NC solar industry provided feedback on AE presentation; Several of their comments are reflected in this presentation
- NC solar industry (through NCCEBA) has formed a working group to determine how to best address the findings of AE's assessments. AE has been invited to participate in their next meeting in late July.

EXHIBIT C


Thank You
Shawn Fitzpatrick
sfitzpatrick@advancedenergy.org