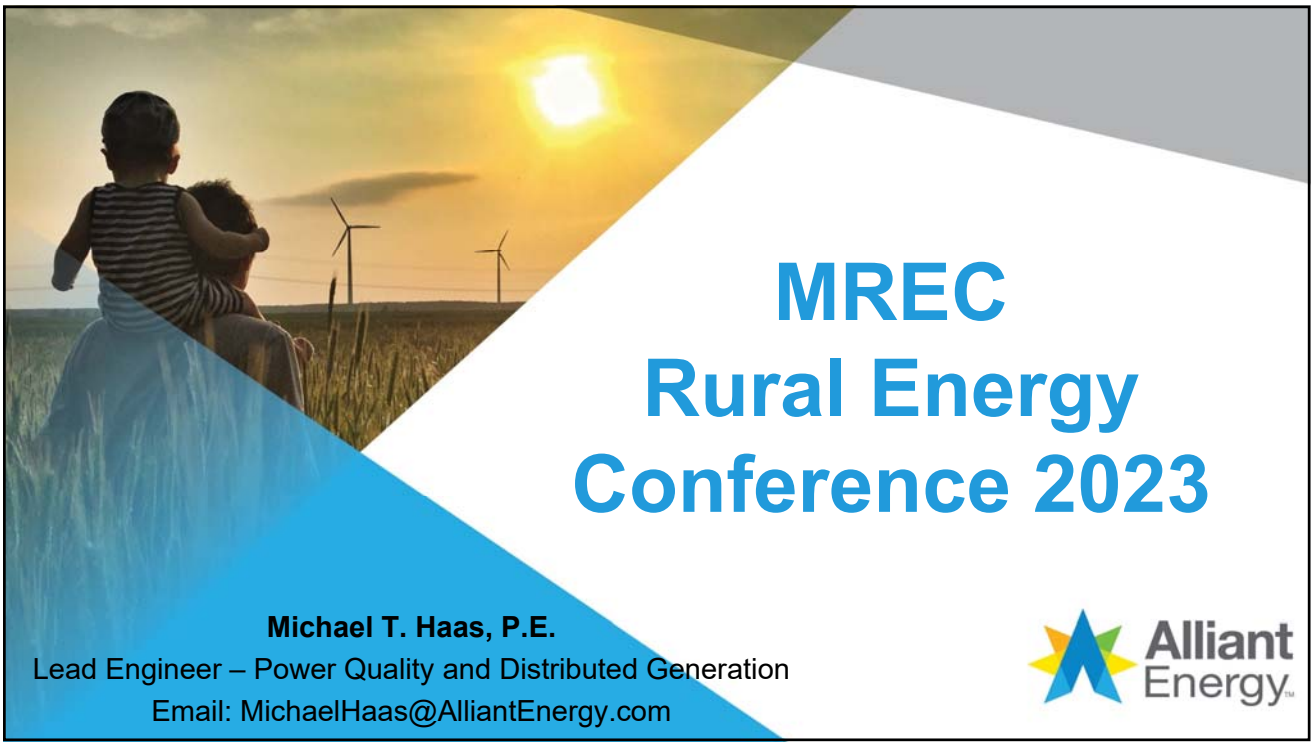


MREC Rural Energy Conference 2023

Michael T. Haas, P.E.
Lead Engineer – Power Quality and Distributed Generation
Email: MichaelHaas@AlliantEnergy.com

Alliant Energy

1

AGENDA

TWO PRESENTATIONS – YOUR CHOICE!

#1 CASE STUDY – SINGLE PHASE HOG FARM SOLAR INSTALL
#2 THREE PHASE SOLAR – DON'T FORGET THE BASICS
(STRAY VOLTAGE KNOWLEDGE STILL APPLIES)

Alliant Energy

2

2

Michael Haas

- Lead Engineer: Power Quality and Distributed Generation
- 5 Years at Alliant Energy.
- Involved with the Agriculture Compliance Team, Design Team, Wisconsin Distribution Engineers, and Engineering Solutions Group.
- Lead Instructor for University of Wisconsin – Stray Voltage Classes
- Public Service Commission of Wisconsin
  - Stray Voltage Committee & Sub Committee
- Before Alliant
  - 10+ Years Consulting
    - Stray Voltage Testing
    - Expert Witness
    - Helped utilities and cooperatives with training, testing, and company/system standards

3

Michael Haas

- When not working at Alliant Energy, you'll likely find me washing, upgrading, or driving the new toy!

1994 CBR F2
100 HP
429 LB

2013 CBR 1000 RR
177 HP
381 LB

2003 CBR F4i
110 HP
370 LB

4

Single Phase Solar

Rural Hog Farm Installation

Alliant Energy

5

Farm As Found

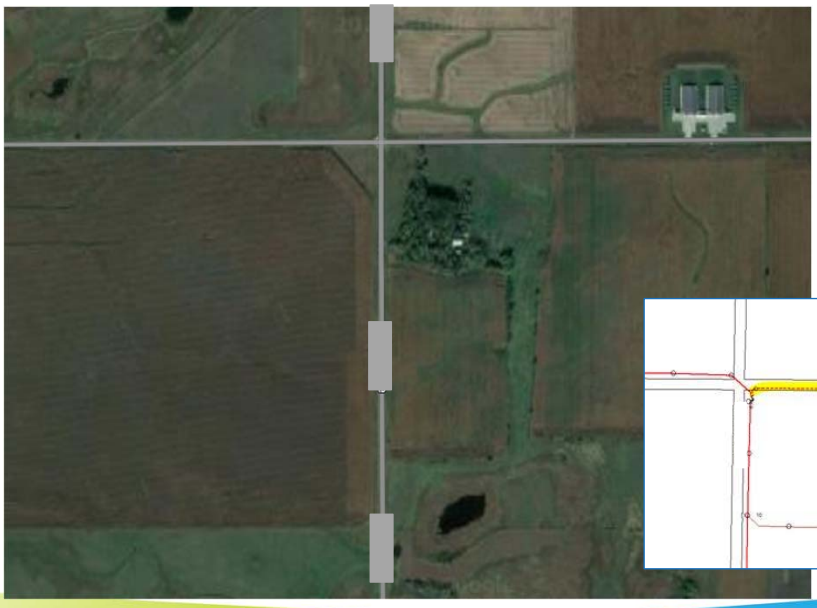
- Single phase 120-240 volt farm customer
- Rural hog facility
- 400A Service
- 15-25 kW Typical

6

Alliant Energy

6

Utility As Found



- Radial line
- Single-phase
- 6A/8A Copperweld
- Tap recently upgraded to 4/0 AL URD.

7

As Found

- Received a solar application:
  - 6x 12.5 kW Inverters = 75 kW
  - Construction was already underway
  - Request to upgrade to a 600A Service due to Solar installation

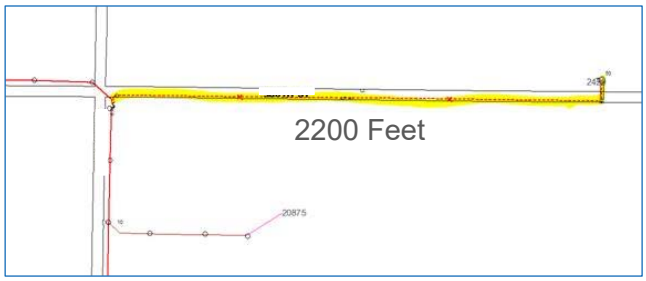
- Initial Thoughts:
  - Typical DER considerations
  - Stray voltage considerations
    - Present?
    - Future?

8

Farm As Found

Condition:	Farm Off No Load	Farm Off 1/2 Load	Farm Off Full Load	Farm On Full Load	Farm On No Load
Current Measurements					
Load Box	0	41.8	83.5	83.5	0
Farm Load (X3)					
Farm Load (x1)					
Secondary Neutral (X2)	0	.25	.46	.67	.77
Triplex					
Primary Neutral	0	1.1	2.18	3.65	3.55
Primary Phase (Calculated)	0.00	1.39	2.78	2.78	0.00
Isolation Jumper					
Voltage Measurements					
Channel 1: PN-RG	.2	.82	1.49	1.79	2.17
Channel 2: SN-RG	.19	.81	1.49	1.78	2.15
Channel 3: PN-SN	0	0	0	.03	.05

R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70



9

Farm As Found – RECAP

- Existing:
  - 400A Service
  - 15-25 kW Typical Load
  - 20 kW Load Box Test Results
- Received a solar application:
  - 6x 12.5 kW Inverters = 75 kW
  - Construction was already underway
  - Request to upgrade to a 600A Service due to Solar installation

R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70

Voltage Measurements					
Channel 1: PN-RG	.2	.82	1.49	1.79	2.17
Channel 2: SN-RG	.19	.81	1.49	1.78	2.15
Channel 3: PN-SN	0	0	0	.03	.05

10

Farm As Found

- How will solar change things:
  - Farm Load Only (15-25 kW Typical)
  - Generation Only
  - Farm Load + Generation
  - What are the differences between load and generation?
  - Neutral Isolation?
- Learned the customer had no plans to add load.
- Learned there are times where there are no animals (or load).

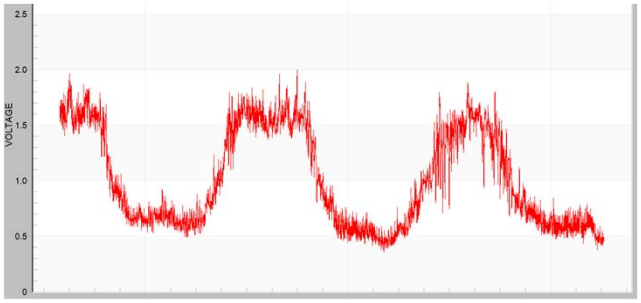
R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70

Voltage Measurements					
Channel 1: PN-RG	.2	.82	1.49	1.79	2.17
Channel 2: SN-RG	.19	.81	1.49	1.78	2.15
Channel 3: PN-SN	0	0	0	.03	.05

11

Farm As Found

- What do we know so far?
  - As is, everything is working well
  - Rp is higher than we expected
  - Rf is higher than we expected
  - Soil conditions are believed to be good
  - Grounding of both systems can be improved.
  - If generation behaves like load, 75 kW of solar is too much!



12

Farm As Found

PSCW Docket 05-EI-106
August 10, 1989

While the Commission will not establish a maximum level for primary neutral to earth voltage on a distribution line, it does note that several utilities, such as Northern States Power and Wisconsin Public Service Corporation, have internal guidelines for such levels which are useful, not only for stray voltage purposes, but also for general planning and operational management. The ranges established are from 2.5 to 5 volts on the primary neutral system, depending on the primary phase to phase voltage levels. Other utilities should submit similar guidelines or show why such guidelines are not appropriate for them. A comprehensive review process to ensure adequate planning and operation of rural distribution systems with a view to minimization of stray voltage concerns will be implemented.

What happened next?

- Customer asked for a Neutral Isolator to resolve 75 kW generation concerns.
  - Thoughts?
  - Vp Impacts?
  - Animal Contact Voltage Impact?
  - "Negative System Impact" (Solar)

R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70

What happened next?

DATE MAILED
AUG 11 1999

BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

COMPARED WITH AND CERTIFIED BY ME TO BE A FULL, TRUE AND CORRECT COPY OF THE ORIGINAL ON FILE IN MY OFFICE
AUG 10 1999
Secretary to the Commission
Public Service Commission of Wisconsin

Investigation on the Commission's Own Motion Into the Practices, Policies and Procedures Concerning Stray Voltage for Electric Distribution Utilities in Wisconsin) 05-EI-106

4. Neutral isolation could be prohibited in the following circumstances:

(a) The removal of the farm grounds cause the primary neutral voltage to increase to unacceptable levels.

(b) The installation of the isolator causes the farm electrical system to be unsafe including because of lack of farm grounding.

5. Neutral isolation could be used only as a short-term, temporary measure in the following circumstances:

(a) An alternative mitigation device such as an equipotential plan is a more economical, safe and effective long-term solution.

(b) The off-farm problem is corrected.

15

What happened next?

Date Mailed
07-16-96

BEFORE THE

PUBLIC SERVICE COMMISSION OF WISCONSIN

Investigation on the Commission's Own Motion Into the Practices, Policies and Procedures Concerning Stray Voltage for Electric Distribution Utilities in Wisconsin 05-EI-115

3.Isolation is not available if it creates unsafe conditions on the farm because of lack of grounding or increases the primary neutral voltage to unacceptable levels.

16

Remember:

- Materials have already been delivered
- Construction has already begun
- Farm load is under 25 kW
- Customer is talking about isolation
- Cannot allow 75 kW generation
- What should we do?
  - Offer options!

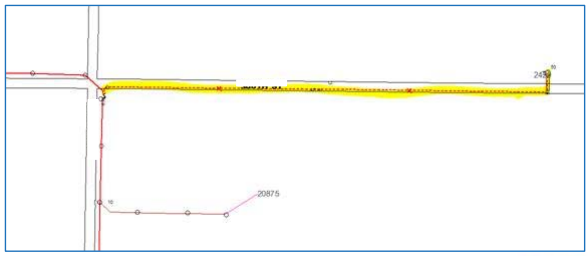
R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70

17

Options Offered

#1 (Informational Note):

With no line changes, we expect unlimited generation export of 75 kW would result in unacceptable primary neutral to remote earth voltages (PNEV). This option will not be allowed.



18

Options Offered

#2:

Limit generation to 35 kW export.

Assuming the farm is in operation and maintaining an expected minimum load, no changes to the line are needed.

19

Alliant Energy

19

Options Offered

#3:

Increase generation export limit to between 40 – 50 kW.

Actual export value will be determined after the following upgrades have been completed and on-site testing conducted to determine effectiveness. Line improvements include:

a. Install deep grounding at junction boxes between farm and corner (4 locations).
b. Install counterpoise between farm and corner.
c. Install additional grounding at farm.
d. Note: Customer pays all upgrade costs to increase generation output
e. Note: We estimate the export limit will be closer to 50 kw than 40 kw after this work is done based on results from a recent stray voltage test

20

Alliant Energy

20

Options Offered

#4:
Allow up to 75 kW generation export based on the following system upgrades:

a. Install deep grounding at junction boxes between farm and corner.
b. Install counterpoise between farm and corner.
c. Install additional grounding at farm.
d. Install single phase #1 AL UG between corner and 3 phase line to the south.
e. Note: Customer pays all upgrade costs to increase generation output

21

21

Options Offered

#5 (Informational Note):
Neutral isolation cannot be used as a method to increase generation export. Installation of a neutral isolator may result in additional curtailment of generation export due to negative system impacts.

22

22

Customer's Decision

#2:
Limit generation to 35 kW export.
Assuming the farm is in operation and maintaining an expected minimum load, no changes to the line are needed.

Customer/installer agreed to add 20 additional ground rods to improve safety as well as a preventative stray voltage measure.

Utility added additional grounding at the junction cabinet, riser, and OH pole line.

How did we do?

Time to test!

- Witness Testing
  - Islanding Test – Shut Down Within 2 Seconds
    - Re-Energize after 5 minute delay
  - Export Limit Test
    - Generation Only
    - Load only
    - Generation + Load
- Stray Voltage Testing
  - NEV Monitoring
  - Load Box Test

Witness Testing

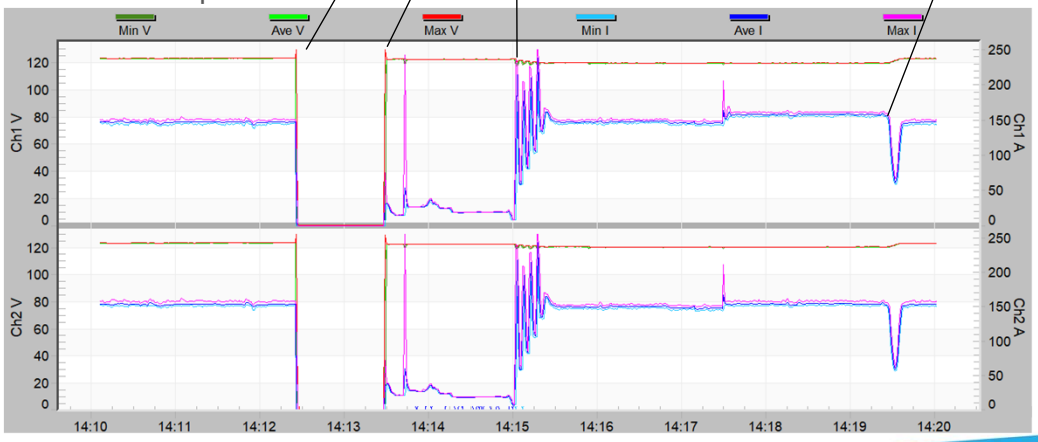
Remove Primary Fuse

Replace Primary Fuse

Farm Fan Load

Solar Online

Power Quality Meter
Volts and Amps



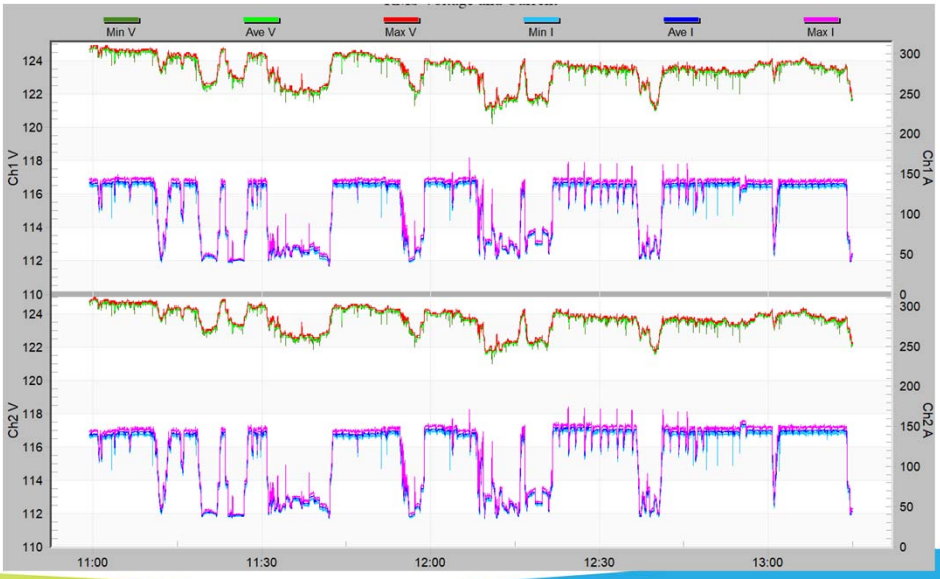
25

Alliant Energy

25

Witness Testing

Power Quality Meter
Volts and Amps

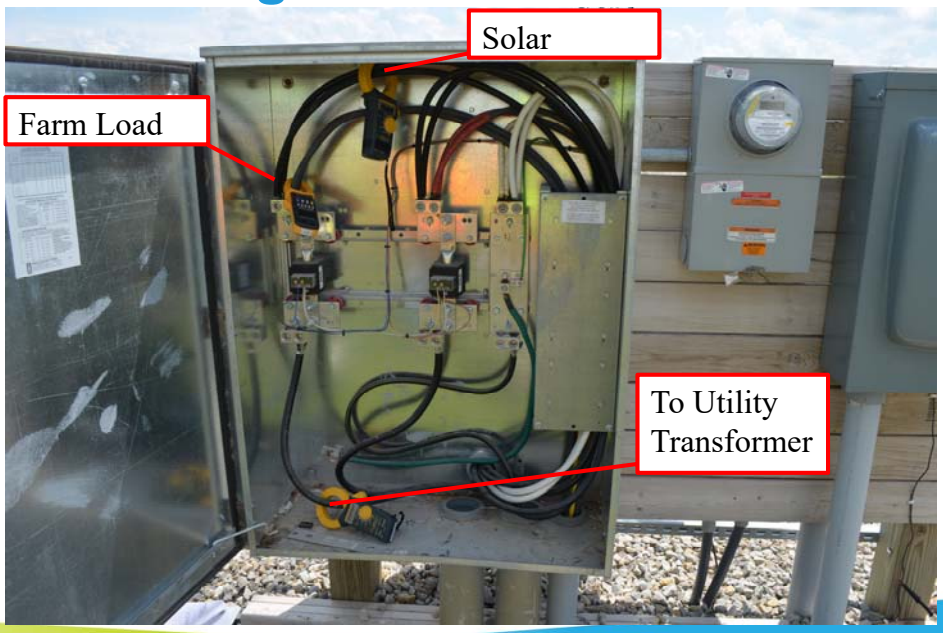


26

Alliant Energy

26

Witness Testing

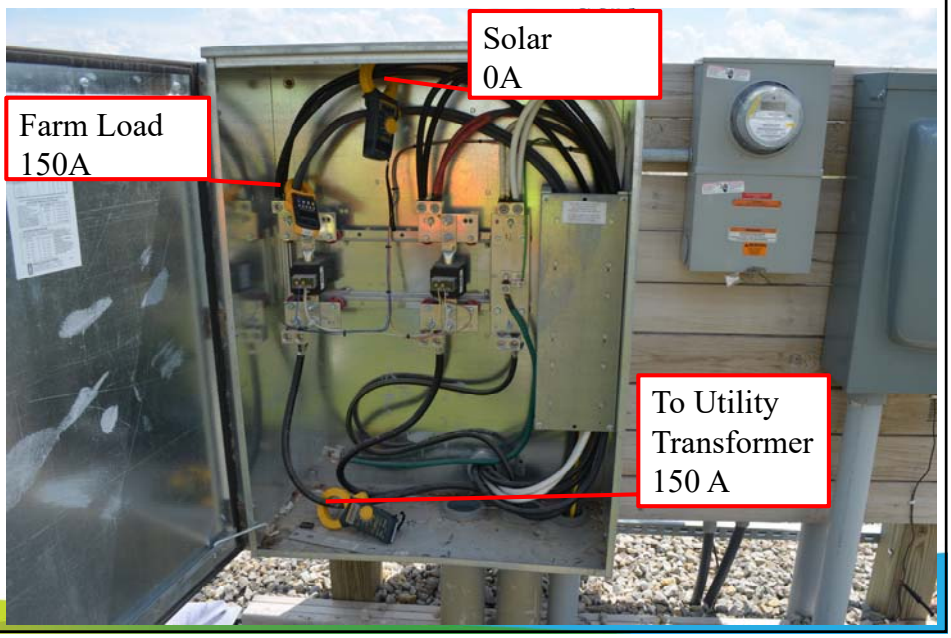


27

27

Witness Testing

Farm On
Solar Off

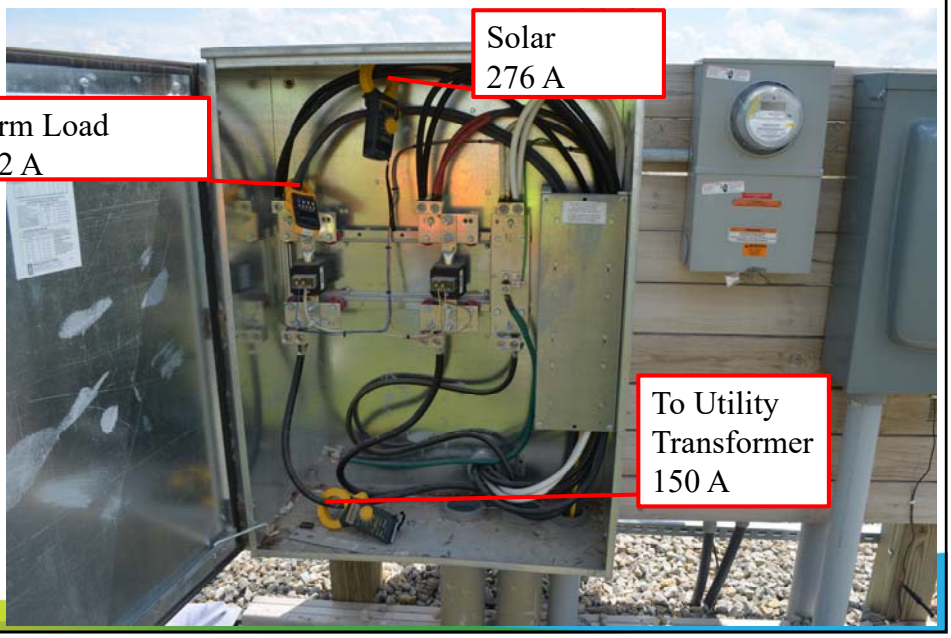


28

28

Witness Testing

Farm On
Solar On

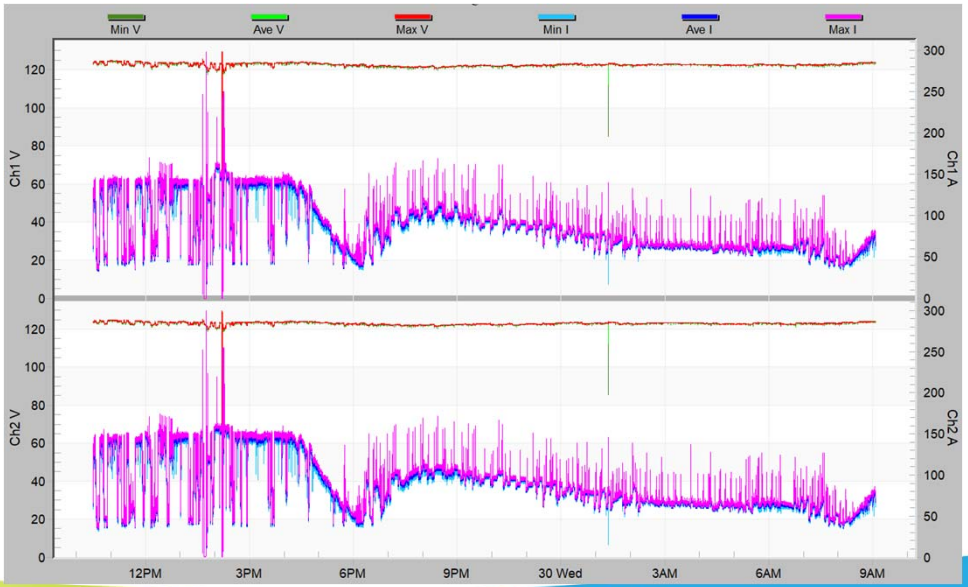


29

29

Witness Testing

Power Quality Meter
Volts and Amps



30

30

Witness Testing

Power Quality Meter
KW

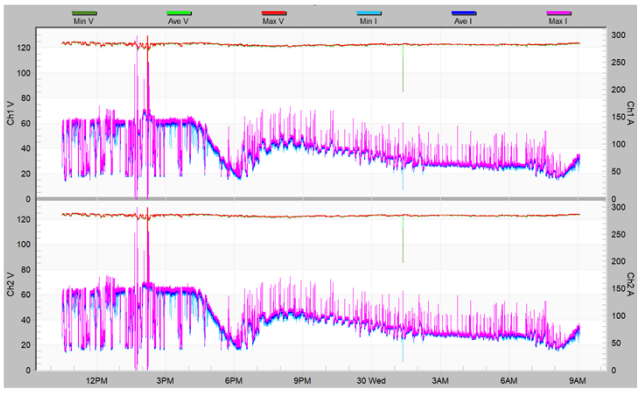
31

Alliant Energy

31

Witness Testing

Volts and Amps



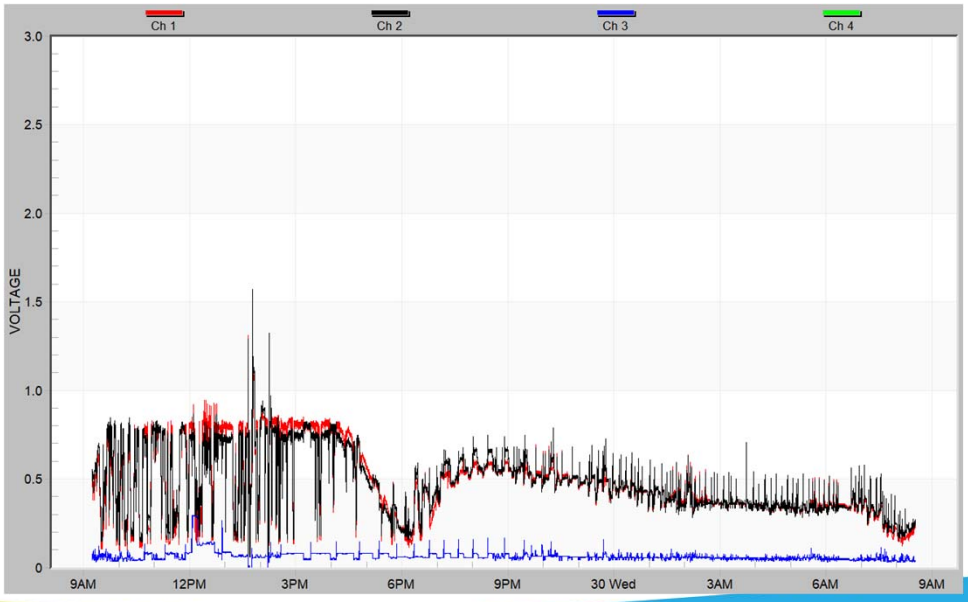
Kilowatts

32

Alliant Energy

32

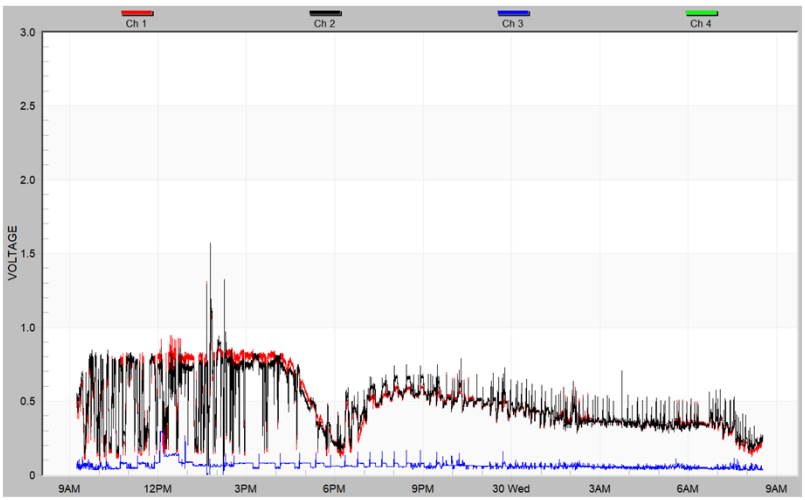
Stray Voltage Results



33

33

Stray Voltage Results



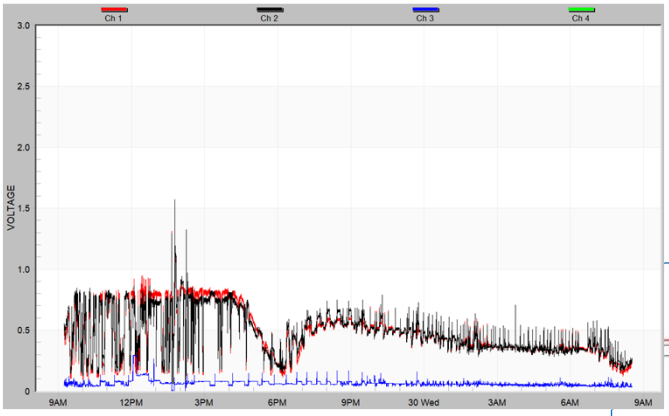
- Does direction matter?
- Should we have allowed 75 kW?
- Did the grounding work?
  - 35 kW generation vs 25 kW Load
- Why are these the stray voltages measured – Why does the graph look like this?

$$V = I * R$$

34

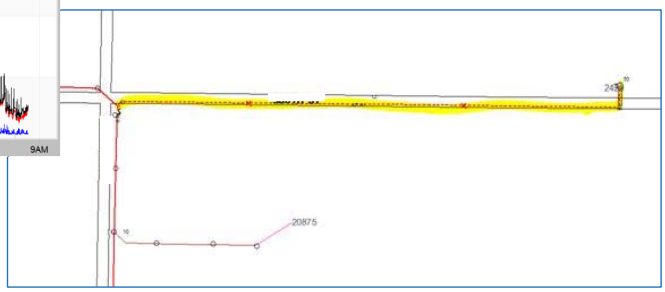
34

Stray Voltage Results



$$V = I * R$$

- Could we allow 75 kW Export?
- How?
- Seasonal concerns?



35

Stray Voltage Results

Before

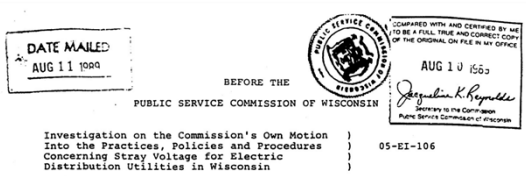
Condition:	Farm Off No Load	Farm Off 1/2 Load	Farm Off Full Load	Farm On Full Load	Farm On No Load
Current Measurements					
Load Box	0	41.8	83.5	83.5	0
Farm Load (X3)					
Farm Load (x1)					
Secondary Neutral (X2)	0	.25	.46	.67	.77
Triplex					
Primary Neutral	0	1.1	2.18	3.65	3.55
Primary Phase (Calculated)	0.00	1.39	2.78	2.78	0.00
Isolation Jumper					
Voltage Measurements					
Channel 1: PN-RG	.2	.82	1.49	1.79	2.17
Channel 2: SN-RG	.19	.81	1.49	1.78	2.15
Channel 3: PN-SN	0	0	0	.03	.05

After

Condition:	Farm Off No Load	Farm Off 1/2 Load	Farm Off Full Load	Farm On Full Load	Farm On No Load
Current Measurements					
Load Box	0	41.8	83.5	83.5	0
Farm Load (X3)				80.6	79.2
Farm Load (x1)				80.6	79.2
Secondary Neutral (X2)	.135	.638	1.18	3.42	3.42
Triplex					
Primary Neutral	.136	.76	1.6	2.48	2.42
Primary Phase (Calculated)	0.00	1.39	2.78	5.47	2.64
Isolation Jumper					
Voltage Measurements					
Channel 1: PN-RG	.060	.256	.465	.682	.645
Channel 2: SN-RG	.059	.252	.461	.718	.691
Channel 3: PN-SN	0	0	0	.058	.056

36

What happened next?



DATE MAILED
AUG 11 1999

BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

COMPARED WITH AND CERTIFIED BY ME TO BE A FULL, TRUE AND CORRECT COPY OF THE ORIGINAL ON FILE IN MY OFFICE
AUG 10 1999
Secretary to the Commission
Public Service Commission of Wisconsin

Investigation on the Commission's Own Motion)
Into the Practices, Policies and Procedures) 05-EI-106
Concerning Stray Voltage for Electric)
Distribution Utilities in Wisconsin)

4. Neutral isolation could be prohibited in the following circumstances:

(a) The removal of the farm grounds cause the primary neutral voltage to increase to unacceptable levels.

(b) The installation of the isolator causes the farm electrical system to be unsafe including because of lack of farm grounding.

5. Neutral isolation could be used only as a short-term, temporary measure in the following circumstances:

(a) An alternative mitigation device such as an equipotential plan is a more economical, safe and effective long-term solution.

(b) The off-farm problem is corrected.

37

37

Stray Voltage Results

Before	
R Total	0.48
R Primary System	0.62
R Farm	3.24
R Farm (alt)	3.19
K (CC1)	0.00
K (CC2)	0.00
Current Return	77.70

After	
R Total	0.15
R Primary System	0.25
R Farm	0.39
R Farm (alt)	0.39
K (CC1)	0.00
K (CC2)	0.00
Current Return	60.43

- Are stray voltages better?
- Is the farm safer?
- Did we make things better?
- 1/0 + Counterpoise vs 4/0?

38

38

Questions?

Michael T. Haas, P.E.
Lead Engineer:
Power Quality and Distributed Generation
Email: MichaelHaas@AlliantEnergy.com

39