

CADMUS

November 16, 2018

Study of Renewable Energy Installation Quality in Rhode Island – Round 2 Final Report

Rhode Island Renewable Energy Growth Program

Presented by:
Matt Piantedosi

Today's Presenters: Matt Piantedosi

Project Lead Senior Reviewer

- Master Electrician
- Cadmus Manager of Solar Operations
- Has worked in Rhode Island since 2014
 - Supporting the REF and REG programs, as well as private solar installers
- Inspected over 600 PV systems to date
- Provides training to electrical inspectors and solar installers on safe PV installations and NEC compliance



REG QA Study Round 2 Purpose

- Study commissioned by OER, on behalf of the DG Board
- Determine whether REG-funded renewable energy installations are “*safe, high quality, performing as expected, and in conformance with the stated specifications*”
- Compare to Round 1 of study (April 2017)

Final Report

Addresses 100 inspections:

- 86 small-scale
- 8 medium-scale
- 6 large-scale

Round 1 vs. Round 2 Study Approach

- Similar/unchanged approaches:
 - Research questions
 - Research methodology/inspection process
 - Comparison to the REF program
- Modified approaches:
 - TSRF readings (shading analysis) at all feasible sites
 - Customer survey
 - Additional data analysis:
 - Comparing rounds 1 and 2 of the study
 - Analyzing average quality scores for non-REF program participants

Sample Selection

Solar Inspection Type	Number of Inspections	Number of Installers
Small-Scale	86	17
Medium-Scale	8	6
Large-Scale	6	4
Total	100	27



Final Results from On-site Inspections

Key Findings

- Inspections focused heavily on compliance with the 2014 edition of the National Electrical Code (NEC) and International Building Code (IBC)
- Other findings were noted as a **recommendation**, with no impact on score
 - Excessive shading
 - Industry best-practices
- 45% of solar PV systems inspected exhibited **major or critical** installation deficiencies
- Most installation deficiencies occurred at:
 - **PV array**
 - Point of **interconnection**
- Average quality scores (2.62) are 0.34 points lower than 2017 scores

Cadmus Inspection Scoring

Score	Classification	Description
5	No Issues	No issues identified on site.
4	Incidental	Issues not expected to impact system operation or safety. Examples: Installation debris left onsite, poor wire management, missing or incomplete labels, and installed equipment not matching program records but considered equivalent.
3	Minor	Issues that pose a mid-to long-term risk of system failure or safety hazard. Examples: Bonding neutral to ground in a meter enclosure, insufficient clearance around boxes, undersized circuit protection, and improperly supported conductors.
2	Major	Issues deemed likely to impact system performance or safety in the short-term, though not an immediate hazard. Examples: Missing equipment grounding, module damage, missing or undersized grounding electrode conductor, improperly secured PV modules, and missing or inadequate thermal expansion joints in long conduit runs.
1	Critical	Issues that pose an immediate risk of system failure and/or safety hazard. Systems are often shut down during the inspection due to safety concerns. Examples: Exceeding current limits on busbars or conductors, exceeding inverter voltage limits, and use of non-DC rated equipment in DC circuits.

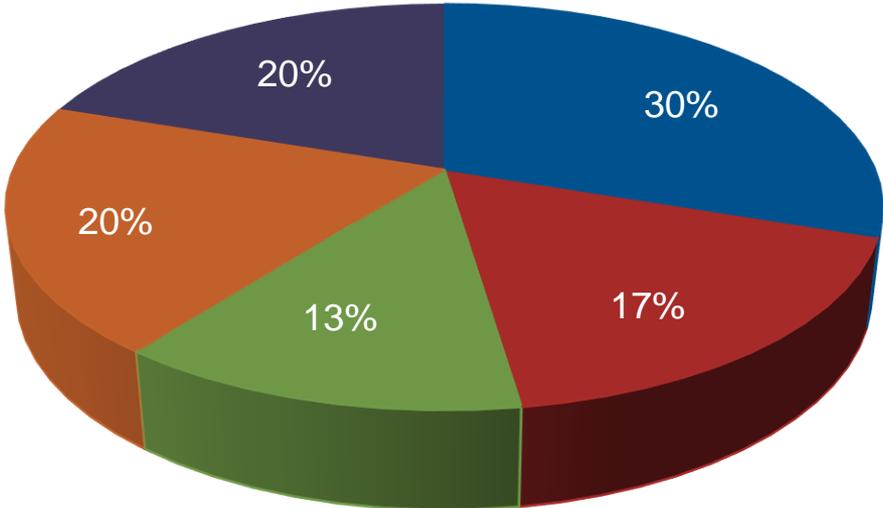


Small-Scale Inspection Results

Small-Scale Inspection Scores

Score	Count
1	26
2	15
3	11
4	17
5	17

■ 1 ■ 2 ■ 3 ■ 4 ■ 5



Inspection Issues by Inspection Element

Inspection Element	Total
AC Combiner	31
AC Disconnect	5
Array	190
Inverter	81
Junction Box	6
Optimizer	4
Overall Observations	3
Production Meter	2
Supply-Side Connection	187
Total	509

Self-Installer and Low-Volume Installer PV Systems

Installers with <8 operational REG projects in study timeframe

- 191 out of 475 total operational projects at initiation of study
- 44 out of 86 small-scale inspections were in this category
 - 12 out of 17 installers inspected were in this category
- 310 violations identified, resulting in average score of 2.52
- The self-installers contacted during timeframe refused inspection

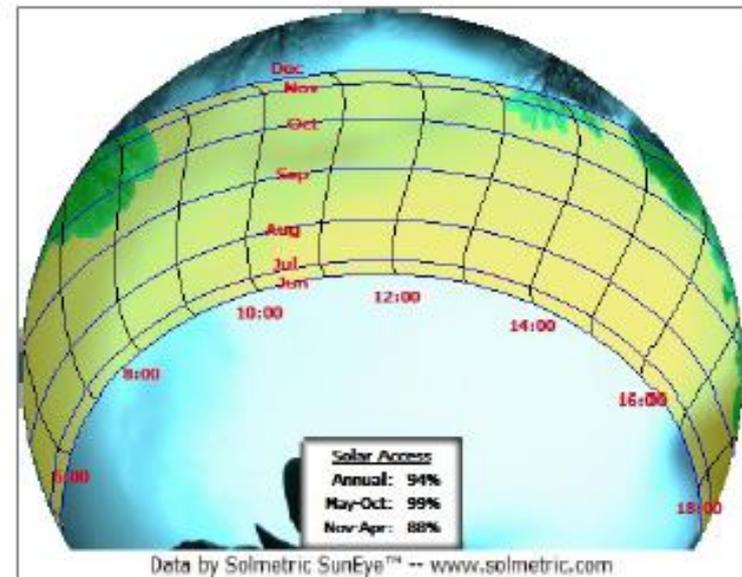
TSRF

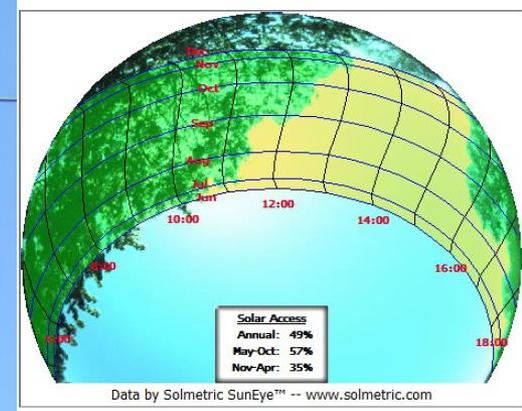
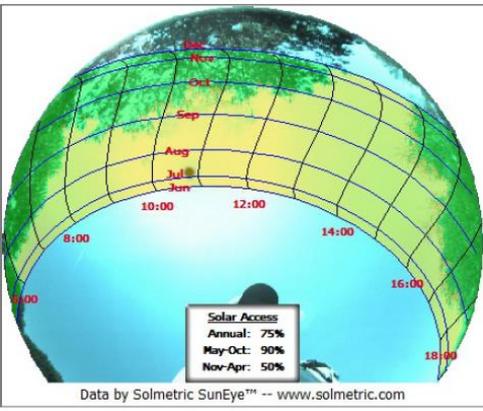
Total Solar Resource Fraction (Tilt & Orientation Factor * Shading (solar access))

- REG does not have a TSRF requirement (REF does)
- TSRF measured at 70 of 100 sites
- **24** systems had a TSRF <80%
 - No commonality among specific installers and low TSRF
- Two notable instances of low TSRF:
 - PV installed on north side of a home (**44%** TSRF, REG1024)
 - Significant shading at a home (**62%** TSRF, REG1526)
- PV oriented north and/or with significant shading are generally a poor investment

Sky01 -- 4/27/2018 12:15 -- se

Panel Orientation: Tilt=23° -- Azimuth=155° -- Skyline Heading=180°
Solar Access: Annual: 94% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 88%
TSRF: 90% -- TOF: 96%





REG1526: 62% TSRF, Tilt 21°, Azimuth 200°

REG vs. REF

- For installers using both incentive programs, inspection scores per installer were an average of 30% higher for projects under REF compared to REG



	REG	REF
Average Score	2.44	3.26





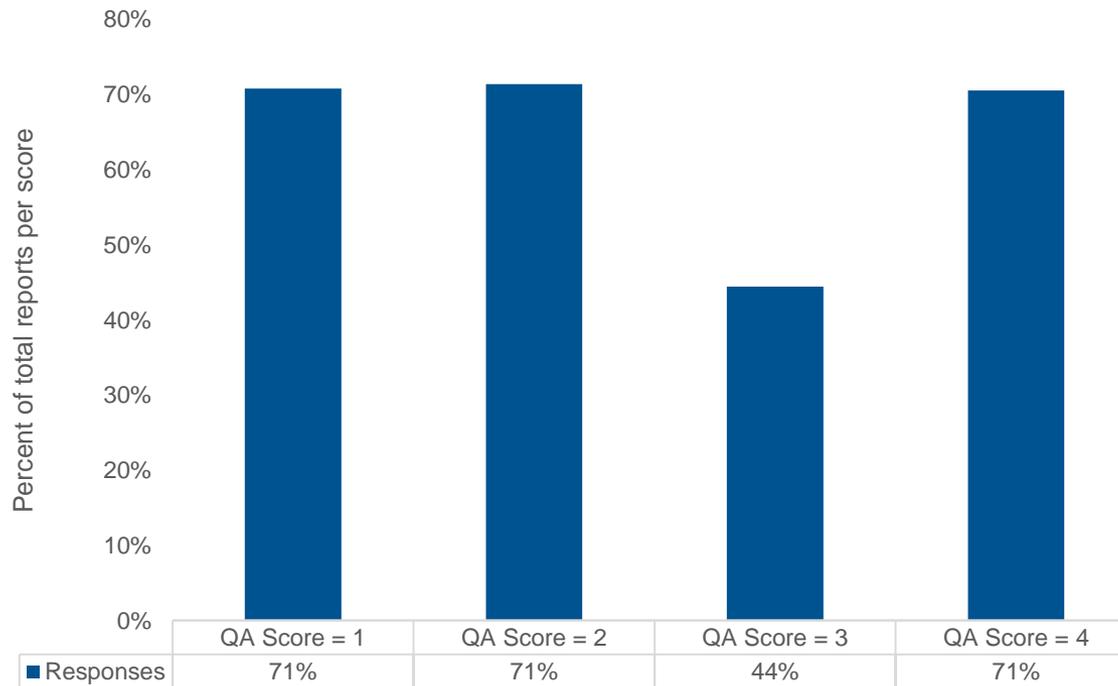
Installer Responsiveness

Installer Responsiveness

- Cadmus confirmed delivery of 87 inspection reports to 20 installers
- 24 systems received a score of 5, requiring no corrective action
- Cadmus could not confirm delivery of 13 inspection reports to four installers.
 - Causes include: installers no longer operating in the state of Rhode Island or out-of-date or unavailable contact information.
- Installer responsiveness tracking characterized by:
 - Likelihood of installers to respond to Cadmus communications
 - Receipt of proof of corrective action
 - Approval of corrective action photos by a Cadmus inspector

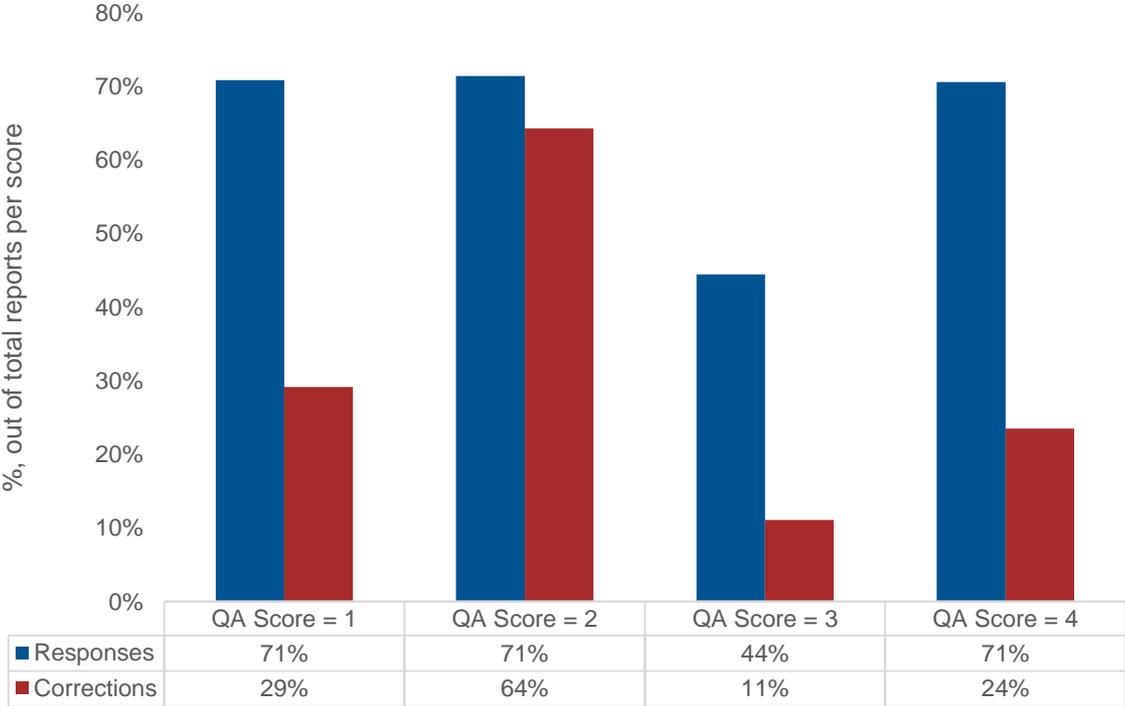
Overall Responses

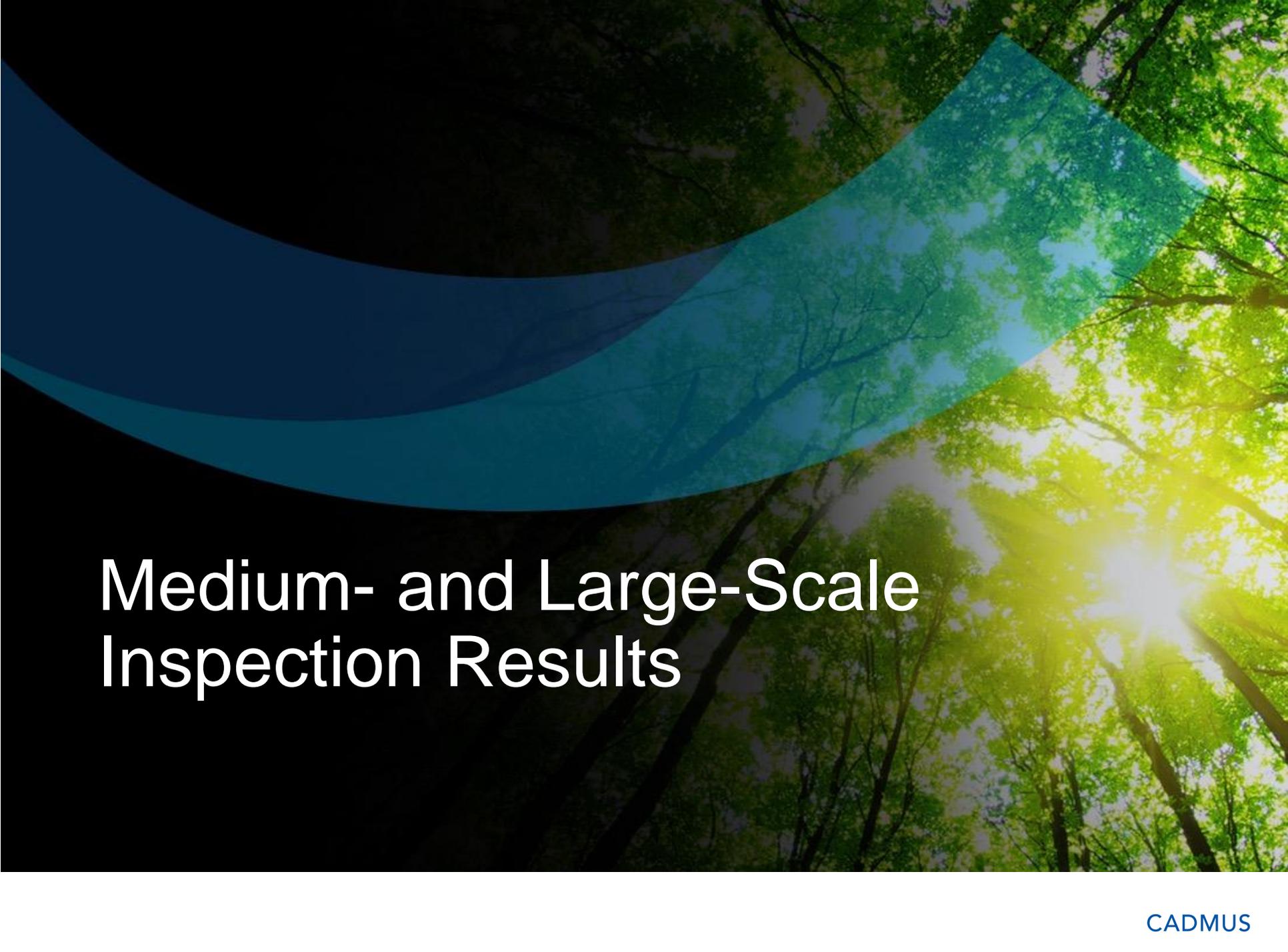
- 72% of all reports sent to installers received some sort of response



Corrective Action

- Only 33% of reports sent to installers resulted in corrective action

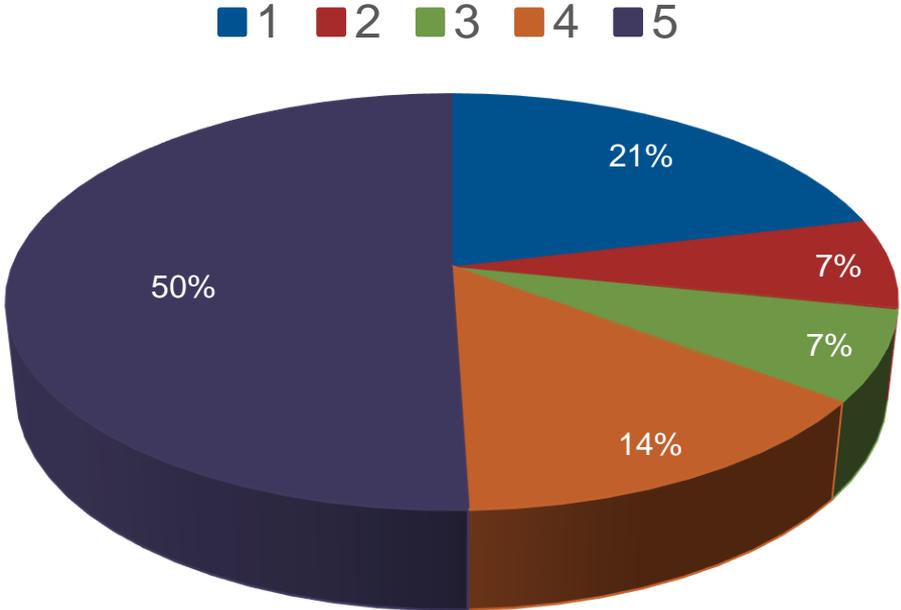




Medium- and Large-Scale Inspection Results

Inspection Scores

Score	Count
1	3
2	1
3	1
4	2
5	7



Inspection Issues by Inspection Element

Inspection Element	Total
AC Combiner	15
AC Disconnect	4
Array	25
Inverter	10
Junction Box	0
Optimizer	0
Overall Observations	1
Production Meter	0
Supply-Side Connection	5
Total	60

Inspection Issues by Inspection Element

- Eight of 14 medium- and large-scale inspections were ground-mounted arrays
 - Roof-mounted medium- and large-scale systems had statistically more inspection violations
- Two major offenders make up a large portion of total inspection issues
 - REG2161 accounted for 19 of 26 large-scale inspection issues
 - REG2156 accounted for 14 of the 34 medium-scale inspection issues



Examples of Common Deficiencies

Racking Mechanical Connections

Small-Scale Array – 25 Observations

- Racking system mechanical connections incorrectly made
- Variations from the installation instructions
- May result in premature failure
- Example: rail missing support



Improperly-Secured Modules

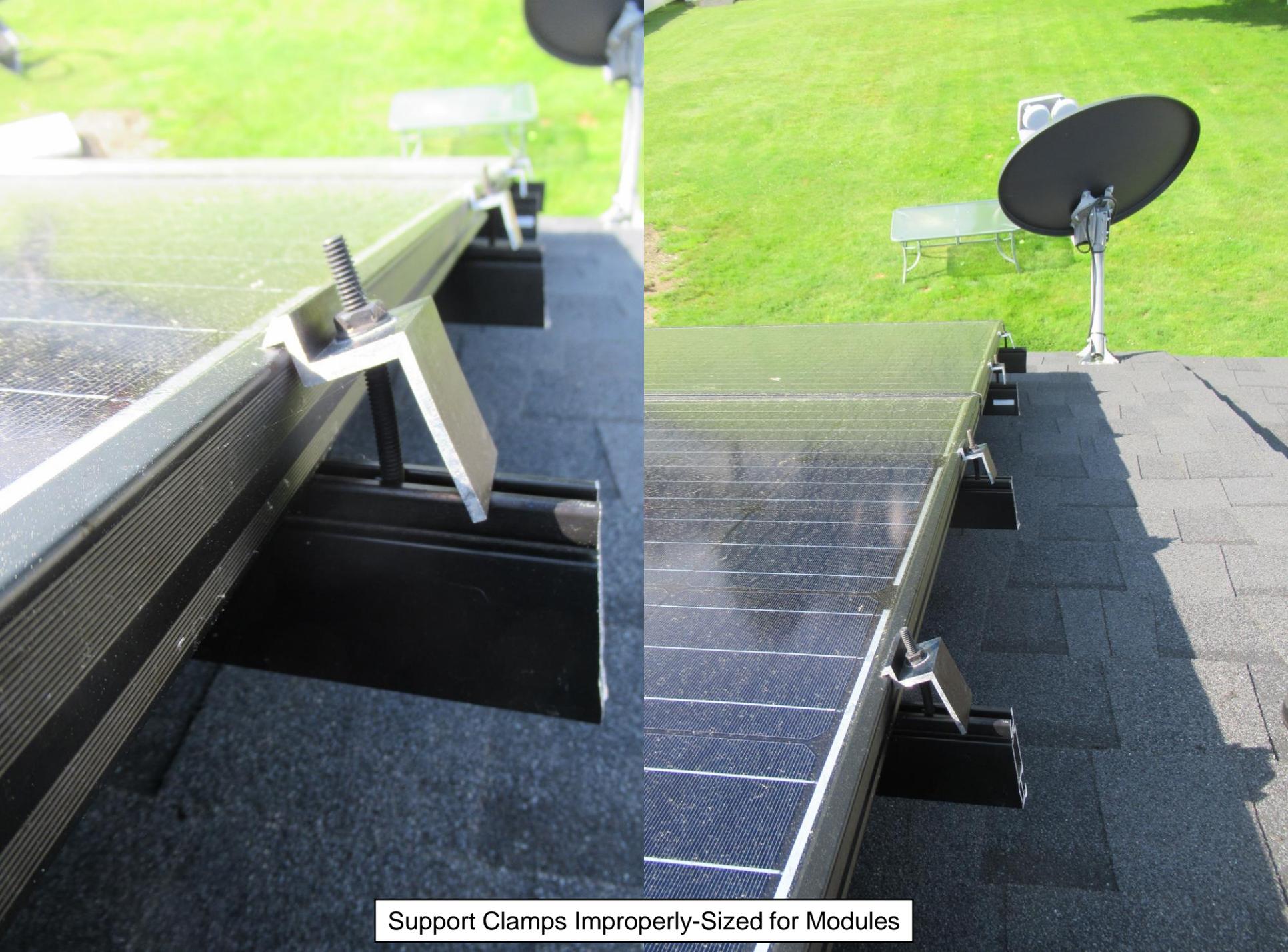
Small-Scale Array – 28 Observations

- PV modules improperly secured and fastened in place
- Missing, incompatible, or inappropriately-installed hardware
- Increased risk of module falling
- Example: missing support clamp





Support Clamps Improperly-Installed



Support Clamps Improperly-Sized for Modules

Unprotected Conductors

Small-Scale Array – 19 Observations

- Conductors improperly secured and protected
- Increased likelihood of faults due to conductor damage
- Example: conductors exposed to physical damage from abrasive roof shingles



Module Frame Grounding

Small-Scale Array – 19 Observations

- No means of grounding module frames
- If fault occurs, it may not facilitate the inverter's ground-fault protection
- Example: Single modules relying exclusively on non-bonding end-clamps



Rapid Shutdown

Medium-Large-Scale Array/Inverter – 2 Observations

- Missing or Deficient Rapid Shutdown Function
- When the rapid shutdown function is not functional or provided, DC wiring may be energized up to 1,000V during daylight hours. This may hinder the ability to safely mitigate issues such as a building fire
- Examples: rapid shutdown function not enabled, or DC conductors exceed 10' limit from array without rapid shutdown function





DC Wiring Greater than 10' from Array without Rapid Shutdown Protection

Unprotected or Improperly-Supported Conductors

Large-Scale Array – 1 Observation

- Conductors are not protected from physical damage.
- Damaged conductors can lead to system failure, danger to workers and others, and fire hazards.
- Example: Conductors installed in a location exposed to physical damage
 - Internally from sharp edges
 - Externally from other sources





Unsupported PV Conductors Submerged in Water

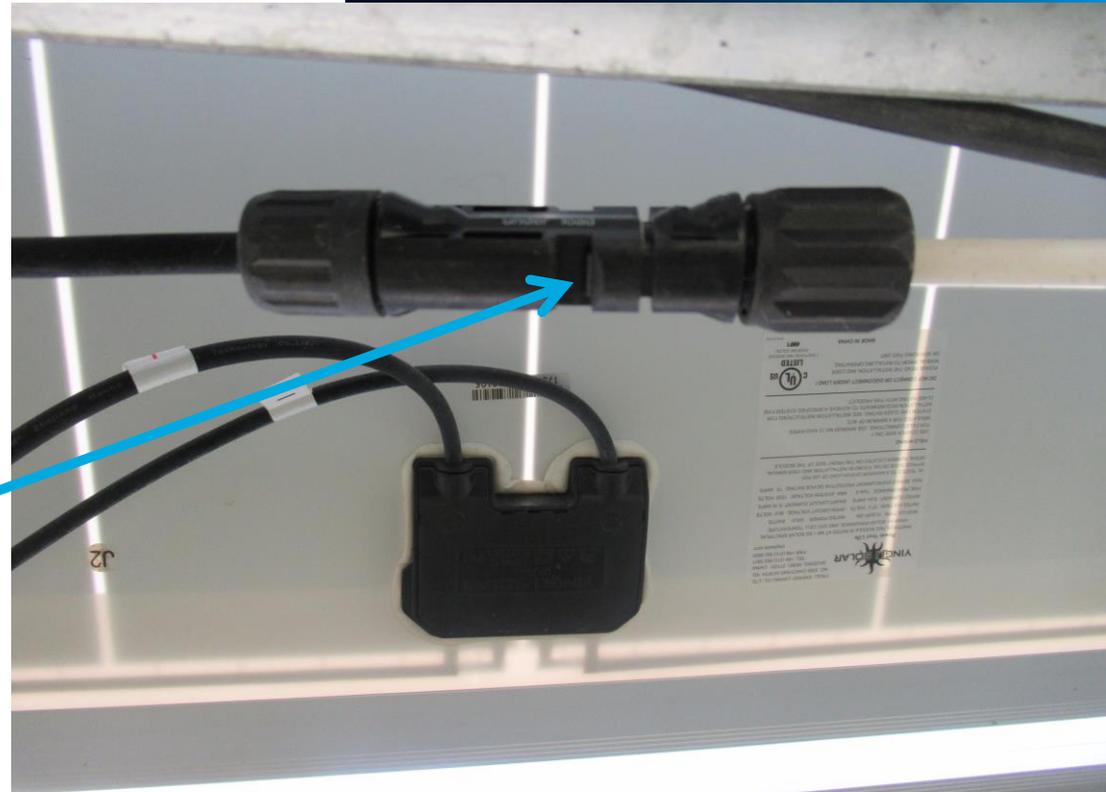


Unprotected Conductors Exposed to External Physical Damage

Array Conductors Improperly Connected

Large-Scale (Array) – 2 Observations

- DC connectors are not properly connected or used outside of the product listing.
- Hazards exist when DC connectors are not properly installed. Due to this DC current's physical nature, poor electrical connections can cause heat, arcing, or a thermal event.
- Example: Connectors that are not fully engaged can produce high temperatures, which can result in poor efficiency or fire.





REG-Specific Interconnection

REG-Specific Interconnection

https://www9.nationalgridus.com/narragansett/business/energyeff/4_interconnection-process.asp

- Unlike traditional “behind the meter” connection, all REG connections are made through a dedicated utility meter
- Solar is a new “tenant” on the property
- Limited methods allowed by National Grid
- **Unlike the 2017 study, Cadmus has not observed any unconventional connection methods violating National Grid’s requirements**



REG-Specific Interconnection

Overhead Service Installations – National Grid Requirements

- **Option 1:**
 - Install parallel service-entrance conductors from the existing service point to a new (REG) meter enclosure
- **Option 2:**
 - Replace existing meter enclosure with multi-gang meter enclosure



REG-Specific Interconnection

Underground Service Installations – National Grid Requirements

- **Only option:** Replace existing meter enclosure with multi-gang meter enclosure

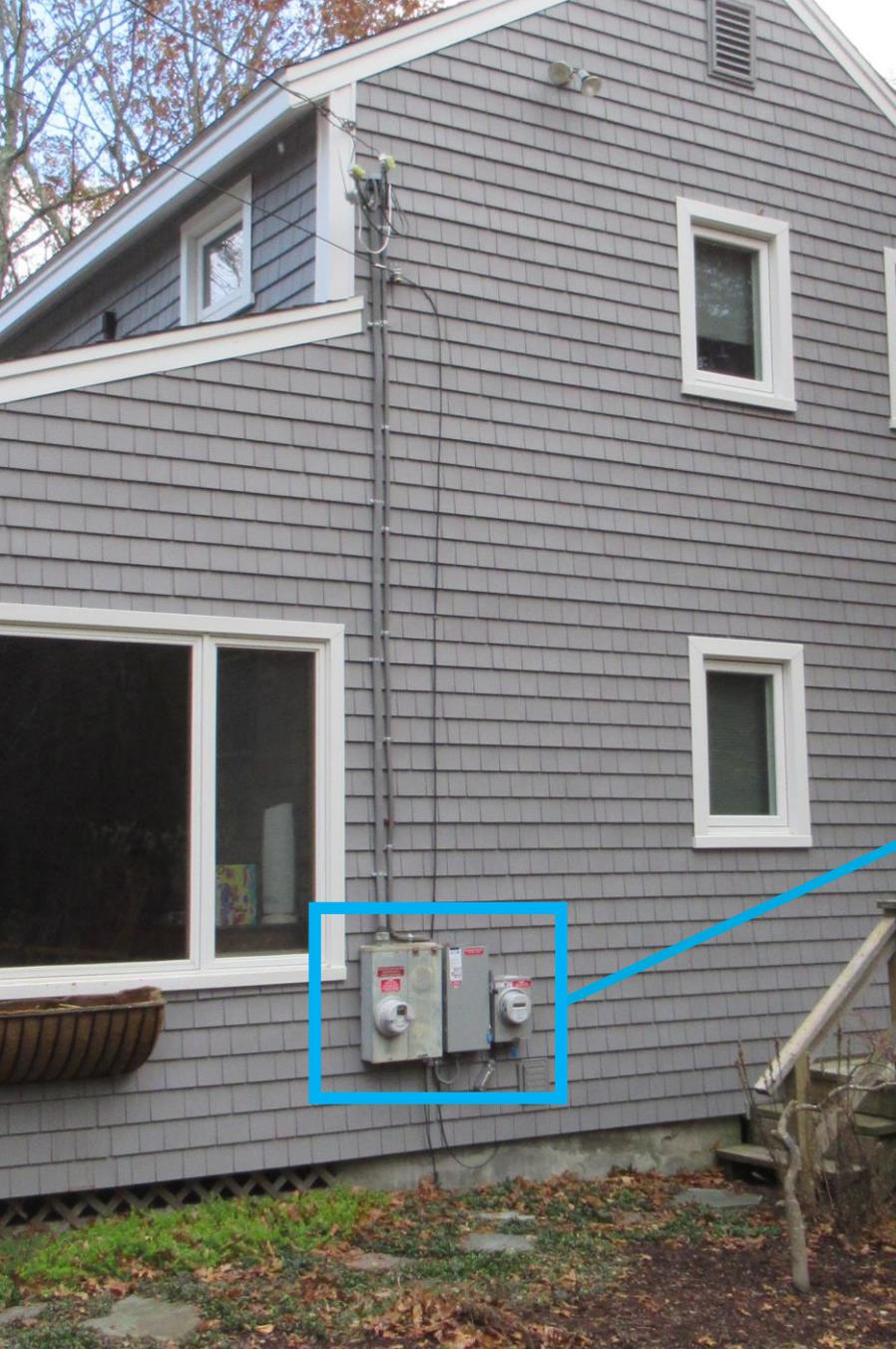


REG-Specific Interconnection

Cadmus observed 4 REF sites during this study period containing an improper metering configuration

- PV connected through unmetered conductors
 - 3 residential
 - 1 commercial
- Installers and National Grid notified upon discovery
- Cadmus produced [guidance document](#) for installer clarification

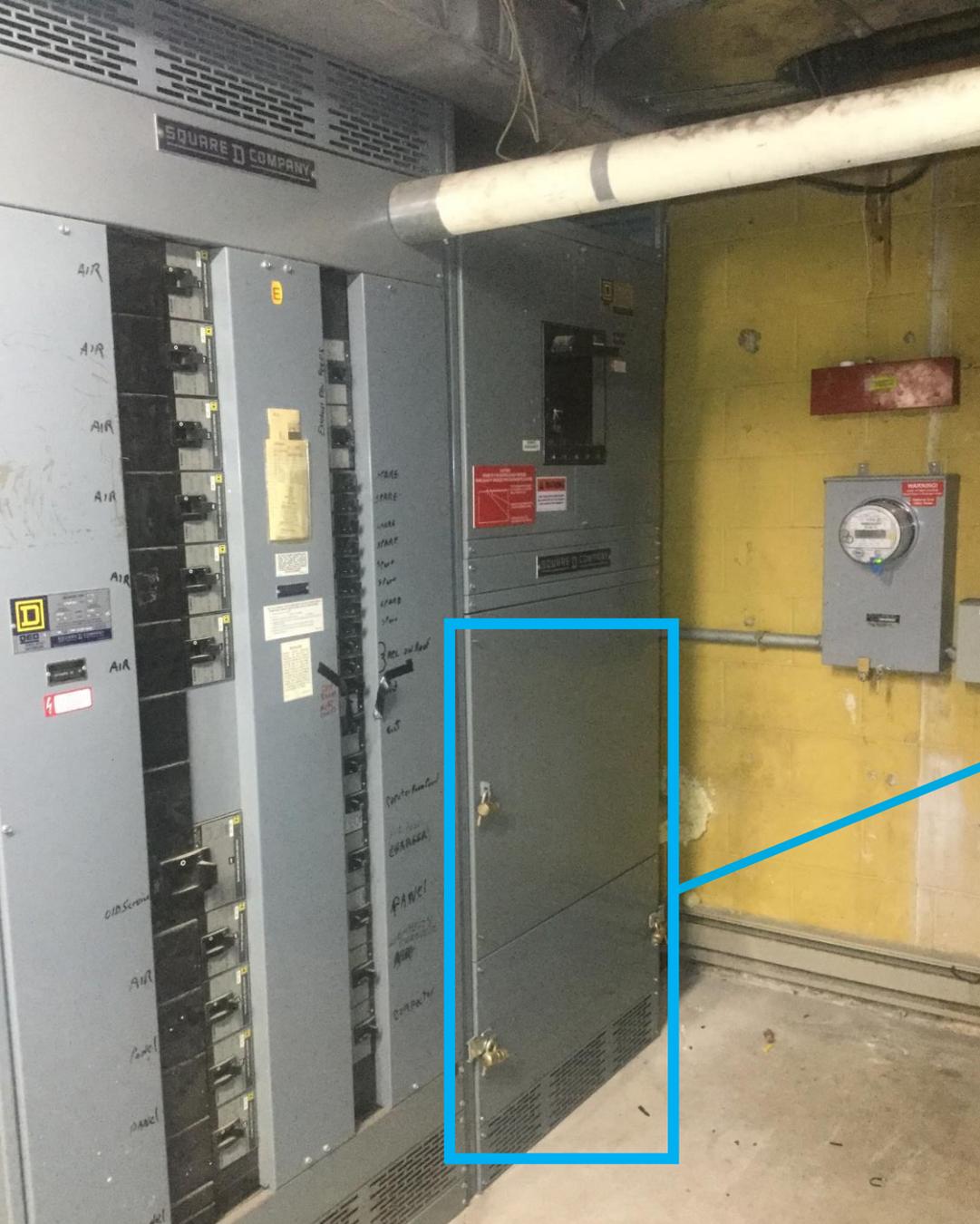




Unmetered PV Connection - REF Program



Unmetered PV Connection - REF Program



Unmetered PV Connection - REF Program



Common Interconnection Deficiencies

Improper Splice Method

Interconnection – 23 Observations

- Splice method not rated for environment or conductor type
- Increased risk of premature failure due to environmental conditions
- Example: connectors not suitable for exposed outdoor locations



Examples of Common Deficiencies

Interconnection – 17 Observations

- Improperly-supported service-entrance cables
- Exceeding the minimum NEC support interval (30 inches) may lead to failure in the long-term, as well as poor aesthetics





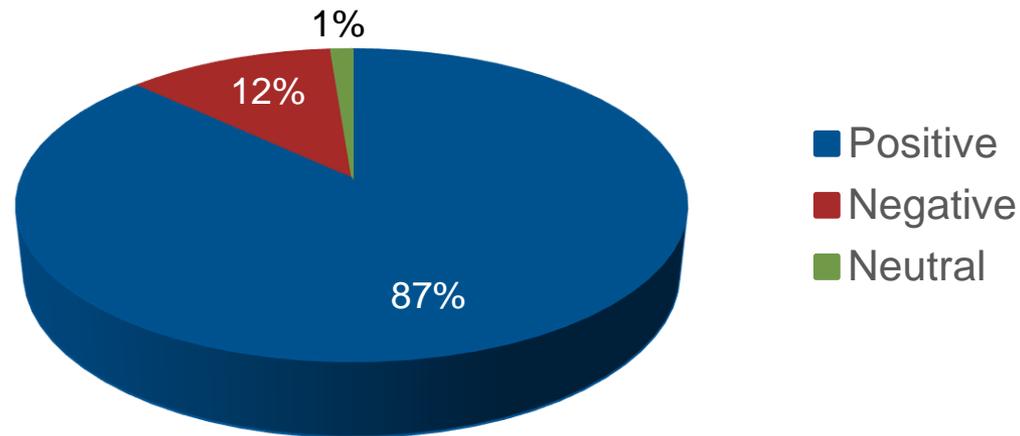
REG Customer Survey

REG Customer Survey

- New effort to augment findings from on-site inspections
- Questions include:
 - Satisfaction with installer's customer service and installation quality
 - Satisfaction with National Grid's role in the REG program
 - Knowledge of REG program specifics
 - Types of quality concerns with their renewable energy installation
- Response Results:
 - 132 of 451 responses received (29% response rate)
 - Identified correlation between one installer's consistent poor quality and very negative customer feedback
 - Identified customer dissatisfaction with revenue generation

Customer Satisfaction

- REG customers were largely satisfied with the program
- Satisfaction with installers did not strongly correlate with installer average quality scores



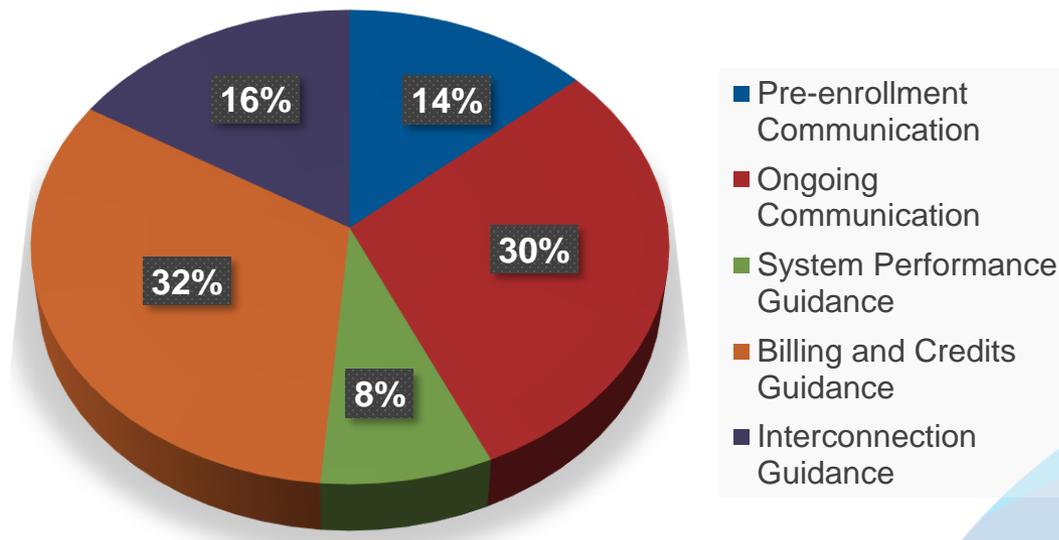
Satisfaction with Installer

Performance Expectations

- 26% of respondents said payments generated by their system were lower than expected.
 - Not informed of the tax implications of cash payments generated by the system.
 - Not informed that monthly payments are dependent on actual energy produced.
 - No receipt of pre-enrollment information regarding how payments would be monetized
 - Significant delays between when the system started producing energy and when credits appeared on the utility bill.

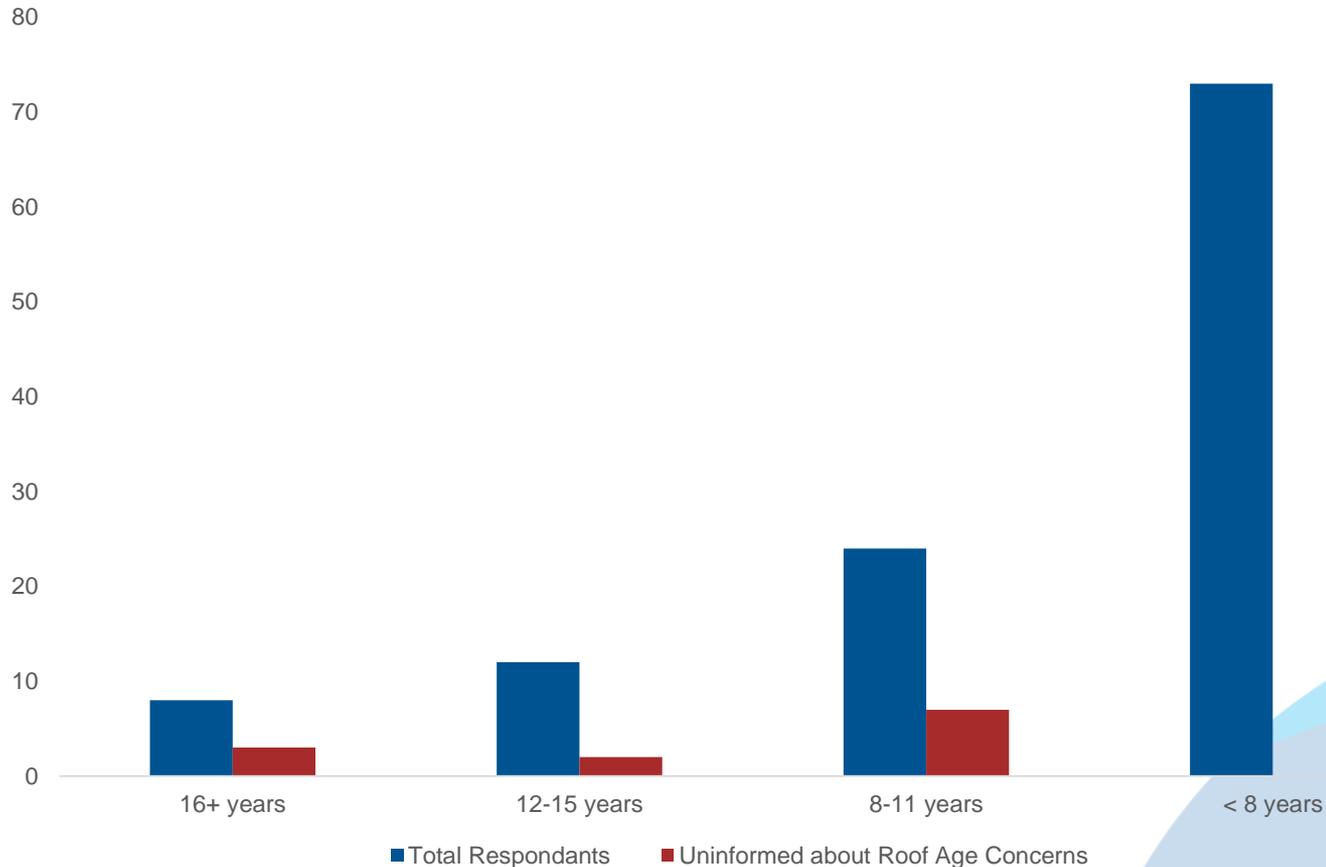
Timelines and Communication

- Over one third of respondents expressed dissatisfaction with timing of the interconnection process
 - Lack of communication from National Grid on project status updates
 - Difficult to find contact information or confusing outreach channels
 - Delayed or no responses from National Grid regarding customer outreach



Roof Age

- 33% of survey respondents had solar PV systems installed when their roof was over eight years old, with some respondents' roofs over 16 years old at the time of installation





Recommendations

Recommendations

Prioritization

Impact ↑	High Priority	Medium Priority
	Medium Priority	Low Priority
	Timeline →	

High-Priority Recommendations

- **Offer Training to Renewable Energy Installers**
 - National Grid & OER
- **Collect and Report Additional Data Related to Installation Quality**
 - National Grid
- **Offer Training to Local Electrical and Building Inspectors**
 - National Grid and/or OER
- **Closely Manage Self-Installations**
 - National Grid and/or OER
- **Require Training for New Program Participants**
 - National Grid, with support from OER
- **Add Inspection Disclaimer Language to REG Tariff Documents**
 - National Grid and OER

Medium-Priority Recommendations

- **Conduct Ongoing REG Quality Assurance Reviews**
 - National Grid and/or OER
- **Implement Performance Metric for Verification of Dual-Meter Accuracy**
 - National Grid

Low-Priority Recommendations

- **Enhance Program Minimum Technical Requirements**
 - OER, with support from National Grid

Progress on April 2017 Recommendations

- **Clarify Requirements for Overhead and Underground Service Connections**
 - National Grid clarified requirements
 - https://www9.nationalgridus.com/narragansett/business/energyeff/4_interconnection-process.asp
- **Offer Building and Electrical Inspector Training**
 - National Grid sponsored a one-day training for Rhode Island building and electrical inspectors in June 2017
 - OER provided contracting/logistical support
- **Observed Consistency with Interconnection Methods**
 - No observed violations to National Grid's interconnection requirements this round

Next Steps

- OER and National Grid discuss findings and recommendations
- Cadmus suggests taking action to ensure the quality of REG-funded installations improves in the near future.

CADMUS

Thank You

Matt Piantedosi
SENIOR ASSOCIATE