Study of Renewable Energy Installation Quality

Renewable Energy Growth Program 2022 Study

Prepared in collaboration with:

RIDGELINE energy analytics

Monday, November 14, 2022

1295741/A

Rhode Island Office of Energy Resources

Document history

Author	Matthew Piantedosi, Ridgeline Analytics Ali Dionigi, Natural Power
Checked	Dan Chawla
Approved	Christopher Mertes

Client Details	
Contact	Shauna Beland
Client Name	Rhode Island Office of Energy Resources
Address	1 Capitol Hill Providence, RI 02908

Issue	Date	Revision Details
A	September 26, 2022	Initial Draft
B	November 14, 2022	Final Draft

Local Office:

60 Railroad Place, Suite 205
Saratoga Springs, NY 12866
USA
Tel: +1 (518) 308 0200

Registered Office:

Natural Power Consultants LLC
60 Railroad Place, Suite 205
Saratoga Springs, NY 12866
USA

Taxpayer Identification Number: 27-0935846

Contents

1. Executive Summary

Natural Power, working under contract with the Rhode Island Office of Energy Resources ("OER"), has completed the process of inspecting and evaluating the installation quality of projects installed through the Renewable Energy Growth ("REG") program. The REG program, a tariff-based program, supports renewable energy system development across Rhode Island.

Natural Power has completed inspections for 90 small scale solar, 11 medium scale solar, 5 large scale solar photovoltaic systems, and 4 small scale plus storage systems. The small-scale solar projects represent most recent operational installations from National Grid provided data for the 2021 and 2022 REG tariff years. The medium and large-scale solar projects represent most recent operational installations from National Grid provided data for the 2015 through 2021 REG tariff years. The small scale plus storage projects included storage projects from the 2021 and 2022 tariff years. This report summarizes the results from these efforts. Inspections were performed according to a standardized inspection process and the use of Natural Power's PV quality evaluation and scoring tool developed specifically for the REG quality assurance program. The inspection tool focused heavily on the 2020 edition of the National Electrical Code ("NEC") requirements.

Key findings outlined in this report:

- Major overhead service interconnection termination issues were identified in several small-scale installations.
- Many small-scale inspections identified labeling issues related to rapid shutdown and disconnect directory requirements.
- Nearly all small-scale inspections identified a missing lock or seal on a hinged disconnect switch enclosure, a new requirement in the 2020 NEC.
- Energy storage system connection in the REG program requires additional equipment and consideration beyond a typical non-REG connection.
- Medium and large system inspections identified DC module connectors cross-mated with different brands, leading to an increased risk of failure.
- The customer survey results showed the REG program participant knowledge is limited, and many survey respondents would like to have more information available.

Natural Power summarized recommendations based on the findings in the quality assurance program.

- Enhance the guidance document with greater details on the grid connection, grounding, labeling and update based on 2020 edition of the NEC code.
- Update the self-installer training webinar to include the 2020 edition of the NEC code.
- Offer targeted training for small-scale installers based on findings from the study.
- Offer support to National Grid to update energy storage system guidance diagrams based on configurations observed in the field.
- Continue inspecting small scale storage projects and increase the sample size.
- Create an information center on the OER website for REG participants to find contact information, frequently asked questions, and additional resources.

2. Introduction

This report outlines the results from Natural Power's quality assurance study reviewing the quality of renewable energy installations funded by the REG program in Rhode Island through the 2022 tariff year. The Rhode Island OER commissioned this study on behalf of the Rhode Island Distributed Generation Board ("DG Board"). These results are based upon inspections completed which includes inspections of 90 small scale solar, 11 medium scale solar, 5 large scale solar photovoltaic systems, and 4 small scale plus storage systems.

2.1. About the Renewable Energy Growth Program

REG, a program administered by National Grid, supports the development of distributed generation projects in Rhode Island. Several technologies are eligible for the program, including solar, wind, hydropower, and anerobic digestion. Participants in the program are enabled to sell their generation output using the long-term tariffs at fixed price. The program updates the ceiling prices, megawatt allocation plan, and recommendations from the quality assurance program on an annual basis. A ten-member board, the DG Board, oversees the development and recommendations for the annual program plan.

A consultant is hired for the quality assurance program annually to ensure the safety, quality, performance, and conformance of the distributed generation projects to the stated specifications. Licensed electricians conducted inspections for the installed systems are used to determine code compliance and verification of system components installed as compared to what was filed for the project interconnection application to National Grid. Final inspection reports are submitted to OER detailing findings from all inspections. Inspections are conducted for small scale projects (<25kW), medium scale projects (25kW-250kW), and large-scale projects (250kW+). To further enhance the quality assurance study, a customer feedback survey is conducted to understand perception of the program, satisfaction, and feedback. A draft report, final report and presentation are completed to convey results and recommendations to the DG Board.

3. Study Goals

The goal of this study is to determine the quality of renewable energy installations funded through the 2022 REG tariff year. Natural Power was commissioned to study the safety, quality, performance, and conformance of the installations. The study analyzed the quality of renewable energy installations for small, medium, large-scale PV installations, and small scale plus storage installations across different installers, basing inspection results on a one to five quality scale. Common and serious installation issues were identified and summarized by elements and severity ranging from incidental to critical. In addition to analyzing the installation issues, the responsiveness of installers to reconciling issues was reviewed. Finally, a small-scale customer survey was conducted to further understand participant's satisfaction and perceptions of the program. From these results, recommendations were made to improve the program in subsequent years.

4. Study Methodology

4.1. Sampling Process

Natural Power prepared a sample of inspections across technologies and installers. Inspections were recommended for all installers, with an average sample of one to five inspections per installer. Table 4.1 outlines the summary of inspections and installers by technology.

Table 4.1: REG Quality Study Sample Selection

Inspections	Projected Number of Inspections	Projected Number of Installers	Actual Number of Inspections	Actual Number of Installers
Small Solar Inspections	90	15	90	15
Medium Solar Inspections	11	8	11	8
Large Solar Inspections	5	4	5	4
Small Scale Plus Storage	6	6	4[1]	4

For the small-scale solar installations, Natural Power selected sites randomly, in proportion to the number of operational sites per installer. The sample targeted inspecting all installers with operational sites enrolled in the REG program for the most recent REG tariff years. Natural Power selected small scale solar projects based on the strategy outlined in Table 4.2. Alternate sites were included for instances where participants were unable to be contacted.

Table 4.2: Small Scale Sampling Summary for 2020-2021 REG Tariff Years

Small Scale Solar Installer Category	Total Operational Installations	Target Sample Size
Large Installer	Greater than 30	10-15
Medium Installer	30 or less	5-10
Small Installer	10 or less	1-5

4.2. Inspection Process

All on-site inspections of the renewable energy systems were completed by Natural Power subcontractors, Ridgeline Energy Analytics and Neo Virtus Engineering. During on-site inspections, licensed electricians collected all relevant data using a mobile device application developed by Natural Power specifically for the REG quality assurance program. Subcontractors scheduled and conducted all inspections with system owners. A standard operating procedure was followed with all communications throughout the inspection process to be cognizant of customers' perception of the program.

4.2.1. On Site Data Collection

To provide timely reporting and tracking of inspections, Natural Power developed a mobile application form specific for the REG quality assurance program, hereinafter called the ("Inspection Tool"). The Inspection Tool was developed to collect, analyze, and report inspections for the program. The specific inspection fields, based heavily on the 2020 edition of the National Electrical Code, ensured consistency of inspections and reporting. The Inspection Tool allowed for the inspection team to import system data, complete inspections on a mobile phone or tablet, and

[1] Natural Power was unable to schedule two small scale plus storage projects due to non-responsiveness from the homeowner and the installer. OER was notified of the non-responsiveness from the homeowner and installers.

produce an inspection report. All inspection reports were reviewed by an engineering manager, and additionally by a Rhode Island licensed electrician and NABCEP Certified PV System Inspector. Additionally, a corrective action report was produced to reconcile issues noted during the inspection process. A summary of the Inspection Tool can be seen in Figure 4.1.

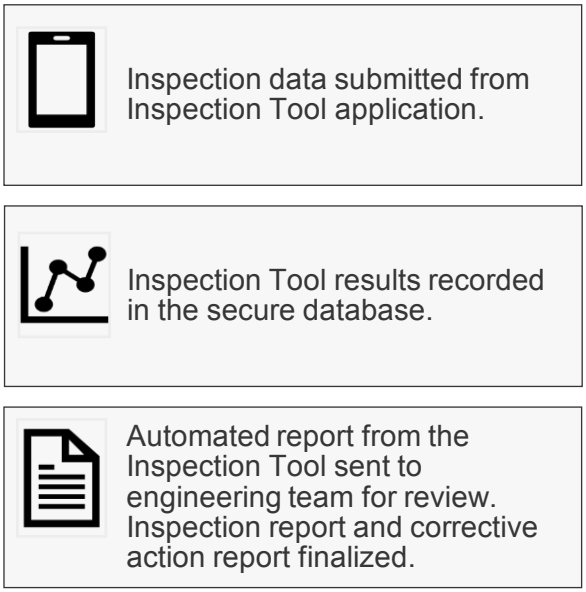


Figure 4.1: Summary of Inspection Tool

Based on identified violations during site inspections, the Inspection Tool generated a quality score. This quality was based on a one to five score that Natural Power used to quantify the quality of the systems. Table 4.3 summarizes the scoring system categorization, descriptions of the categorizations, and examples of violations seen based on the categorization.

Table 4.3: Inspection Tool Scoring System

Defect Category	Summary	Examples	Typical Score
No Issues	No identified issues.	No issues.	5
Incidental	Minimal issues not expected to impact safety or system operations.	Poor wire management, missing or incomplete labels.	4
Minor	Mid to long term risk of safety or system failure.	Bonding issues, insufficient clearance, undersized circuit protection, improperly supported conductors.	3
Major	Short term risk likely to affect system performance or safety, though not posing immediate hazard.	Missing grounding equipment, module damage, missing or undersized grounding electrode conductors, improperly secured modules, cross-mated DC connectors, improper service conductor connectors.	2
Critical	Immediate risk of system failure and/or safety hazards.	Exceedance of current limits on busbars or conductors, exceeding inverter voltage limits, and use of non-DC rated equipment in DC circuits.	1

A scoring algorithm was developed that calculates the score based on the issues observed. A PV system with incidental issues would generally score a four out of five using the Inspection Tool scoring scale. However, if there were many incidental issues the score may become three out of five, instead of a four out of five.

The Inspection Tool is heavily weighted on the 2020 edition of the National Electrical Code compliance and product installation instructions. The highly specific tool allows for consistency across inspections, and straightforward comparison and analysis of results.

4.3. Report Delivery and Installer Follow-Up

4.3.1. Inspection Reports

The Inspection Tool automatically stores and collects inspection data. Additionally, the application automatically sends a draft report to the engineering team after the inspection was submitted through the Inspection Tool. This automation allows for review and approval of inspections in a timely manner. After processing, the reports are delivered to installers if any violations were found. In addition, a corrective action response ("CAR") template is created to aid installers in reporting reconciliation of issues. All inspection reports are uploaded to a secure ShareFile site after review and processing for OER.

4.3.2. Procedures for Follow-Up with Installers

Natural Power used a REG quality assurance specific email for all follow-ups to ensure installers received information from a specific sender for all inspection details. Template emails were used for initial contact and for follow up emails with installers. After initial contact with the installer was made, Natural Power followed up on a weekly basis if corrective action was not made. Natural Power tracked the installer response rate between the initial delivery of the inspection reports and CAR's and the date of response with suitable corrective action made, or response noting corrective action will be made.

4.4. Data Aggregation and Analysis

Natural Power reviewed the aggregate data for frequency of installation issues and deficiencies. Natural Power used the Inspection Tool quality score as a metric for determining the quality of installations. In addition, Natural Power observed the frequency of component issues by PV component. A summary of statistics Natural Power analyzed is shown in Table 4.4.

Table 4.4: Summary of Metrics Analyzed

Metric	Unit
Average Inspection Tool score	1-5
Weighted average Inspection Tool score	1-5
Average Inspection Tool score per installer	1-5
Frequency of system deficiencies	Total occurrences
Average time from initial outreach to completed corrective action items	Days

5. Study Findings

Natural Power has completed 10 inspections including 90 inspections of small-scale installations, 11 inspections of medium-scale installations, 5 inspections of large-scale installations, and 4 small scale plus storage systems.

5.1. Small Solar PV System Findings

Natural Power completed inspections of 90 small-scale solar PV installations falling in the 2021 and 2022 tariff years.

5.1.1. Overall Small-Scale Solar Installation Quality Scores

Table 5.1 summarizes the small-scale inspection count per quality score. Natural Power calculated the average quality score for the small-scale PV installations. The average unweighted score across inspections was 2.38.

Table 5.1: Small-Scale Quality Score Summary

Score	Category Description	Installations with Quality Score
1	Critical and/or major deficiencies	13
2	Major deficiencies	48
3	Multiple minor deficiencies	15
4	Incidental/minor issues	10
5	No deficiencies or incidental deficiencies	4

Source: Natural Power Inspection Data

Figure 5.1 shows the proportion of quality scores for the small-scale installations inspected. 15.7% of installations have a quality score of four and five with no issues to minor issues, 16.9% of installations have a quality score of three with several minor deficiencies, and 67.4% of installations have a quality score of one and two with major to critical deficiencies.

Source: Natural Power Inspection Data

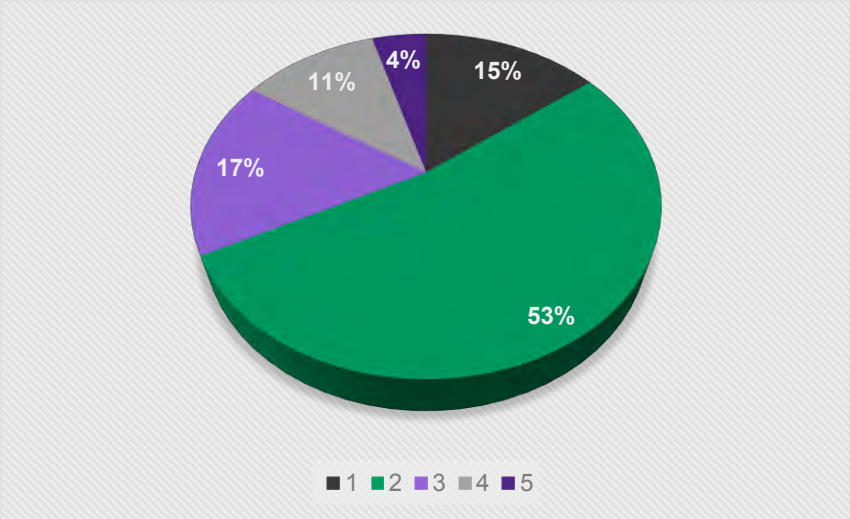


Figure 5.1: Proportion of Small-Scale Quality Scores

Natural Power also calculated the weighted quality score for the small-scale installations, as the unweighted average does not account for the proportion of installations per installer. This approach creates a larger emphasis

on high volume installers. The weighted average quality score of 2.28 is 4% lower than the unweighted average, suggesting higher volume installers may have more deficiencies in installations. The weighted average score increased by approximately 30% from 2021 to 2022 REG installations, suggesting improvement in installation quality. The use of a weighted average presents a more representative analysis of the program, as the sample is disproportionate to the overall program installations.

Natural Power compared the tariff 2021 and tariff 2022 results as shown in Table 5.2.

Table 5.2: Comparison of Tariff 2020 and Tariff 2021 REG tariff years

REG Tariff Year	Unweighted Average Score	Weighted Average Score	Number of Cases Inspected
2021	2.23	1.97	62
2022	2.74	2.56	28

Source: Natural Power Inspection Data

The sample for the 2022 tariff year is relatively small and may not be accurate for the REG 2022 tariff year.

5.1.2. Quality Score for Low Volume Installers

Natural Power further studied the installation quality by installer, specifically by low volume installers with 10 or fewer installations in the 2021 and 2022 REG tariff years. Overall, 10% of low-volume installers had a quality score of 4 and above with incidental issues observed, 10% of installations had a score of 3.5 to 4 with minor issues noted, 40% had a score of 2 to 3 presenting major deficiencies, and 40% of low-volume installers had a score of 1 to 1.8 presenting critical issues. Table 5.3 outlines the average scores for low-volume installers.

Table 5.3: Low-Volume Installer Average Quality Scores

Installer	Average Score
101	1.0
102	1.0
103	1.0
104	1.8
105	2.0
106	2.5
107	2.5
108	2.8
109	3.5
110	4.3

Source: Natural Power Inspection Data

5.1.3. Most Common Installation Issues

Natural Power tracked the occurrences of issues by major component in the PV installation. Table 5.4 shows the major components of PV installations and the occurrences of issues observed based on the components. Issues were often noted on the supply-side connection.

Table 5.4: Summary of Issues Observed by Major PV Components

PV Component	Incidental	Minor	Major	Critical	Total Occurrences
Array	0	2	1	0	3
DC Disconnect	1	0	0	0	1
Junction Box	1	1	1	0	3
Inverter	7	7	2	1	17
AC Combiner	2	10	5	0	17
AC Disconnect	5	8	1	0	14
Supply-Side Connection	213	152	63	0	428

Source: Natural Power Inspection Data

Table 5.5 outlines several deficiencies commonly observed during inspections. Although the array showed very few deficiencies, several small-scale arrays were not safely accessible during this study. There were a very large number of deficiencies identified at the supply-side connection. This is likely because the method required by the program is unique and unconventional with a supply-side connection anywhere outside of this program. The supply side connection is the point of interconnection and refers to the utility side of the main breaker or disconnect switch. The three most common supply-side connection findings are:

1. In most cases, the PV system disconnect did not have the proper directory labeling. Because this particular connection is on the utility side of the existing main breaker, a directory is required to indicate the additional disconnect that needs to be turned off in the event of an emergency. In addition, several PV disconnects were missing the rapid shutdown labeling required by the NEC. This labeling informs firefighters that the system is equipped with rapid shutdown and identifies the rapid shutdown switch.
2. Many of the connectors used to tap into the existing outdoor electrical service conductors were not listed for outdoor use. The two most-common types observed were insulation-piercing connectors and insulated mechanical lugs, both intended for use inside an enclosure. This issue is limited to an overhead electrical service where parallel services are provided from the weatherhead to individual meter sockets.
3. The new PV service connection was not grounded in accordance with NEC requirements. This includes wiring the PV system disconnect like a second “tenant” on the house, connecting the PV grounding system to the main house grounding electrode system, and bringing the house grounding electrode system up to the current code requirements.

In addition, nearly all disconnect switches inspected were missing a lock or seal on its hinged door. This is a new requirement for the 2020 NEC and is intended to prevent unauthorized access to energized conductors. Without a lock, seal, or other component “requiring a tool” to open, energized conductors may be easily accessible to unqualified people, creating a potential shock hazard.

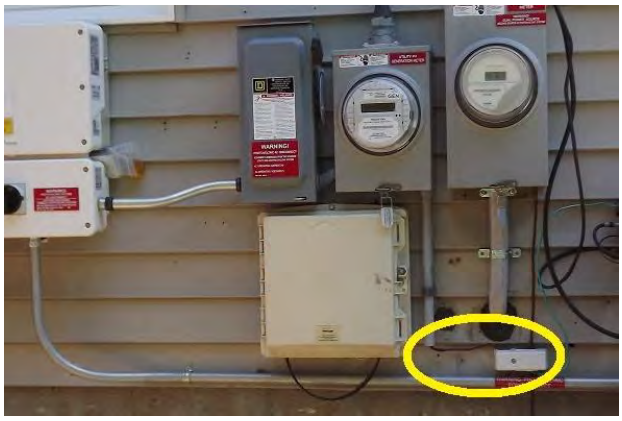
One large installer consistently used the wrong conductor type on their overhead service interconnections, allowing for a non-UV rated conductor insulation to be exposed outdoors, Natural Power observed nine occurrences of this violation, which consisted of 100% of this particular configuration for this installer. One other occurrence was observed from another installer.

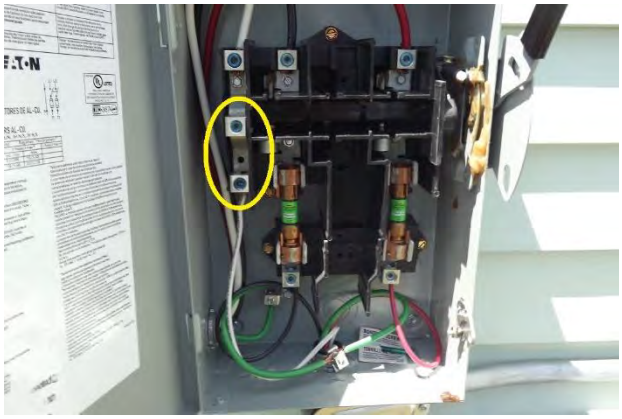
Table 5.5: Summary of Small Scale Common Inspection Issues

Pictures of Issues	Description of Issues

	The PV system disconnect is missing the following labeling/directories:
	• Directory of power sources at the house (NEC 705.10).
	  ○ Showing how to safely de-energy all power to house.
	• PV system disconnect identification label (NEC 690.13(B)).
	• Rapid shutdown switch label (NEC 690.56(C)(2)).
	  ○ Notifying firefighters this switch will initiate rapid shutdown.
	• Rapid shutdown directory (NEC 690.56(C)).

	Example of PV system disconnect with proper rapid shutdown and identification labeling. (Missing directory of power sources.)
	Example of directory of power sources.

Pictures of Issues	Description of Issues
	Indoor-rated insulation-piercing connectors used on service connection. Connector also installed directly on bare conductors, not suitable for application. (NEC 110.3(B))
	Indoor-rated mechanical lugs used on service connection. (NEC 110.3(B))
	PV grounding system improperly connected to intersystem (communication) system bonding termination. (NEC 250.64(C) and 250.94)

Pictures of Issues	Description of Issues
	White neutral conductor not bonded to grounding electrode system in PV service disconnect. (NEC 250.24(C))
	Hinged cover on disconnect switch missing lock or seal, allowing unqualified access to energized conductors. (NEC 690.13(A) and 690.15(A))
	Non-UV rated conductors used for new PV service. (NEC 110.3(B) and 310.10(D))

Source: Natural Power Site Inspections

5.2. Medium Solar PV System Findings

Natural Power completed 11 inspections of medium-scale solar PV installations that fell in the 2020 tariff year.

5.2.1. Overall Medium-Scale Solar Installation Quality Scores

Table 5.6 outlines the results, summarizing the inspection count per quality score for medium-scale installations. Natural Power calculated the average quality score for the medium-scale PV installations. The average unweighted score across inspections is 3.00.

Table 5.6: Medium-Scale Quality Score Summary

Score	Category Description	Installations with Quality Score
1	Critical and/or major deficiencies	2
2	Major deficiencies	3
3	Multiple minor deficiencies	1
4	Incidental/minor issues	3
5	No deficiencies or incidental deficiencies	2

Source: Natural Power Inspection Data

5.2.2. Quality Score by Installer

Natural Power further studied the installation quality by installer. Overall, 62.5% of installers had a quality score of 3 and above with incidental to minor issues observed, and 37.5% had major to critical installation issues noted. Table 5.7 summarizes the average quality score by installer.

Table 5.7: Installer Average Quality Scores

Installer	Average Score
201	1.0
202	2.0
203	2.0
204	3.0
205	3.3
206	4.0
207	4.0
208	5.0

Source: Natural Power Inspection Data

5.2.3. Most Common Installation Issues

Natural Power tracked the occurrences of issues by major component in the PV installation. Table 5.8 shows the major components of PV installations and the occurrences of issues observed based on the components. Major issues identified on the medium scale systems included cross-mated DC connectors, missing or undersized grounding electrode conductors, undersized PV breaker (risk of nuisance tripping), and module/racking grounding issues.

Table 5.8: Summary of Issues Observed by Major PV Components

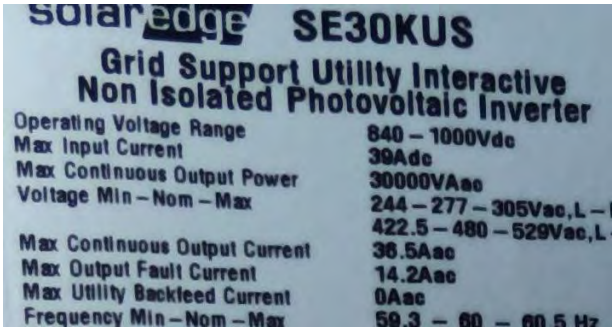
PV Component	Incidental	Minor	Major	Critical	Total Occurrences
Array	4	7	4	0	15
Inverter	3	5	0	0	8
AC Combiner	3	0	1	0	4
Supply-Side Connection	22	5	2	0	29

Source: Natural Power Inspection Data

Table 5.9 summarizes common deficiencies found in the medium-scale projects inspected.

Table 5.9: Summary of Meduim Scale Common Inspection Issues

Pictures of Issues	Description of Issues
	Cross-mated DC connectors: NEC 690.33(C) and UL standard QIJQ require mating of identical brands or product family unless evaluated for cross-mating. No such test exists between different brands.
	Array grounding hardware corroded and not suitable for the environment. (NEC 110.3(B) and 690.43)

Pictures of Issues	Description of Issues
 	Undersized circuit breaker for inverter continuous output current. Inverter max continuous output current: 36.5A 36.5 x 125% = 45.6A (NEC 705.30(B)) 50A breaker required. 45A observed.

5.3. Large Solar PV System Findings

Natural Power completed 5 large scale solar PV inspections falling in the 2015, 2017 and 2021 tariff years.

5.3.1. Overall Large-Scale Solar Installation Quality Scores

Table 5.10 outlines the results, summarizing the inspection count per quality score for the large-scale installations. Natural Power calculated the average quality score for the large-scale PV installations. The average unweighted score across inspections is 2.8.

Table 5.10: Large-Scale Quality Score Summary

Score	Category Description	Installations with Quality Score
1	Critical and/or major deficiencies	0
2	Major deficiencies	3
3	Multiple minor deficiencies	0
4	Incidental/minor issues	2
5	No deficiencies or incidental deficiencies	0

Source: Natural Power Inspection Data

5.3.2. Quality Score by Installer

Natural Power further studied the installation quality by installer for the large-scale projects. A summary of inspection scores by installer is found in Table 5.11.

Table 5.11: Installer Average Quality Scores

Installer	Average Score
301	2
302	2
303	4
304	4

Source: Natural Power Inspection Data

5.3.3. Most Common Installation Issues

Natural Power tracked the occurrences of issues by major component in the PV installation. Table 5.12 shows the major components of PV installations and the occurrences of issues observed based on the components. Issues were often noted in the array. Major issues included cross-mated DC connectors, modules and racking not properly grounded, and ground-fault protection configuration.

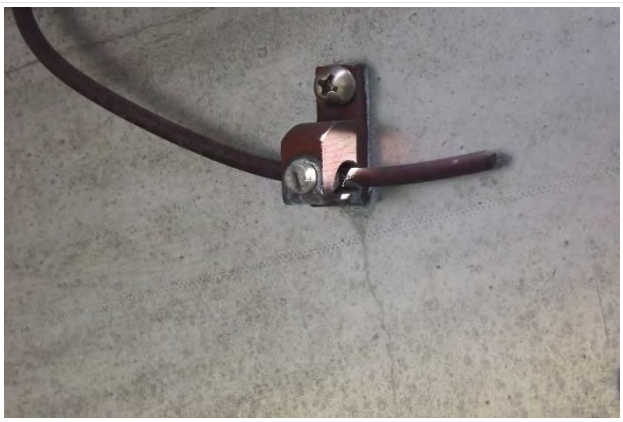
Table 5.12: Summary of Issues Observed by Major PV Components

PV Component	Incidental	Minor	Major	Critical	Total Occurrences
Array	0	7	2	0	9
Inverter	1	3	0	0	4
AC Combiner	1	0	1	0	2
AC Disconnect	1	0	0	0	1
Supply-Side Connection	1	0	0	0	1

Source: Natural Power Inspection Data

Table 5.13 summarizes common deficiencies found in the large-scale projects inspected.

Table 5.13: Summary of Large Scale Common Inspection Issues

Pictures of Issues	Description of Issues
	Cross-mated DC connectors: NEC 690.33(C) and UL standard QIJQ require mating of identical brands or product family unless evaluated for cross-mating. No such test exists between different brands.
	Modules and racking not properly grounded due to improper/unlisted bonding means between rows. (NEC 690.43)
	Galvanic reaction between copper ground lug and steel racking. (NEC 110.14)

Pictures of Issues	Description of Issues
	DC string conductors not properly supported or protected. (NEC 300.4 and 690.31(C)(1))

5.4. Small Scale Plus Storage Findings

Natural Power completed four small scale plus storage inspections falling in the 2021 and 2022 tariff years.

5.4.1. Overall Small Scale Storage Quality Scores

Table 5.14 outlines the results, summarizing the inspection count per quality score for the small scale plus storage installations. Natural Power calculated the average quality score for the small scale plus storage installations. The average unweighted score across inspections is 2.50.

Table 5.14: Small Scale Storage Quality Score Summary

Score	Category Description	Installations with Quality Score
1	Critical and/or major deficiencies	2
2	Major deficiencies	0
3	Multiple minor deficiencies	1
4	Incidental/minor issues	0
5	No deficiencies or incidental deficiencies	1

Source: Natural Power Inspection Data

5.4.2. Quality Score by Installer

Natural Power further studied the installation quality by installer for the small scale plus storage projects. A summary of inspection scores by installer is found in Table 5.15Table 5.11.

Table 5.15: Installer Average Quality Scores

Installer	Average Score
401	1.0
402	1.0
403	3.0
404	5.0

Source: Natural Power Inspection Data

5.4.3. Most Common Installation Issues

Natural Power tracked the occurrences of issues by major component in the energy storage system (“ESS”) installation. Table 5.16 shows the major components of small scale plus storage installations and the occurrences of issues observed based on the components. Issues were often noted in the ESS labeling and supply side connection. Major issues included structural related to clearance and ventilation, as well as one occurrence of non-outdoor rated connectors on the service connection, similar to many of the small scale installation findings. Natural Power also observed one system containing the backup loads panel connected directly to the REG meter under normal operation. This would likely result in inaccurate metering of the PV system production.

Energy storage system connection and configuration is far more complex than a PV system connection. Unlike a typical utility-interactive PV system where the inverter will shut down upon loss of primary utility power, an ESS requires external components such as a microgrid interconnect device (“MID”) for grid isolation. For a configuration on an REG system, the PV output travels through the REG meter under normal operation, like a non-storage configuration. However, the addition of an automatic transfer switch is required to switch the PV output to a backup loads panel (normally connected to the existing meter) along with the ESS during a grid outage. Although the

guidance on National Grid's website[2] indicates this, the diagrams do not accurately represent this and can be easily misinterpreted.

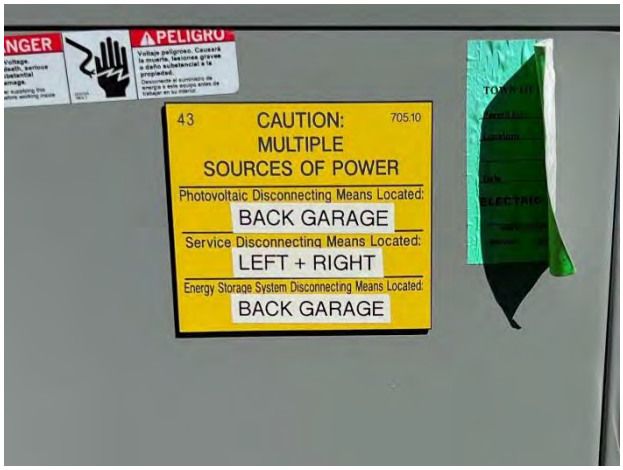
Table 5.16: Summary of Issues Observed by Major Components

Component	Incidental	Minor	Major	Critical	Total Occurrences
ESS Labeling	8	3	0	0	11
ESS Configuration	0	0	1	0	1
ESS Structural	0	0	2	0	2
Supply Side Connection	9	6	1	1	17

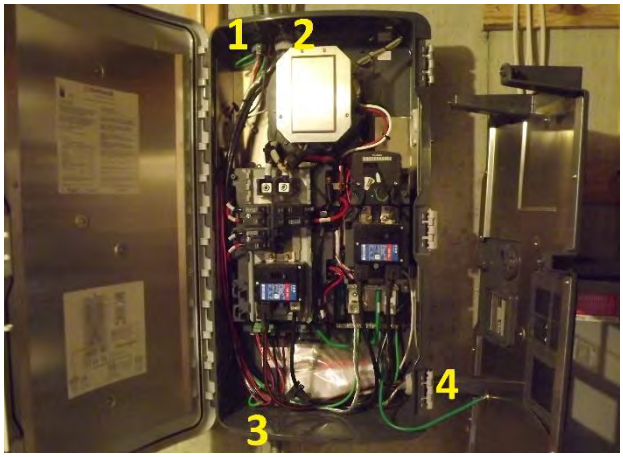
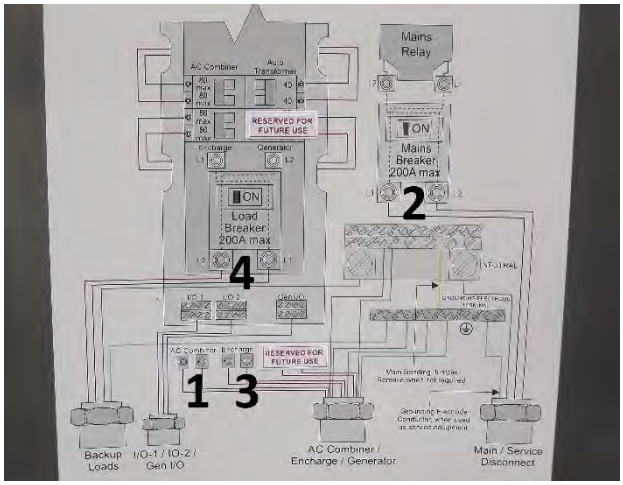
Source: Natural Power Inspection Data

Table 5.17 summarizes common deficiencies found in the small scale storage projects inspected.

Table 5.17: Summary of Small Scale Plus Storage Common Inspection Issues

Pictures of Issues	Description of Issues
 	Example of proper directory labeling indicating the presence and location of all sources at the service equipment, as required by NEC 690.56(B), 705.10, and 706.21. This was missing on 3 of the 4 inspections.

[2] https://ngus.force.com/RI/s/article/RI-Interconnection-Documents

Pictures of Issues	Description of Issues
  	ESS not configured in accordance with National Grid requirements. This system contains the backup loads panel connected directly to the REG meter under normal operation. National Grid requires an automatic transfer switch for connection between the existing utility metered loads and REG metered equipment (PV/ESS). The upper photo shows the system controller/microgrid interconnect device. The middle photo shows the wiring diagram for this controller, and the bottom photo shows the main electric meters and the PV AC combiner and disconnect. The numbered items are as follows: 1. PV AC combiner output connected to the appropriate terminals in the system controller. 2. Wiring directly from REG meter to the system controller, missing the automatic transfer switch required by National Grid. 3. Battery wiring and termination. 4. Backup loads panel wiring and connection inside the system controller.

Pictures of Issues	Description of Issues
	ESS located in basement without additional ventilation. Installation instructions require installation in a well-ventilated area, and a minimum 6” clearance above a floor.

5.5. Installer Responsiveness to Quality Installation Issues

Natural Power tracked installer responsiveness from initial outreach to receipt of response from the installer. There were 23 installer responses that provided corrective action. 8 responses were received notifying Natural Power that corrective action would be made, but there were delays in the installers availability to conduct corrective action. On average it took 13 days from initial outreach for receipt of installer response. Figure 5.2 outlines installer response by email reminder. 45% of responses were accounted for after initial contact, 26% were accounted for after the second email and 29% account for response after the third email.

Source: Natural Power installer responsiveness data

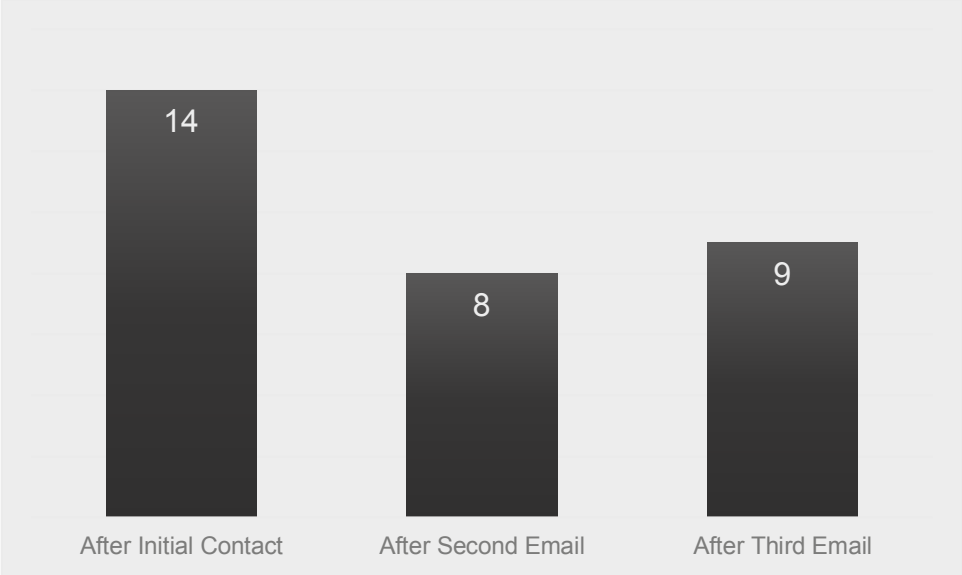


Figure 5.2: Installer Response by Email

Summarizes installer response by the initial score received from the inspections. 3% of responses received a score of 5 on the initial inspection report, 19% received a score of 4, 10% received a score of 3, 58% received a score of 2, and 10% received a score of 1. Overall, the average inspection score with installer response was 2.48.

Source: Natural Power installer responsiveness data

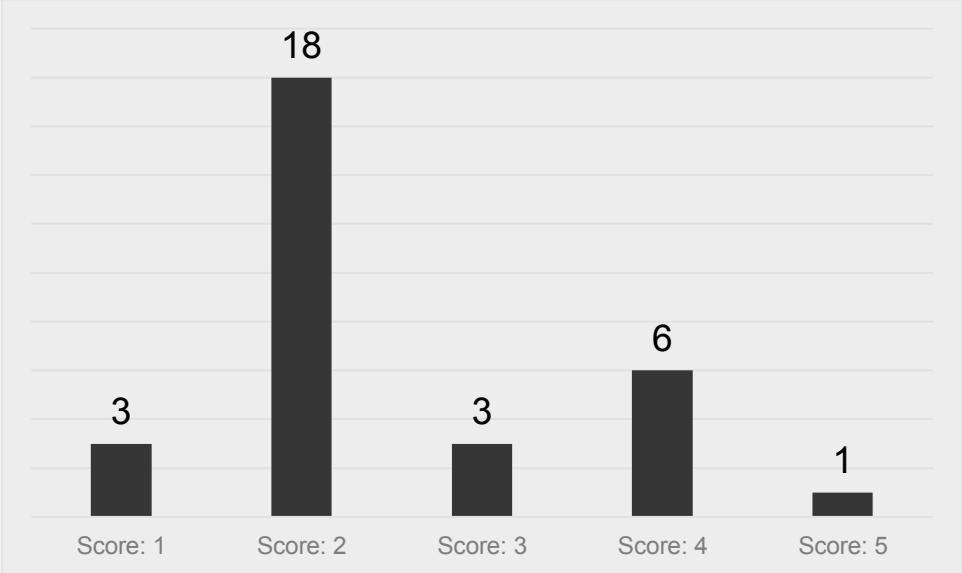


Figure 5.3: Installer response by score

5.6. Customer Survey

In parallel with the inspection process, Natural Power surveyed small scale REG program participants with operational sites from the 2021 and 2022 REG tariff years on June 24th, 2022. A reminder email was sent on July 8th, 2022, to those who had not completed the survey. Of the REG program participants, 76% were from the 2021 REG tariff year and 24% were from the 2022 REG tariff year. The survey included 541 participants, with 79% of participants opening the invitation, 18% invitations unopened, 1.5% bounced invitations, and 1.5% opted out of the survey. Of the opened invitations, 13% completed the survey.

The survey asked questions related to program prior knowledge, perception of system quality, satisfaction with installers and National Grid, feedback on the quality assurance inspection process, cost, and customer support.

5.6.1. Customer Feedback on Installer

Several questions surveyed the respondent's satisfaction with their system installer. Questions targeted installer performance of installations and customer service. The survey participants were asked to rate the performance from "very satisfied" to "not satisfied at all" for the following questions:

- How would you rate your satisfaction with your installer's performance when installing your system?
- How would you rate your satisfaction with your installer's customer service (e.g., responsiveness to questions and concerns, clarity, and timeliness of communication)?

Figure 5.4 outlines participant satisfaction with the installer's installation performance. The responses show general satisfaction for installation performance from installers in the 2021 and 2022 survey.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

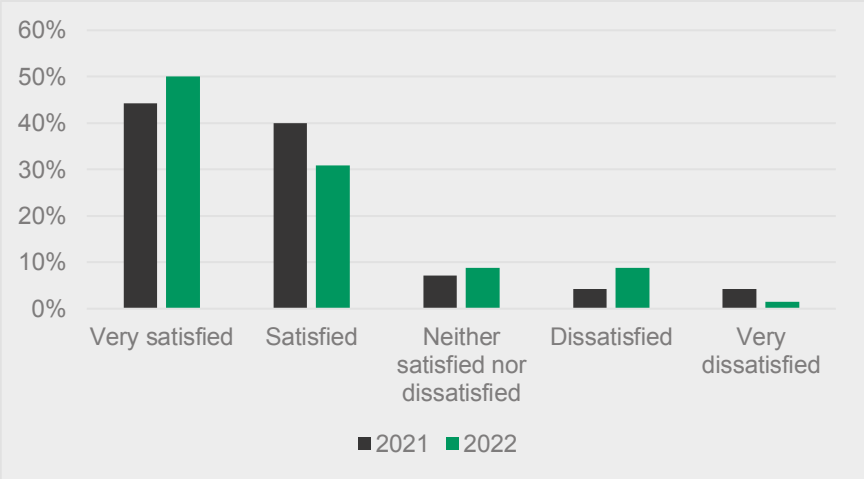


Figure 5.4: Satisfaction with Installer's Installation Performance

Figure 5.5 outline the satisfaction with installer customer service. In total for 2022, 72% of participants were satisfied (2% less than 2021), 12% were indifferent (5% less than 2021), and 16% were dissatisfied (7% more than 2021) with their installer's installation performance and customer service. Overall, the results show participants had favorable satisfaction of their installers in the 2022 quality assurance survey, however, there has been a slight increase in dissatisfied participants from the 2021 survey to the 2022 survey.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

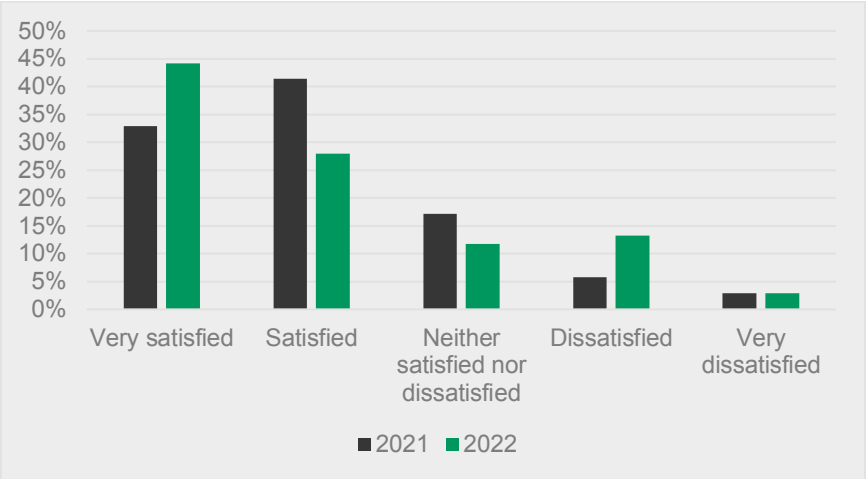


Figure 5.5: Satisfaction with Installer's Customer Service

5.6.2. Performance and Benefit Expectations

Survey participants were asked questions related to the performance and payment expectations. The respondents were asked to rate their system's production and REG payments from "much lower" to "much higher" than their expectations for the following questions:

- How does the system's production/energy output compare with what you expected?
- How different are the Renewable Energy Growth payments compared to what you anticipated?

Figure 5.6 summarizes the participant satisfaction with the production of their system. 83% of participants found their production to be as expected or higher, and 17% found production to be lower than expected in 2022. Participant satisfaction increased approximately 22% from the 2021 survey.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

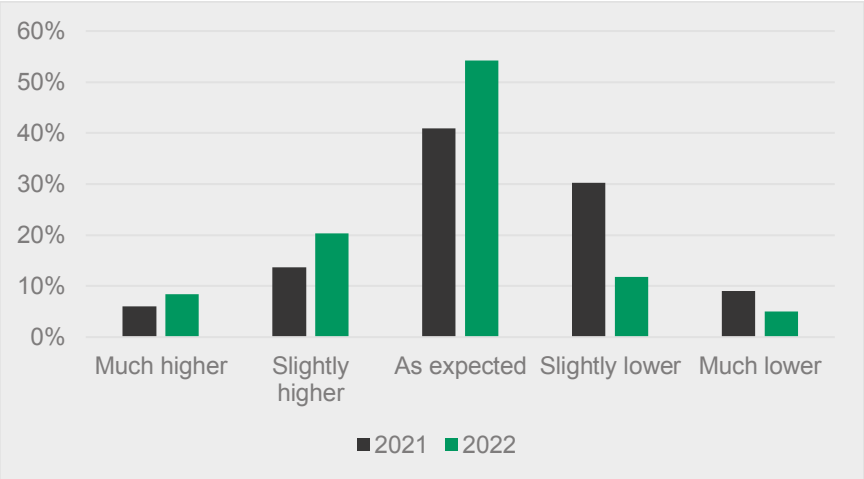


Figure 5.6: System Production Satisfaction

Figure 5.7 summarizes the participants perception of the REG payments. 43% of participants found the payments to be as expected or higher than expected, and 57% of participants found the payments lower than their expectations in 2022. Payment satisfaction decreased 9% from the 2021 survey. While production was slightly lower than the expectations of the participants, the payments were split between meeting or being higher than expectations and being lower than expectations.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

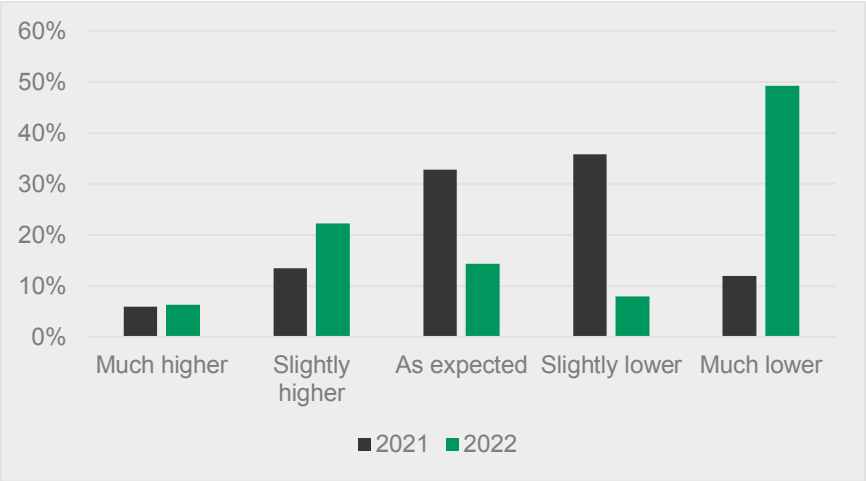


Figure 5.7: REG Payment Perception

Survey respondents were asked the following question related to the percentage of their monthly bill that is covered by payments:

- Approximately what percentage of your electric bill over the course of an entire year is covered by your Renewable Energy Growth bill credits and payments?

Figure 5.8 shows the results from survey respondents on the percentage the REG bill credits and payments cover the electricity bill. Overall, 68% of respondents found credits cover 51% and above of their electricity bill and 32% of respondents cover 50% or less of their electricity bill in 2022. In the 2022 survey, a 10% increase in respondents finding their credits covering 51% and above of their electricity bill from the 2021 survey was reported.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

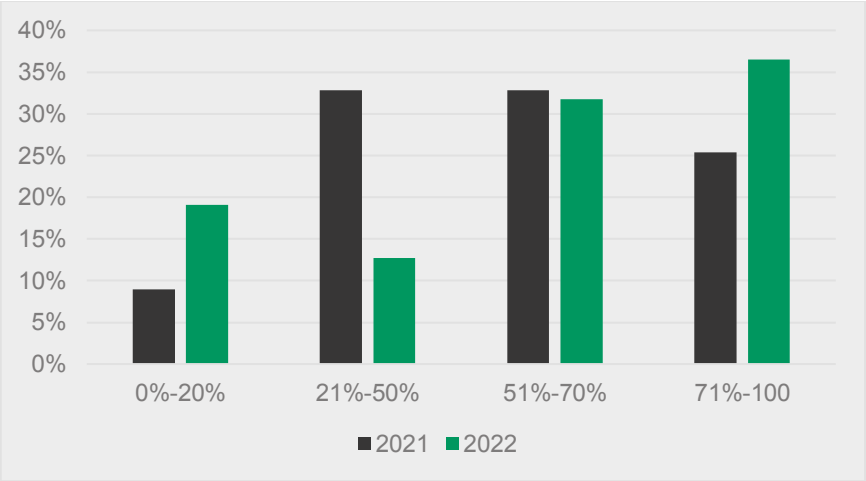


Figure 5.8: Electricity Bill Coverage Over the Course of a Year

5.6.3. Quality Concerns

Respondents were asked if their system was operating as expected, of the respondents 12% answered no in the 2022 survey. Natural Power subsequently asked the following question:

- What part(s) of your system is not operating as expected? (Select all that apply)

Figure 5.9 outlines the survey respondents quality concerns by PV system component. Several free response answers were given noting quality concerns with the output of the system not meeting expectations.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

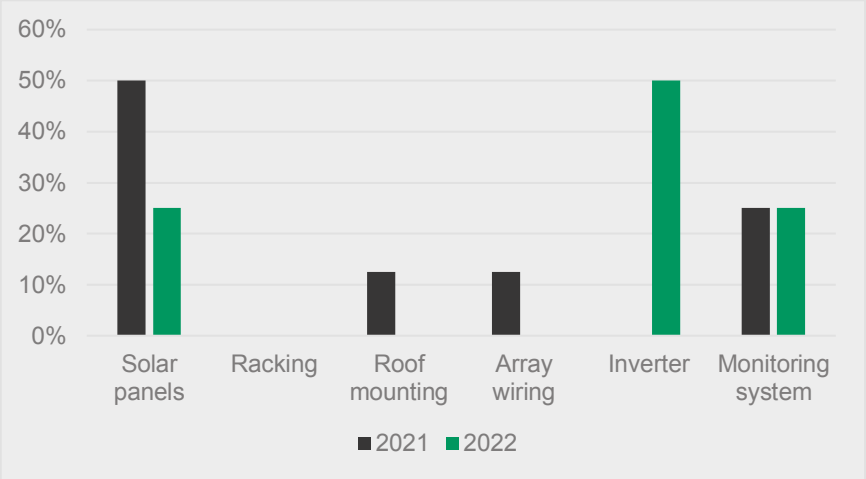


Figure 5.9: Quality Concerns from Survey Respondents

5.6.4. Roof Age

Natural Power found that 60% of survey respondents were not made aware of the possibility of moving the system to facilitate roof replacement at some point in the next 20 years, and 40% were made aware of roof replacement over the lifetime of the system. These results are consistent with the 2021 survey. Solar PV systems have a lifetime of 20 to 25 years. The lifespan of asphalt shingles is 15 to 20 years, the lifespan of architectural shingles is 20-30 years, and the lifespan of premium shingles is between 25 to 40 years[3]. The installation of a PV system on a roof in the middle or end of its lifespan poses warranty and safety concerns of roof leakage, collapse, or costly removal of the system and reinstallation for roof replacement.

Survey respondents were asked the following question about the age of their roof system:

- If your renewable energy installation is installed on your roof, what was the age of your roof at the time of installation?

Figure 5.10 shows a summary of the roof age of the survey respondents. 37% of installations were installed on roofs that are 8 years or older in 2022, a 5% increase from the 2021 survey. As the average expectancy of asphalt shingles is 20 years, PV systems are recommended to be installed on roofs no older than approximately 5-8 years old. PV system costs often do not include the removal and reinstallation for roof replacement.

[3] Lane, Catherine. "How Long Do Roofs Last? 5 Roof Types and Their Lifespans." Roofing Calculator, 9 June 2021, roofingcalculator.com/news/how-long-do-roofs-last.

Source: Rhode Island OER REG Quality Survey 2021 and 2022 SurveyMonkey Results

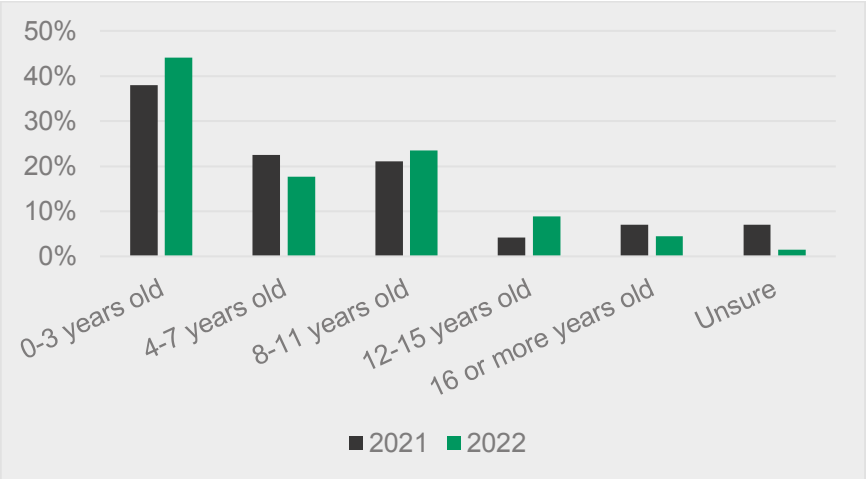


Figure 5.10: Survey Respondents Roof Age

5.6.5. Consumer Disclosure Form

Natural Power surveyed respondents' knowledge of the consumer disclosure form and found that 26% signed the form, and 74% were unsure of the if they had signed the form in 2022. These results are consistent with the 2021 survey. Overall, a large portion of the survey respondents were unsure of if they signed this form, suggesting there is not enough knowledge related to this form.

6. Conclusions and Recommendations

Natural Power noted trends in the results of the survey and from inspections. Several recommendations have been noted in the following sections from high priority to low priority based on the timeline these recommendations should be completed. High priority recommendations should be completed as soon as possible, and medium priority recommendations should be completed within six-months to a year. Figure 6.1 outlines the priorities and the timeline the recommendations should take place.

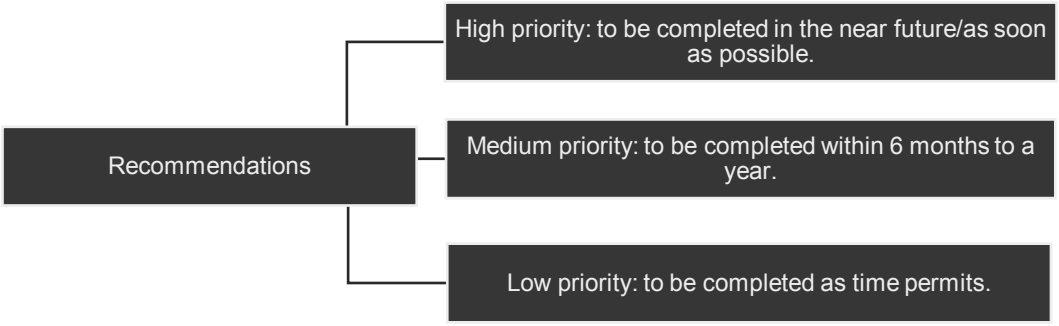


Figure 6.1: Recommendation Priorities and Timeline

6.1. High-Priority Recommendations

6.1.1. Installer Training

From the results of the inspections, Natural Power has noted several low-volume installers in the small-scale sample have lower quality scores as compared to the large volume installers. Natural Power recommends providing additional technical guidance and/or training session for these installers to raise awareness of the unique type of interconnection required for these systems. As noted in prior studies, the grid connection for this program is very unconventional for a residential application and installers have minimal guidance with the unique program and electrical code requirements. Natural Power recommends creating a one-to-two-page guidance document outlining the grounding requirements specific to this program's grid connection for small scale installations. In addition, Natural Power recommends creating a 1-2 hour in person training session for installers, summarizing the study's findings, and outlining best-practices for small-scale installations. Additionally, to enhance installer attendance Natural Power recommends offering NABCEP continuing education credits for attendees of the in-person training session. Ridgeline is a NABCEP continuing education provider and can register this course for NABCEP continuing education credit.

6.1.2. Inspections/Guidance During Construction

Natural Power recommends conducting 15-30 inspection-type site visits during the construction phase to offer installers with on-the-job training. These site visits can count towards one of the required program inspections for each installer.

6.2. Medium-Priority Recommendations

6.2.1. Self-Installer Training Webinar Update

Natural Power recommends re-recording the self-installer webinar training for self-installers, as the current self-installer training is approximately five years old and is not based on the latest-adopted edition of the NEC requirements.

6.2.2. Continued Quality Assurance Studies

Based on study findings, Natural Power recommends the continuation of quality assurance studies for REG funded renewable energy installations to further improve quality.

6.2.3. Continued Small Scale and Storage Inspections

Natural Power recommends inspecting small scall solar and storage installations to ensure the safety, quality, and conformance of installations. Natural Power recommends increasing the number of inspections of storage from 6-8 to 8-10 installations across different installers to collect enough data to understand typical deficiencies, trends, and areas in need of improvement.

6.2.4. Minimum Technical Guidance Document Updates

Natural Power recommends updating the Minimum Technical Guidance document with updates from the 2020 edition of the NEC that was adopted in Rhode Island on February 1, 2022. Natural Power also recommends supporting National Grid with providing updates to their energy storage system guidance diagrams based on configurations observed in the field. Although their guidance describes the proper requirements, the diagrams do not accurately represent it and they can be easily misinterpreted.

6.2.5. Enhance Program Knowledge

The Quality Assurance Survey found 78% of participants that completed the survey would like to be provided a contact list of who to contact when issues occur, 41% of participants would like to have a frequently asked questions forum or report to help solve common issues, 30% of respondents would like to have an online community to talk to other REG participants, 20% are content with the status of the REG program, and 5% provided additional responses requesting info on storage and pricing. Based on these responses, Natural Power recommends creating an information center for REG participants to find contact information, frequently asked questions, and additional resources on the OER website.

natural power

Creating a better environment

naturalpower.com
sayhello@naturalpower.com

25 years

For full details on our ISO and other certifications, please visit our website.