CADMUS

Solar Program Installation Requirements Review

January 2022

Prepared for:

Energy Trust of Oregon
421 SW Oak Street
Portland, Oregon 97204

Prepared by:
Danielle Côté-Schiff Kolp
Katie Harrison
Sarah Tyrrell
Guy Rice
Amanda McLeod
Jeff Cropp

CADMUS

Memo

To: Board of Directors

From: Jeni Hall, Program Manager – Advanced Solar
David McClelland, Sr. Program Manager – Solar
Sarah Castor, Program Manager – Evaluation & Engineering

cc:

Date: January 11, 2022

Re: Staff Response to the Solar Program Installation Requirements Review

Energy Trust's Solar program periodically updates its installation requirements for solar photovoltaic systems receiving incentives. The program last updated the installation requirements in 2017 and needs to do so again to reflect changes in technology and industry standards. Energy Trust undertook this review with the goals of updating the Solar Electric Installation Requirements to reflect the current market, providing solar trade allies a voice in the process, and building a methodology to ensure continued regular updates going forward.

As part of this review, feedback was collected from solar trade ally companies across the state as well as subject matter experts representing a broad range of backgrounds and expertise including local code officials, utility representatives, equipment manufacturers, and system design specialists. The list of participants was assembled taking into consideration the dynamic nature of the solar industry and the changing role of solar as a valuable distributed energy resource on the grid.

The information that was collected by this extensive effort led to recommendations that go beyond updating the Solar Electric Installation Requirements and include suggested enhancements for the program focused on: trade ally satisfaction, installation verification, star rating, system design, safety and code alignment, battery energy storage system design and installation, utility collaboration, and capturing smart inverter capabilities.

The Solar program is committed to continuous improvement and focused on making the program scalable and responsive to the needs of the changing solar market and the modern utility grid. The recommendations outlined in the report will be prioritized and incorporated as part of the program changes that are rolling out starting this year in response to guidance from House Bill 3141 and to focus on supporting a robust and diverse solar workforce installing solar systems that increase equity, resilience and grid flexibility. The Oregon Structural Specialty Code (OSSC), which contains the state's solar building code requirements, is in the process of being updated and the Program will update the solar electric installation requirements after those building codes have been finalized.

Going forward, the Solar program plans to repeat the survey of solar trade allies annually to gather suggestions for changes to the installation requirements and will repeat the interviews with subject matter experts, manufacturers and utility representatives on at least a biannual cycle.

Table of Contents

Tables

Figures

Introduction

Energy Trust of Oregon (Energy Trust) is an independent, nonprofit organization that offers numerous energy efficiency and solar incentive programs for customers of the investor-owned utilities in Oregon. Energy Trust's solar program has cash incentives that decrease the upfront cost of a solar installation, which are only offered by contractors in Energy Trust's Solar Electric Trade Ally network.

Solar trade allies are solar installation contractors that work with Energy Trust to stay updated on Energy Trust standards, incentives, and installation quality requirements. Energy Trust rates the solar trade allies on a regular basis, including an overall score on a 5-star scale for program, quality, and customer service scores. These ratings are intended to help improve the quality of installations[1] and provide guidance and education to solar trade allies. The ratings are also used to determine the solar trade ally's eligibility for Energy Trust program offerings, such as Business Development Resources, Solar Leads, and Pilot Programs.

All systems installed by solar trade allies must meet Energy Trust's Solar Electric Installation Requirements. The purpose of the requirements is to "help promote the performance and longevity of systems that receive Energy Trust incentive funding."[2] The requirements include criteria related to electrical and building codes, but also emphasize system performance and longevity.

For the project to receive the incentive, the solar trade ally follows a design review and project verification process outlined by Energy Trust's program requirements. Before beginning construction, the solar trade ally submits a project application, which includes technical documentation and a shade report. Then, Energy Trust completes a design review to identify issues prior to system construction. Once the solar trade ally has received approval from Energy Trust, the project begins construction.

Once the project installation and inspection are complete, an Energy Trust-designated third-party program verifier performs an on-site or remote verification. For both verification types, the verifier ensures that the installed system meets Energy Trust's Solar Electric Installation Requirements. The solar trade ally is notified whether the project has met all program requirements or if corrections are required. For the project to receive the incentive, the solar trade ally must complete the corrections and update the project in Energy Trust's system. Energy Trust engaged with Cadmus to review the Solar Electric Installation Requirements and suggest updates, using both stakeholder feedback and the 2020 National Electrical Code (NEC). Cadmus interviewed and surveyed various stakeholders, including industry experts in electrical codes, system design, solar installation best practices, solar racking and roof flashing, and fire codes; inverter manufacturers; utility partners; and solar trade allies.

---

[1] Energy Trust of Oregon: Solar PV Evaluation Report2017. https://www.energytrust.org/wp-content/uploads/2017/02/2011-2015_ETO_PV_Evaluation_Report_wSR.pdf

[2] Energy Trust of Oregon: Solar Electric Installation Requirements. 2017. https://insider.energytrust.org/wp-content/uploads/sle_rq_pv_sysreq.pdf

Cadmus involved stakeholder feedback in the project's three main objectives:

- Provide recommended updates to the Solar Electric Installation Requirements document.
- Provide local solar trade allies with a voice in the process for updating the Solar Electric Installation Requirements.
- Provide a methodology to ensure continued regular updates going forward.

By updating the Solar Electric Installation Requirements with stakeholder feedback and the NEC, Energy Trust is better equipped to advance its efforts to economize solar installations across Oregon, while maintaining a commitment to quality.

Methodology

For this study, Cadmus sought feedback from solar trade allies, industry experts, and Energy Trust staff. Cadmus' outreach included interviews and an online survey, as well as a literature review of relevant sources from across the country.

Study Population

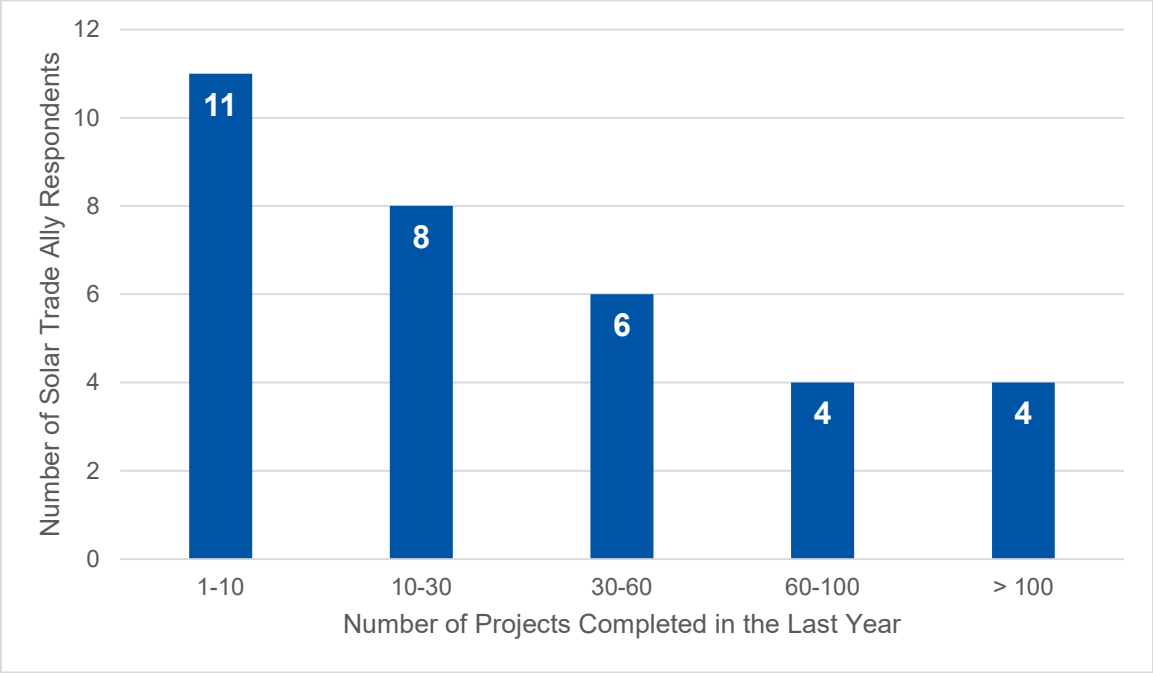
The details of the study population from which Cadmus gathered feedback are outlined below.

Solar Trade Allies

Cadmus prepared and administered an online survey to all 62 active solar trade allies in Oregon as of early 2021. Thirty-six solar trade allies (58%) responded to the survey, the majority of which operate in the state of Oregon. Five of the respondents install between one third and two thirds of their projects outside Oregon, and one respondent installs over two thirds of their projects outside of Oregon. See Appendix A for the list of solar trade allies that wished to be named in the study.

Cadmus grouped the operational size of the solar trade allies by the number of projects they had completed in one year. Figure 1 shows the number of respondents in each size category, defined as the number of projects completed in the last year in Energy Trust territory for an incentive. Three solar trade allies did not provide estimated number of projects, so the total is 33 instead of 36.

Figure 1. Surveyed Solar Trade Ally Energy Trust Territory Project Counts



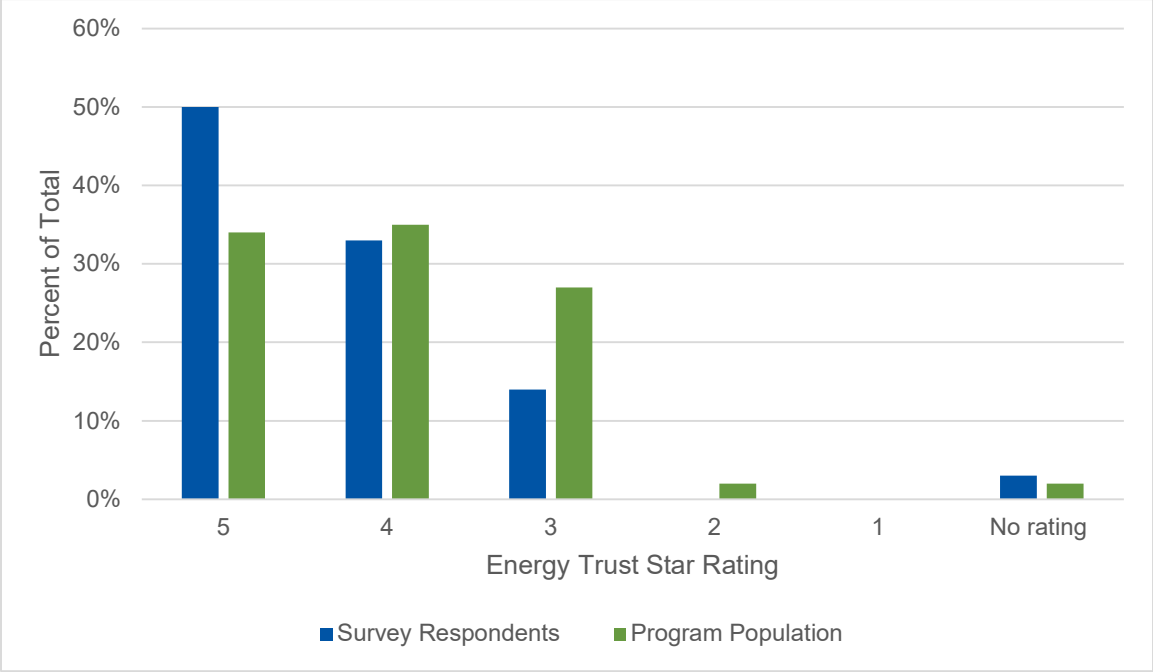
Cadmus also differentiated solar trade ally respondents by type of completed projects: residential or commercial. These categories are shown below in Table 1.

Table 1. Trade Ally Respondent Installation Type

Installation Type	Number of Respondents	Percentage of Total
Primarily Residential	21	58%
Evenly Split	11	31%
Primarily Commercial	4	11%
Total	**36**	**100%**

Most solar trade ally respondents were highly rated on Energy Trust's Trade Ally scale. Half of respondents were rated the highest, with five stars, and another one-third of respondents were rated with four stars. These two ratings cumulatively represent 83% of the study population, with no respondents being rated lower than three stars. Figure 2**Error! Reference source not found.** illustrates the star ratings of the survey respondents and the solar trade ally program population. The survey population skewed to higher star level respondents.

Figure 2. Solar Trade Ally Rating Summary



Industry Experts

Cadmus interviewed 16 industry experts who had a broad range of backgrounds and areas of expertise, including system design specialists, electrical and fire code, installation best practice experts, solar racking and roof flashing specialists, utility staff, and an inverter manufacturer. See the list of interviewees in Table 2.

Table 2. Industry Experts Interviewed by Cadmus

Interviewee	Area of Expertise
Jerry Henderson, Energy Assurance Company	System design, NEC, structural
Bill Brooks	NEC
Ryan Mayfield, Founder & CEO, Mayfield Renewables	System design
Nick Armstrong	Battery energy storage systems and solar installation best practices
Jeff Spies	System design, best practices
Johan Alfsen, Sr Director of Product Marketing, K2 Systems	Solar racking and roof flashing best practices
Brian Crise, Chief Electrical Inspector, City of Portland	NEC and installation best practices
Jeff Herman, City of Portland	Fire code and solar access pathways
Sarah Wilder, Solar Workforce Program Analyst, US DOE	System design and installation best practices
Maciek Rupar, Director of Technical Services, National Roofing Contractors Association	Roofing best practices
John Taecker, UL	Battery energy storage systems, roofing/flashing/racking, and system safety
Pete Jackson, Chief Electrical Inspector, City of Bakersfield, CA	NEC and NFPA
Audrey Burkhardt, Portland General Electric	Utility perspective on smart inverters, solar and storage
Tim Treadwell, Portland General Electric	Utility perspective on smart inverters, solar and storage
Erik Anderson, Pacific Power	Utility perspective on smart inverters, solar and storage
Greg Smith, Sonnen	Battery energy storage systems
Anonymous Representative, SolarEdge	Solar installation best practices

Energy Trust Solar Program Staff

At the beginning of the study, Cadmus held a joint interview with several of the Energy Trust solar program staff. During this interview, Cadmus collected feedback about recent and historical challenges and successes of the program, the star rating system, the verification process, and areas of potential improvement for the installation requirements.

Data Collection Activities

The details of Cadmus' methodology for the interviews, surveys, and literature review are outlined below.

Interviews

Cadmus compiled an industry expert interview guide consisting of several sections, listed below:

- Background and general program feedback
- Battery Energy Storage Systems
- Roofing, flashing, and racking
- System design and installation best practices
- System safety (fire and electrical code)
- Utility interviews on smart inverters and solar and storage

Respondents did not address all sections, though were generally eager to share feedback on Energy Trust's Solar Electric Installation Requirements. Most interviews lasted 30 to 60 minutes.

Online Survey

Cadmus worked with Energy Trust to draft an online survey for solar trade allies that covered several topics, listed below:

- Program participation of residential and/or commercial installations
- Number of annual installations
- Satisfaction with various elements of the Solar program, staff, and star rating system
- Specific feedback on suggested language changes to the installation requirements document
- Benefits or challenges of the program

Cadmus sent the survey to all solar trade allies active in 2021, with the incentive of a chance to win one of two $100 gift cards. The gift cards were given to two randomly selected trade allies that successfully completed the survey. The survey was available online for four weeks, with two reminder emails sent over that period. The response rate was a robust 58% (36 of 62). Cadmus gave respondents the opportunity to request a phone call to discuss their survey responses further. Cadmus spoke to six solar trade allies and made several attempts to speak to the five others who requested a call.

Literature Review

Cadmus reviewed Energy Trust's Solar Electric Requirements and the updated NEC code-compliance documents. Cadmus also incorporated best practices from solar verification programs around the country. Some examples include Massachusetts Clean Energy Center's (MassCEC's) Solar Loan Program, Rhode Island Energy Fund Grant, and the New York State Energy Research and Development Authority's (NYSERDA's) Solar Guidebook.

Findings

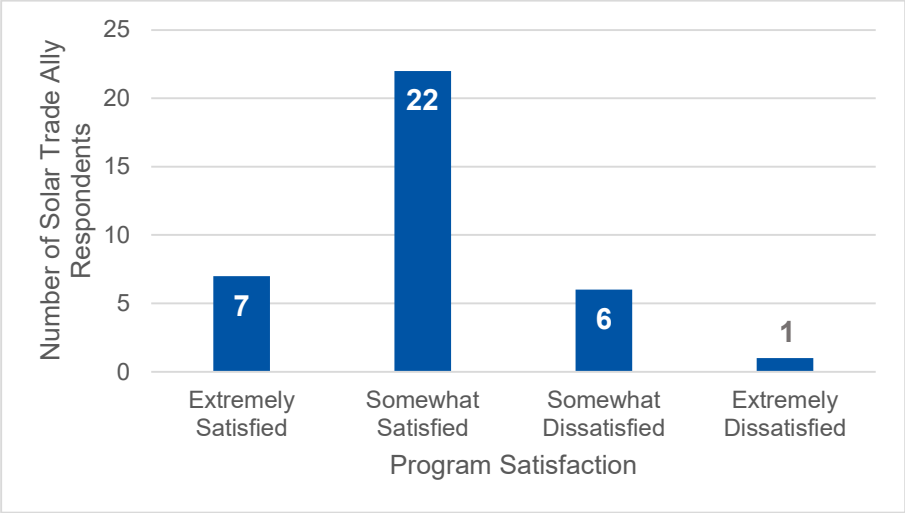
Using the information collected in the industry expert interviews and solar trade ally survey, Cadmus organized findings into several categories:

- Program satisfaction
- Verification and star rating impacts
- System design, including total solar resource fraction (TSRF) and DC to AC ratio
- Installation best practices, including the customer manual and labeling, roofing, and flashing
- System safety and codes
- Battery storage
- Utility collaboration
- Smart inverters

Program Satisfaction

Based on survey results, most solar trade allies are satisfied with their program participation, illustrated in Figure 3 **Error! Reference source not found.** below.

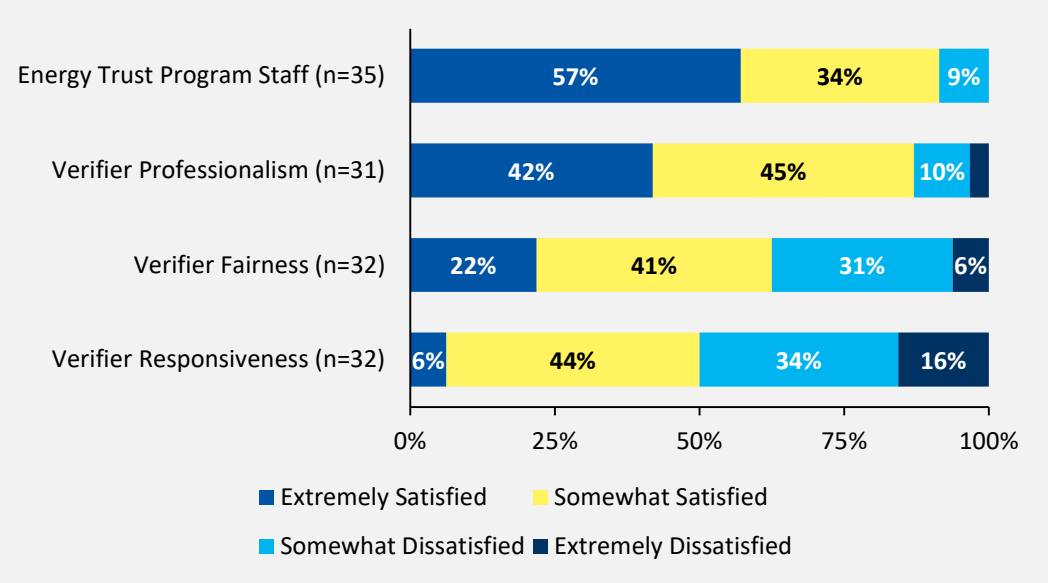
Figure 3. Solar Trade Ally Program Satisfaction



Survey results indicate solar trade allies are generally satisfied with the program and with the Energy Trust staff who manage it. As shown in Figure 4, 57% of solar trade allies were extremely satisfied with Energy Trust program staff, 34% were somewhat satisfied, and 9% were somewhat dissatisfied. No respondents rated themselves as extremely dissatisfied with program staff. Solar trade allies were largely satisfied with the professionalism of project verifiers, with 87% extremely or somewhat satisfied. Responses about verifier fairness were more mixed, with 63% extremely or somewhat satisfied, 31% somewhat dissatisfied and 6% extremely dissatisfied. Solar trade allies were the least satisfied with

verifier responsiveness, with 50% extremely or somewhat satisfied and 50% extremely or somewhat dissatisfied.

Figure 4. Program Satisfaction by Category



As mentioned previously, most solar trade ally respondents are rated at four or five stars. As a result, the survey results reflect the perspectives of higher rated solar trade allies. Five-star rated allies are overrepresented, making up 34% of active solar trade allies, but 50% of survey respondents. Four-star rated solar trade allies are proportionally represented, making up 35% of active solar trade allies, and 33% of survey respondents. Three-star rated solar trade allies are the most underrepresented group: they make up 27% of all active solar trade allies, but 14% of survey respondents.

Though survey results may not capture the full breadth of solar trade ally experiences, the high response rate indicates engagement and responsiveness to the program.

Satisfaction Recommendations

- Consider providing an expected timeframe for responses to solar trade ally inquiries to help improve perceived verifier responsiveness.
- Consider providing solar trade allies with training on the point decrement methodology for different requirements to improve the perception of fairness.

Verification and Star Rating Impacts

Nearly half of surveyed solar trade allies said they were enrolled in the remote verification process using Site Capture, a third-party software tool. Thirteen respondents provided feedback for the remote verification process. Only two of the 13 trade allies said that Site Capture was a useful or simple tool to

use. The remaining 11 trade allies did not like the remote verification process or felt that it could be improved. Barriers included:

- Additional staff labor hours needed to complete the process (5 respondents)
- Process takes too long (2 respondents)
- Language/descriptions could be improved (2 respondents)
- Not a practical use of time (1 respondent)

Some of the most constructive suggestions to improve the remote verification process are outlined below:

- "There are some redundancies to these remote verifications and don't seem to save time. The verification takes a long time so if we miss a label, we have to call the customer back after the job's done with for a month and explain why we are back. It seems like they could operate on a spot check type of system (for contractors that have a good star rating or established relationship). Slows down the pipeline as it moves through our company. We had an incentive amount delayed for weeks because the panels we installed were not in the listed dropdown menu in SiteCapture."
- "This can be a mixed bag - on the one hand, it's an extra step that our crew must take, and requires training for all new team members. It can be a bit of a labor-suck… and we have frankly had to create an entire new full-time position to manage this effort. In terms of reducing soft costs, currently this appears to actually be INCREASING those costs. However, from a QA standpoint, we find it valuable."
- "Update or eliminate the following [data collection fields from the remote verification form]:
  - 1) " MLE quantity, and photo of monitoring showing all operating" comment: for Rapid Shutdown-only devices, a photo of monitoring is not possible. Add question about whether device has monitoring?
  - 2) Voltage and current for Input #1 from inverter display or monitoring comment: Many inverters such as SolarEdge do not provide individual voltage and current readings on the display or monitoring. Edit language or drop the question altogether.
  - 3) Is the only AC disconnect the Load side or Supply side disconnect? Comments: Clarify if this question also refers to the Rapid Shutdown Initiation Device. We often use a simply AC disconnect for the RSID and it's confusing to ask if the only AC disconnect is the load side or Supply-side disconnect when it's clearly not, but we already covered it with the RSID questions."

Cadmus recommends that Energy Trust review and incorporate the remote verification feedback provided in the full survey responses.

Star Rating System

The Energy Trust's star rating system for solar trade allies is unique, with no similar rating systems found in Cadmus' research. Most solar installer ratings rely completely on customer reviews, through services in EnergySage, Yelp, and local quality assurance organizations. Unlike Energy Trust's star rating system,

these customer reviews were not based on industry code or system design best practices. In Cadmus' recent experience and research, we identified a clear customer demand for solar installer quality assurance verification, indicating that Energy Trust's solar trade ally program is broadly desired.

In Cadmus' survey, solar trade allies were asked what impact the star rating system has on their company and on the Oregon solar industry. The results are discussed in the following sections.

Perceived Benefits of the Star Rating on Trade Ally Company

Solar trade allies indicated that the greatest positive impact of the star rating on the trade ally company was bolstering customer trust, with marketing material and installation practices being the next most positively impactful and customer education least impactful. These results are illustrated in Figure 5 Figure 5. Star Rating Impact on Solar Trade Ally Company below, with high-level findings for each component shown in Table 3.

Figure 5. Star Rating Impact on Solar Trade Ally Company

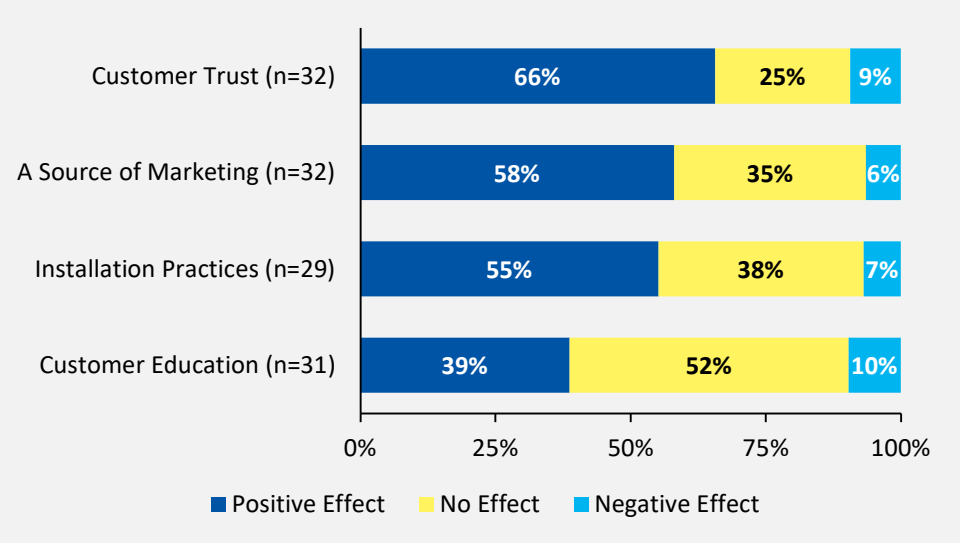


Table 3. High-Level Results of Star Rating Impact on Trade Ally Company

Customer Trust	Most trade allies indicated that the star rating system had a positive impact on their company regarding customer trust, with most of the remaining trade allies noticing no impact. Perceived positive impact was highest among four- and five-star rated solar trade allies. Simply participating in the program does not appear to impact customer trust, shown by the neutral impact for three-star rated solar trade allies.
A Source of Marketing	Trade allies rated the effect of the program on their company marketing, with responses split between no effect and positive effect. Solar trade allies with higher ratings, or those with a record of improvement, indicated positive impacts on marketing.
Installation Practices	Most solar trade allies indicated that their star rating had a positive effect on installation practices. However, four- and five-star rated trade allies expressed the most negative responses. The responses did not elaborate further on why the star rating negatively affected installation practices.
Customer Education	Solar trade allies indicated a positive impact on customer education of 39%, however, 52% indicated no impact. Most interestingly, the only solar trade ally that noted a negative impact was one with a consistent five-star rating.

Perceived Benefits of Star Rating System on Oregon Solar Industry

Solar trade allies indicated that the greatest positive impact of the star rating system on the Oregon solar industry was bolstering customer trust, with marketing material and installation practices being next most positively impactful and customer education least impactful. This trend followed a very similar distribution as the perceived impact of the star rating system to the trade ally company. These results are illustrated in Figure 6Figure 6 below, with high-level findings for each component shown in Table 4.

Figure 6. Star Rating Impact on Oregon Solar Industry

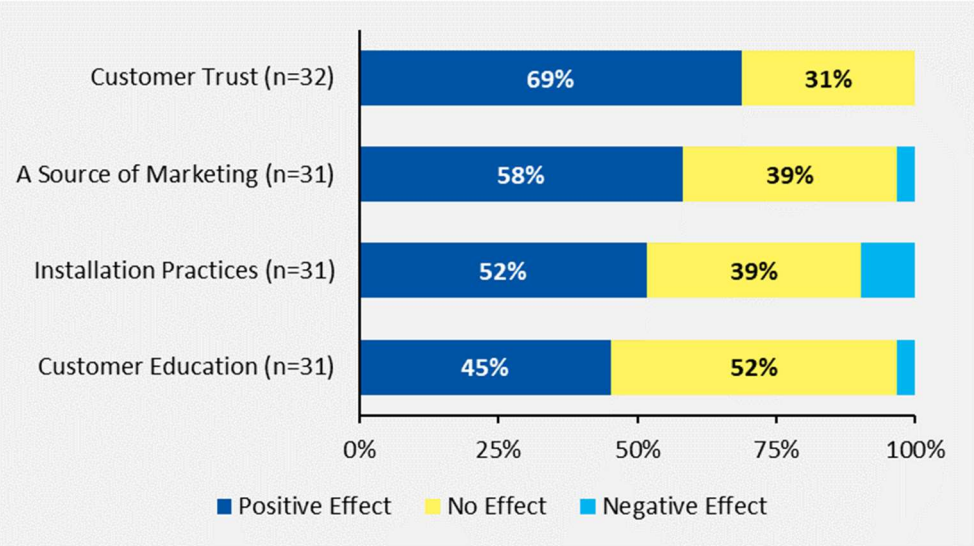


Table 4. High-Level Results of Star Rating Impact on Oregon Solar Industry

Customer Trust	Most solar trade allies indicated the star ratings positively impacted customer trust in the Oregon solar industry. This is a clear success for the program, as the rating system has a demonstrative impact on market confidence. Solar trade allies with a five-star rating predominantly said the program has a positive impact on the industry.
A Source of Marketing	Solar trade allies indicated the program positively impacted marketing for the Oregon solar industry. Trade allies who noted a negative effect had recently declined in their rating or had a consistent low rating. Those who noted a positive effect generally had a five-star rating or demonstrated growth.
Installation Practices	Solar trade allies indicated a positive or neutral effect of the star ratings on installation practices for the Oregon solar industry. Trade allies who expressed the star ratings negatively affected installation practices in the Oregon solar industry consistently had lower ratings, while trade allies who expressed positive effects generally had five-star ratings. Trade allies with a three- or four-star ratings were equally split in noting positive effects or no effects on the industry.
Customer Education	Nearly half of solar trade allies indicated that the star rating system positively impacted customer education in the Oregon solar industry. These respondents had a five-star rating over the past three scoring periods. A few trade allies, who had either consistently lower ratings or a recent decline to a three-star rating, noted a negative effect on the industry.

General Star Rating System Feedback

Cadmus gave solar trade allies the opportunity to provide detailed responses and suggestions regarding the star rating impacts on their business. Solar trade allies were divided on the perceived benefits of the star rating system: 15 trade allies said the star rating system positively benefitted their company while 13 said it had a negative impact (n=28). A few clear themes surfaced from these responses, outlined below.

- ***Impact on business growth.*** As with any incentive initiatives or programs, Energy Trust's Solar program had both intended and unintended outcomes. Many, if not all, of the trade allies' suggestions and complaints can be tied directly back to one fundamental negative outcome: trade allies feel that while the star rating system was intended to help them improve their work and provide trust in the industry, it has also fostered unwanted competition. By incenting good work with additional benefits, the rating has also made the inspection process stressful and doubly impactful on the success of their business and livelihood. A low rating does not simply mean they need to improve, but also impacts their ability to grow their business. Instead of reacting to low ratings, verifier mistakes, or minor notations in the spirit of constructive feedback, some trade allies view the process as a direct threat to their business.

  Even those who expressed this concern admitted that the rating system does help them improve, but said they worry that (1) it is not helpful to make the system publicly available, and (2) the rating oversimplifies customer satisfaction by only accounting for unresolved customer complaints.

- ***Feedback clarity***. Because the rating has such a direct impact on the continued success of a trade ally's business, some trade allies expressed a desire to have the impacts of infractions be made clearer, as well as having remediating steps or trainings be available to them. Many trade

allies noted that the rating process helped them identify areas of improvement and aided in their overall success.

Two trade allies provided suggestions on improving clarity: (1) one requested a more granular report rather than a general summary, and (2) one requested photos of reports showing exactly what the verifier found wrong.

- ***Verifier accountability.*** Solar trade allies expressed frustration that there was not a process to contest corrections. They understand verifiers can make mistakes and want to see more accountability on the verifier side.

Some of the verbatim feedback from installers included:

- "The verification process is hit and miss at times, and the lag time between install and verification can be frustrating. ETO requirements should be based on 2020 code without additional stipulations that are ETO specific. The point system is quite frustrating as well, especially when dealing with corrections that are false or arbitrary."
- "The verification program has been painful and costly. I believe our verifier is fair in as much I don't think he has singled us out. But the zero tolerance, zero exception regardless of how minor the perceived violation or expensive the fix approach to verification is not congruous with the rest of our experience with the program. There is also a 'I can't see evidence X, Y or Z was done therefore I assume it wasn't' and the job does not pass. Those failures cost our company money to respond every time. One concrete improvement I would like to see: when the verifier fails a job, they should include the photo they perceive is evidence of our failure. Often we have to engage in a back and forth to figure out what they are talking about."
- "I feel like the corrections have not been consistent and are at times very ticky tacky. I don't think it's a good system that you can spend days and days working at an install and take real care and consideration with craftsmanship and get dinged a few points for forgetting something like a zip tie on a disconnect or a label."

Most trade allies (25 of 32) said they had a clear understanding of the tiers of benefits offered to trade allies that achieve higher star ratings, but only a fraction (9 of 33) said the trade ally report gave them clear guidance on how to improve their company's star rating. Trade allies generally felt that the star system was better suited for internal use and that verifiers should also be held accountable for mistakes. For example, one trade ally said: "I think instead of scoring trade allies on a star system your focus should be on supporting the trade allies making sure everyone is installing above average systems. As a trade ally and partner with Energy Trust it doesn't make me feel very good that you might rate another company down the street higher than me [and consequently] sending competition to someone else. Leave the star rating system for Google and BBB."

Verification and Star Rating Recommendations

- Energy Trust should review and incorporate the remote verification feedback provided in the full survey responses.
- When corrections are required, provide a photo to expedite the conversation and rectification.
- Consider making the star-ratings internal, for Energy Trust and trade ally use only. The external customer facing network could show only the highest rated trade allies; for example, only 4s and 5s, but the actual star value will not be published. Trade allies rated at 1 to 3 stars will not be listed on the website.
- We also recommend that Energy Trust develop a formal system for installers to challenge verifier's findings, with Energy Trust staff acting as arbitrators for disagreement. The current system does not provide effective mechanisms for installers to clarify that verifiers are 100% accurate, so a new system would provide sufficient accountability to alleviate installer concerns and ensure there is consensus between all entities on the identified issues.
- Less than a third of trade allies felt the report gave clear guidance on how to improve a star rating, so consider including clear action items in the report, and consider offering periodic Question and Answer sessions.

System Design

When discussing system design requirements for the program, Cadmus' conversations with solar trade allies, industry experts, and Energy Trust staff was mainly focused on the Total Solar Resource Fraction (TSRF) requirement and DC to AC ratio.

Total Solar Resource Fraction

The current solar installation requirements state that on-site shade analysis must meet 75% TSRF at the worst-case location and that remote analysis must meet 80% TSRF system average to be eligible for an incentive. One trade ally recommended "making the on-site shading analysis and remote report pass the same threshold to increase industry safety, [and] reduce customer costs, with minimal negative impact to a customer's production." A few trade allies also noted a desire to reduce the TSRF limit to 65% or 70%, or said Energy Trust could provide a lower incentive to those installations below 75%.

However, 80% TSRF is widely considered industry standard. The 80% threshold was established to ensure economic feasibility of projects, originally suggested by a consortium of industry experts, including NREL.[3] Numerous organizations use an 80% threshold, such as the New York State Energy Research and Development Authority (NYSERDA) and Rhode Island Energy Fund Grant. NYSERDA uses 80% TSRF as their minimum threshold, with pro-rated incentives for projects below 80%. Some, like the Massachusetts Clean Energy Center (MassCEC), do allow down to 70% TSRF.

[3] NREL, (2015). "Best Practices in PV System Installation." Retrieved from https://www.nrel.gov/docs/fy15osti/63234.pdf

DC to AC Ratio

Solar trade allies may design a system with a higher or lower DC:AC ratio due to project economics, equipment availability, and site-specific characteristics. Systems with a DC:AC ratio greater than one can forego production during peak hours of sun due to clipping loss, which is when the DC power exceeds what the inverter can convert. However, due to the high cost of inverters, typically the lost revenue from clipping loss is not enough to offset the additional cost of more inverter power. Solar projects do not operate at their full DC capacity for the majority of the time, and therefore inverters with lower peak power relative to the nameplate capacity of the array may operate with minimal impact on system performance.

Energy Trust's requirements currently has an upper limit of a 135% inverter output power rating. The main feedback from solar trade allies was that Energy Trust should consider being more flexible with this threshold, especially if the trade ally can provide evidence that a higher ratio improves project economics and performance. One industry expert said if the system designer can provide energy modeling demonstrating the need to exceed the program's 135% ratio, Energy Trust should accept this model for consideration. A trade ally also stated that some commercial and industrial systems exceed the 135% threshold, which does not harm the inverter and helps the project finances. The 135% threshold is generally ideal for most systems, because systems at 135% do not clip often. However, because oversizing within manufacturers' allowable limits does not harm the inverter, Energy Trust can consider flexibility above the 135% threshold if trade allies demonstrate the need.

Other Design Considerations

Lastly, some trade allies felt that Table 1 (temperature adder) in the Installation Requirements document could use additional clarifying text.

System Design Recommendations

- Consider establishing a process for reviewing remote analysis tools as more enter the market.
- Because the solar program is likely moving to a flat incentive amount for regular residential installations, consider lowering the TSRF to 70%.
- The DC:AC ratio upper limit should remain at 135% for all solar installations, but Energy Trust should allow solar trade allies to request a higher threshold. Energy Trust can require trade allies to include in their request energy models and economic analysis to demonstrate the need to exceed 135%. Cadmus does not think Energy Trust should change the threshold for commercial or industrial projects, because 135% is still generally ideal in those contexts. As the energy storage industry continues developing, if new inverter ratio recommendations arise, Energy Trust can consider updating the thresholds as needed.
- Consider adding clarification text for Table 1 in the Installation Requirements document on temperature adders.

Installation Best Practices

When discussing installation best practices with subject matter experts, we addressed topics including the customer manual, labeling, and flashing roof attachments.

Customer Manual

Subject matter experts differed in opinion about the customer manual. One solar trade ally found the inclusion of the customer manual to be unnecessary and laborious. On the other hand, a program verifier found the manual to be necessary, so that customers have on-site information for their solar PV system. Most subject matter experts and several trade allies preferred to allow for digital customer manuals, with a consensus that some form of documentation is critical to ensure proper education for the customer and potential future owners. The customer could automatically receive a digital copy, in the form of a single PDF file emailed to the customer, and request a manual copy if desired. The customer should also be given instructions to keep the file saved in a secure location, and can print it if desired.

Industry experts agreed that giving the customer guidelines on how to disconnect the system is critical, and this requirement should not be removed, but could be modified in its form of delivery. Also, subject matter experts and trade allies said that the inverter manual and warranties should be included. Even though these manuals are readily available online, the experts saw value in providing customers with one resource that contained all relevant system information.

Labeling

Labeling was a source of frustration for Energy Trust stakeholders. Solar trade allies stated there are variations in the electrical code and voiced frustration with the current Energy Trust requirements. They expressed that it is easy to "over-label" and it is important to label the right items on the system. The solar trade allies are looking for clearer instruction in Energy Trust's requirements regarding label coloring and location. Many trade allies expressed confusion about the sentence: "when required, inverter disconnect label shall be placed on or near the disconnect box and not on the inverter chassis." Labeling errors occur in about 15% of projects verified (requirements 2.3.5 and 2.3.17), which is twice as much as the next most common error type (2.1.5 on system design documentation at 8%). Stakeholders agreed that a clear labeling guide would be helpful.

Flashing Roof Attachments

Micro-flashing, self-flashing, and flexible flashing are manufacturer descriptions used for a class of over-the-shingle roof mounts that do not include mechanical flashing – typically aluminum – to be installed under the roof shingles. This technology has gained popularity in the solar industry because it can reduce labor and installation costs. Cadmus reviewed solar trade ally claims, interviewed NRCA and UL, and found that there is no industry standard certification for micro-flashing or flexible flashing for asphalt shingle roofs, a common roof type for residential properties. From the perspective of the National Roofing Contractors Association, this type of flashing could impact the warranty of a roof. The lifespan of the flashing compared to the lifespan of the roof would be mismatched, as micro-flashing is

not a long-term method for flashing. There were also concerns about durability and water resistance, which needs to be further investigated.

Installation Best Practices Recommendations

- Consider requiring that the inverter owner's manual and corresponding manufacturer warranties are included in the customer manual.
- Consider automatically providing the customer with a digital customer manual via a single emailed PDF and provide an option to receive it as a hard copy. The customer should also be instructed to keep the file saved in a secure location.
- Consider developing a resource for labeling that includes background reasoning, label placement, and label coloring.
- Given that there is currently no industry standard for micro-flashing, Energy Trust should continue not permitting micro-flashing or other flexible flashing. If testing and certification for micro-flashing becomes available, Energy Trust can revise its requirement at that time.

System Safety and Codes

The experts agreed that the Equipment and Installation section (2.3) of the Solar Installation Requirements needs to be updated to include power control systems under the NEC 2020 section 705.13. Mismatching connectors is a common and potentially dangerous deficiency in solar installations. The problem occurs when the factory-installed whip and connector on the solar module is attached to a connector that is not the same type or brand and is not listed to be paired. All manufacturers provide a list of compatible connectors, and installers are responsible for ensuring they buy the correct connectors for the panels. Energy Trust should (a) adopt the NEC 2020 690.33(C) section verbatim, (b) continue to monitor this issue and (c) consider developing educational resources for trade allies. Cadmus has a best-practice document on connectors, summarized below.[4]

> *PV connector best practices for solar installations include: research, verify, and purchase products that have matching connectors; consult the connector's instruction manual and verify the correct tool(s) for field connector installation; never expose connectors to moisture or chemical substances; and test connections to ensure a tight fit by gently pulling on all connected parts.*

When discussing safety, the topic of energy storage emerged, with experts saying it would be worthwhile to consider adding phrasing specific to fire safety when installing a battery energy storage system (BESS). Additional discussion of battery systems is presented in the next section.

[4] Cadmus and Massachusetts Clean Energy Center. n.d. "PV Connector Guidance and Installation Best-Practice." White Paper. https://files-cdn.masscec.com/solar-loan/QAResource2019PVConnectorGuidance.pdf

System Safety and Codes Recommendations

- Include mismatched connector information based on NEC 2020 690.33(C).
- Consider providing educational resources for solar trade allies related to avoiding mismatching connectors.
- Update section 2.3.10 B to align with NEC 2020 690.15(A), which further clarifies disconnection location.
- Update section 2.3.10 D to reflect rapid shutdown code requirements.
- Update the footnote referenced in section 2.6.1 to include the correct link.

Battery Storage

Much of the conversation with subject matter experts regarding battery energy storage systems (BESS) was focused on the need to keep up with the rapidly evolving technology. This theme is not specific to Energy Trust: trade allies and inspectors in the broader solar industry need to continue to become educated on the latest BESS technology. Subject matter experts widely agreed that Energy Trust could fill the role as an educator.

Along with education, cost continues to be a substantial barrier to BESS implementation. Stakeholders agreed that incentives will be necessary to increase opportunities for BESS adoption. Subject matter experts mentioned that the battery section (2.8) needs to include safety considerations for lithium-ion batteries. Some subject matter experts expressed concern for inspectors' lack of familiarity with lithium-ion battery technology. Sections 2.8.5, 2.8.6, and 2.8.7 are not applicable for lithium-ion systems. When installing BESS in garages, the code requires bollards and/or raised platforms for vehicle impact protection, however it is currently not clear when the code requirement applies. The Sustainable Energy Action Committee (SEAC) proposed revisions to the International Fire Code as part of the International Code Council (ICC) Code Development Process currently underway that clarify the vehicle impact protection requirement to aid code officials and contractors in consistently identifying and addressing the risk.[5] Energy Trust can plan to follow their lead on safety for BESS installation.

Inverter Manufacturer-Suggested Solar Trade Ally Education

An inverter manufacturer identified solar trade ally education is needed on BESS systems, outlined below.

- ***Implications of Different BESS Coupling Configurations.*** BESS can be paired with PV in two ways: AC-coupled or DC-coupled. Trade ally contractors should be trained on these different configurations and what that means for system installations.
- ***Electrical Design.*** In addition to the BESS-PV pairing configurations, the way the system interacts with the grid is a unique challenge. The Federal ITC, some states, and some administrators of incentive or utility programs, require certain configurations. These include restricting where the

[5] Sustainable Energy Action Committee, Series 10, 13, and 14. Retrieved from https://www.seacgroup.org/ourwork

BESS can charge from and where it can discharge to. The design and line-diagram creation for these configurations are relatively new, and many trade allies may not be able to accurately demonstrate proper configurations in design documents yet.

Battery Storage Recommendations

- Consider developing a battery storage guide and/or webinar series to educate trade allies and other stakeholders on (1) the fundamentals of BESS, and (2) updates to the latest BESS technology.
- Clarify which requirements apply to lithium-ion battery technologies.
- Update section 2.3.4 D to remove the wording "except with program pre-approval" so the UL9540 listing is required for BESS, which aligns with the International Residential Code, International Building Code, International Fire Code, and NEC.

Utility Collaboration

Cadmus interviewed two representatives from Portland General Electric (PGE) and one from Pacific Power. These interviews allowed us to better understand Energy Trust's role of technical design review and on-site or remote system verification in the distributed energy resources (DER) market, as well as the future of DERs, including BESS.

Distributed Energy Resources

Representatives from PGE and Pacific Power do not have specific DER goals at this time but do understand their importance. PGE staff said there is potential for battery storage in the market and they are currently offering a residential "Smart Battery" pilot program with implementation support from Energy Trust. They are in the process of developing a specific plan to roll out an electric vehicle charger pilot program in 2021 and are looking into the capabilities of battery storage for demand response programs. PGE is particularly interested in solar customers, whom they think may be more likely to have BESS, electric vehicle chargers, and smart thermostats. Similarly, Pacific Power is in the process of determining how to leverage customer-owned DER equipment for grid benefit. The long-term benefits of and technical path for using DERs is not well-documented for either utility. Pacific Power does not currently offer a battery program, however its sister utility, Rocky Mountain Power, does have a battery program available to all Utah customers[6] and is in discussions with the Idaho commission. This program design could potentially be rolled out to additional Rocky Mountain Power and Pacific Power territories over time.

Value of the Energy Trust Role

Before sending a project incentive, Energy Trust's existing quality management process for the Solar program includes published above-code design and installation requirements, a technical "paper study" design review, and a site visit to verify that installation requirements were met. Both PGE and

[6] https://www.rockymountainpower.net/savings-energy-choices/utah-wattsmart-battery-program.html

Pacific Power agreed that there is still value in the Solar program's quality management process (despite the solar industry's maturity), and that these requirements have helped to reduce installation issues and will be important to continue once storage programs are more widely accessible. PGE mentioned that the collaboration and sharing of granular data on system size and location could be improved in the quality management process.

Cadmus also asked utility staff if there is value in pre-selecting which DER system settings are enabled at the time of installation. PGE is interested in a "smart" inverter demonstration project and collecting details about inverter equipment manufacturers and model numbers in order to modify settings via the cloud. PGE also noted that interconnection standards for smart inverters need to be adopted before they can officially set any standards. Pacific Power is interested in using smart inverter settings for future demand response battery programs, but also said it is premature to establish connection settings.

Both PGE and Pacific Power understand the need and expectation for battery storage programs and goals in Oregon. However, neither are far enough along in the design and planning of these programs to dictate needed parameters. Both utilities are willing and hopeful to continue this planning process in conjunction with Energy Trust. Energy Trust could immediately benefit the utilities by continuing to coordinate a trade ally network specifically for battery installers (which the utilities noted was done very well and they would like to have continued).

The Future of Distributed Energy Resources

Both utilities agreed that a solar program quality management process could support new IEEE 1547 standards to enable smart inverter functionality. PGE said it would be beneficial for a third party, such as Energy Trust, to check systems once a new standard has been established.

In order to help increase the adoption of DER, PGE proposed that Energy Trust provide more trade ally training on demand response events to help them field customer questions. Trade allies are the first or main point of contact for customers, so it is imperative that they have a comprehensive understanding of how DERs and DER programs work. PGE wants to learn more about how trade allies view the Solar program and how they market it to customers. Pacific Power said that additional trade ally education is needed so they better understand the technical aspects of solar coupled with storage, the added safety risks, and the economic benefits. In the future, PGE expects to see more solar + storage customers and hopes that Energy Trust will continue to manage trade allies and set standards and requirements for DERs. Pacific Power would like to shift to broader DER incentive programs over specific technology programs in the future and to continue collaborating with Energy Trust.

Data Collection

For future data collection on projects being interconnected, PGE is transferring all project-level data to PowerClerk. PGE currently only captures interconnection date and size, while PowerClerk can capture much more project-level information. PGE has a goal to eventually move all data over to PowerClerk and have a unified application with the Energy Trust. Pacific Power also wants to use a shared data system, which would be helpful when verifying solar + storage installations. All parties agreed that a much more efficient and effective method of data sharing across organizations should occur, which would yield

large benefits for the utilities, minimize the time burden on trade allies, and, by extension, improve the customer experience.

Utility Collaboration Recommendations

- Energy Trust, PGE, and Pacific Power should continue and expand discussions on the possible future role of Energy Trust supporting smart inverter and BESS programs.
- Provide educational training and materials for trade allies and customers on battery systems, in partnership with PGE and Pacific Power.
- Begin a coordinated effort to standardize PowerClerk data field requirements and data sharing protocols between organizations to streamline the process, reduce the time burden for trade allies, and increase the accessibility and completeness of data for all parties.

Smart Inverters

Cadmus spoke to one solar inverter manufacturer about the updated IEEE 1547-2018 standards for advanced or 'smart' inverters and the support that the solar program quality management process could provide to enable 'smart' inverter functionality.

Smart Inverter Online Monitoring & Control

The responding manufacturer noted that nearly all smart inverters on the market include a free online portal to monitor the production of the PV system and inverter operation. The installer is responsible for setting up the online portal for the customer. At present, the discussion of integration of smart inverters with grid asset management systems and Distributed Energy Resource Management System (DERMS) is a utility-level conversation. Energy Trust should continue to monitor progress in this space and update smart inverter requirements accordingly.

The online portal provides several benefits to consumers. When connected to the internet, the portal allows manufacturers to complete remote diagnostic checks to identify system errors, such as out of date firmware, or incorrect system configurations that may impede inverter operation. Rather than sending a technician to the site, or sending a new inverter to the customer's home, the manufacturer can identify these issues and, in some cases, resolve them remotely.

IEEE 1547-2018 Standard

The inverter manufacturer indicated that on-site verification of compliance with the IEEE 1547-2018 standard is not always necessary. A system will not be allowed to interconnect unless the inverter follows utility service territory requirements. For all systems, smart inverter design must comply with the NEC and interconnection requirements for the utility service territory.

The manufacturer suggested taking several steps:

- For all systems, conduct a desktop review of equipment and system design to ensure that it follows the NEC and utility territory standard. Perhaps conduct on-site verification that the

correct inverter(s) was installed in a manner compliant with NEC and utility requirements. (It is important to note that Energy Trust employs both remote and on-site verifications of systems.)

- For large commercial and utility-scale systems, commission tests depending on system size and complexity. Follow up with type testing individual system components, commissioning confirmations, and trip function testing.

Solar Trade Ally Education

The inverter manufacturer identified solar trade ally education is needed on smart inverters systems, especially related to mode and control settings. The focus can be on the different inverter settings, the implications of those settings, and how those settings should prepare the inverter for different energy storage pairing configurations.

Smart Inverter Recommendations

- Require that smart inverters be connected to the internet. Energy Trust may consider additional incentives for smart inverters if the goal in Oregon is to obtain better grid services.
- Require IEEE 1547-2018 and utility requirements for all systems.
- Consider providing solar trade allies with training on smart inverter mode and control settings, especially related to different inverter settings, the implications of those settings, and how those settings should prepare the inverter for different energy storage pairing configurations.
- Energy Trust should continue communicating with utilities on development of their grid modernization status and programs, updating smart inverter requirements accordingly.

Suggested Future Updating Process

Cadmus recommends collecting solar trade ally feedback and updating the installation requirements on an annual basis. Nearly all trade allies (35 of 36) agreed to participate in an annual online survey. Furthermore, 34 of 36 respondents want to be included in this report as having given feedback, showing that the collaborative partnership is strong within the Energy Trust solar trade ally network. Industry expert interviews might be performed on a one or two-year cadence.

After surveying solar trade allies, Energy Trust may consider providing trade allies with a memo that summarizes themes and results. Providing trade allies with the outcomes of the survey reinforces the collaborative feedback loop.

During the annual review process, Energy Trust can incorporate code changes, new best practices, or other needs identified by Energy Trust staff.

Summary of Recommendations

The following are the recommendations from the body of the report.

Satisfaction Recommendations

- Consider providing an expected timeframe for responses to solar trade ally inquiries to help improve perceived verifier responsiveness.
- Consider providing solar trade allies with training on the point decrement methodology for different requirements to improve the perception of fairness.

Verification and Star Rating Recommendations

- Energy Trust should review and incorporate the remote verification feedback provided in the full survey responses.
- When corrections are required, provide a photo to expedite the conversation and rectification.
- Consider making the star-ratings internal, for Energy Trust and trade ally use only. The external customer facing network could show only the highest rated trade allies; for example, only 4s and 5s, but the actual star value will not be published. Trade allies rated at 1 to 3 stars will not be listed on the website.
- We also recommend that Energy Trust develop a formal system for installers to challenge verifier's findings, with Energy Trust staff acting as arbitrators for disagreement. The current system does not provide effective mechanisms for installers to clarify that verifiers are 100% accurate, so a new system would provide sufficient accountability to alleviate installer concerns and ensure there is consensus between all entities on the identified issues.
- Less than a third of trade allies felt the report gave clear guidance on how to improve a star rating, so consider including clear action items in the report, and consider offering periodic Question and Answer sessions.

System Design Recommendations

- Consider establishing a process for reviewing remote analysis tools as more enter the market.
- Because the solar program is likely moving to a flat incentive amount for regular residential installations, consider lowering the TSRF to 70%.
- The DC:AC ratio upper limit should remain at 135% for all solar installations, but Energy Trust should allow solar trade allies to request a higher threshold. Energy Trust can require trade allies to include in their request energy models and economic analysis to demonstrate the need to exceed 135%. Cadmus does not think Energy Trust should change the threshold for commercial or industrial projects, because 135% is still generally ideal in those contexts. As the energy storage industry continues developing, if new inverter ratio recommendations arise, Energy Trust can consider updating the thresholds as needed.
- Consider adding clarification text for Table 1 in the Installation Requirements document on temperature adders.

Installation Best Practices Recommendations

- Consider requiring that the inverter owner's manual and corresponding manufacturer warranties are included in the customer manual.
- Consider automatically providing the customer with a digital customer manual via a single emailed PDF and provide an option to receive it as a hard copy. The customer should also be instructed to keep the file saved in a secure location.
- Consider developing a resource for labeling that includes background reasoning, label placement, and label coloring.
- Given that there is currently no industry standard for micro-flashing, Energy Trust should continue not permitting micro-flashing or other flexible flashing. If testing and certification for micro-flashing becomes available, Energy Trust can revise its requirement at that time.

System Safety and Codes Recommendations

- Include mismatched connector information based on NEC 2020 690.33(C).
- Consider providing educational resources for solar trade allies related to avoiding mismatching connectors.
- Update section 2.3.10 B to align with NEC 2020 690.15(A), which further clarifies disconnection location.
- Update section 2.3.10 D to reflect rapid shutdown code requirements.
- Update the footnote referenced in section 2.6.1 to include the correct link.

Battery Storage Recommendations

- Consider developing a battery storage guide and/or webinar series to educate trade allies and other stakeholders on (1) the fundamentals of BESS, and (2) updates to the latest BESS technology.
- Clarify which requirements apply to lithium-ion battery technologies.
- Update section 2.3.4 D to remove the wording "except with program pre-approval" so the UL9540 listing is required for BESS, which aligns with the International Residential Code, International Building Code, International Fire Code, and NEC.

Utility Collaboration Recommendations

- Energy Trust, PGE, and Pacific Power should continue and expand discussions on the possible future role of Energy Trust supporting smart inverter and BESS programs.
- Provide educational training and materials for trade allies and customers on battery systems, in partnership with PGE and Pacific Power.
- Begin a coordinated effort to standardize PowerClerk data field requirements and data sharing protocols between organizations to streamline the process, reduce the time burden for trade allies, and increase the accessibility and completeness of data for all parties.

Smart Inverter Recommendations

- Require that smart inverters be connected to the internet. Energy Trust may consider additional incentives for smart inverters if the goal in Oregon is to obtain better grid services.
- Require IEEE 1547-2018 and utility requirements for all systems.
- Consider providing solar trade allies with training on smart inverter mode and control settings, especially related to different inverter settings, the implications of those settings, and how those settings should prepare the inverter for different energy storage pairing configurations.
- Energy Trust should continue communicating with utilities on development of their grid modernization status and programs, updating smart inverter requirements accordingly.

Future Updating Recommendations

- Collect solar trade ally feedback and update the installation requirements on an annual basis.
- Expert interviews should be conducted every one- to two-years, depending on the industry and state changes.
- Energy Trust should consider providing trade allies with a memo that summarizes themes and results from the annual feedback review.

Appendix A. Solar Trade Ally Survey Respondents

A list of 34 of the 36 solar trade allies who responded to the survey, and agreed to be listed, are shown below in Table 5.

Table 5. Solar Trade Ally Company Respondents

Company Name
Abundant Solar
Alternative Energy Systems, Inc.
Advanced Energy Systems
A &R Solar
Blue Raven Solar
Common Energy
Double J Electric Inc
DPI Solar
E2 Solar
Earthlight Technologies
EC Electric
Eco Solar & Electric
Elemental Energy
Enterprise Electric
Green Ridge Solar
Imagine Energy
Jam Roofing
National Solar USA
Neil Kelly
Energy Wise Lighting
Energy Wise Services
Power Northwest Inc.
Premier Solar
Pure Light Power
Solar Energy Solutions
Solar Man
Sunbridge solar
Sunlight Solar
Sunthurst Energy
Synchro Solar
Tesla
True South Solar
The Green Store LLC
Precision Heating & Indoor Air Quality, Inc.