DNV·GL

Technical Due Diligence

Connecticut Green Bank SHREC Securitization

Connecticut Green Bank

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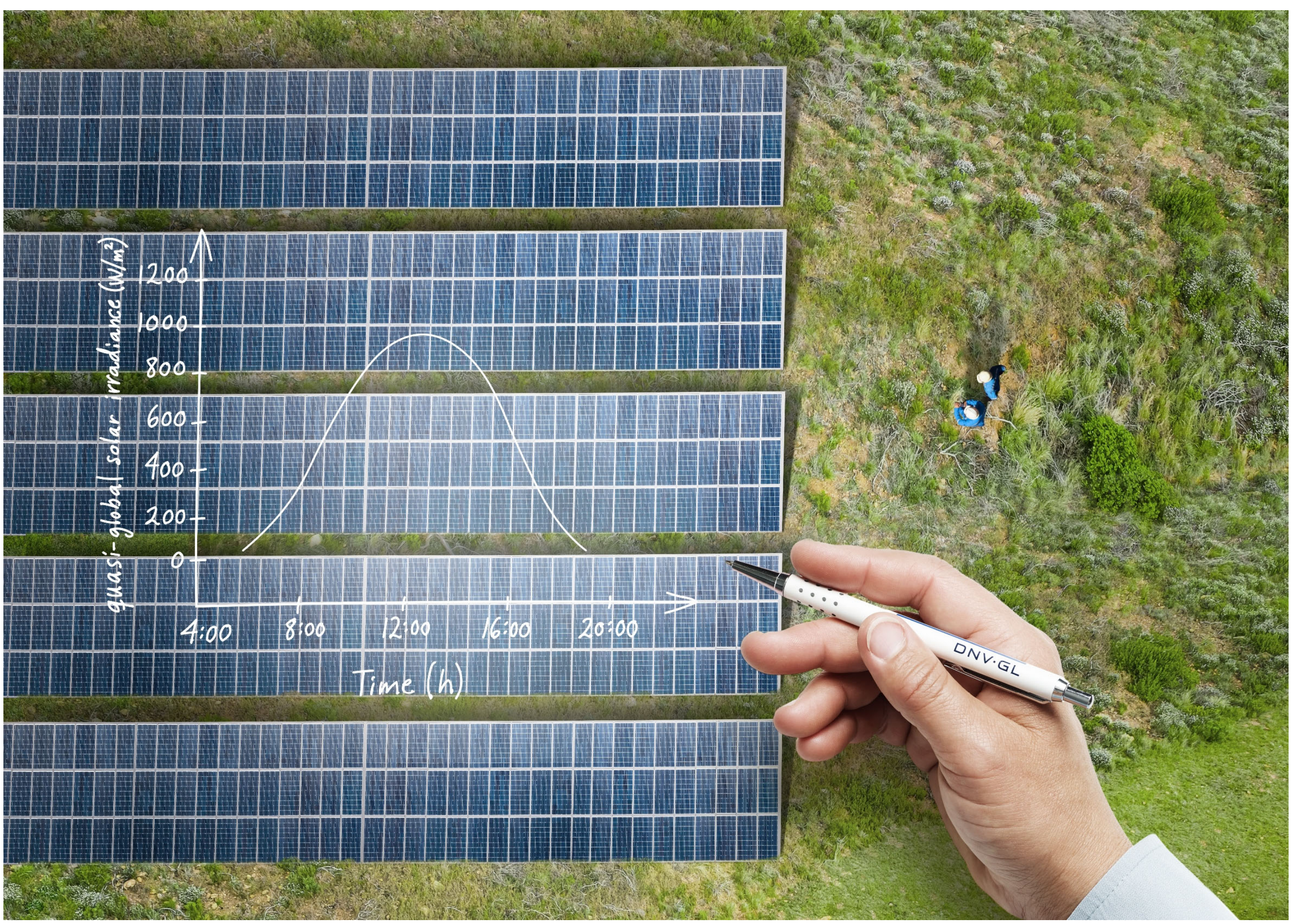

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Customer:	Connecticut Green Bank	Renewables Advisory
	300 Main Street, Stamford, CT 06901	333 SW Fifth Avenue, Suite 400
Contact person:	Mike Yu	Portland, OR 97204
Date of issue:	22 May 2020	Tel: +1 503.222.5590 x128
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Prepared by:	Verified by:	Approved by:
D. Chatterjee Engineer Solar Independent Engineering	D. Schoborg Sr. Engineer Project Development & Engineering	F. Ray Sr. Engineer Solar Independent Engineering

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Reference to part of this report which may lead to misinterpretation is not permissible.

Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	22 November 2019	Initial Release	D. Chatterjee	D. Schoborg	F. Ray
B	24 March 2020	Report updates, including site inspection updates	D. Chatterjee	D. Schoborg	F. Ray
C	29 April 2020	Client feedback and updates	D. Chatterjee	D. Schoborg	F. Ray
D	22 May 2020	Client feedback updates	D. Chatterjee	D. Schoborg	F. Ray

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List of abbreviations

Abbreviation	Meaning
AC	Alternating Current
AHJ	Authority Having Jurisdiction (local permitting authority)
ANSI	American National Standards Institute
AVL	Approved Vendor’s List
BOM	Bill of Materials
BPE	Buyer’s Percentage Entitlement
CEC	California Energy Commission
COD	Commercial Operation Date
CPR	Clean Power Research
DC	Direct Current
EL	Electroluminescence
EPBB	Expected performance based buy-down incentives
EPC	Engineering, Procurement, and Construction
FIT	Feed-in-Tariff
GHI	Global Horizontal Irradiation
GOES	Geostationary Operational Environmental Satellite
HALT	Highly Accelerated Life Testing
IAV	Interannual Variability
IBC	Interdigitated Back-Contact
IBTS	Institute for Building Technology and Safety
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IG	Integrated Ground
IRC	International Residential Code
kW_{PTC}	PVUSA Test Conditions defined as 1000 W/m2 POA irradiance, 20 deg C ambient temp, and 1 m/s wind speed.
MPA	Master Purchase Agreement
MPPT	Maximum Power Point Tracking
MSA	Maintenance Services Agreement
NABCEP	North American Board of Certified Practitioners

Abbreviation	Meaning
NEC	National Electrical Code
NOAA	National Oceanic and Atmospheric Association
NREL	National Renewable Energy Laboratory
NSRDB	National Solar Radiation Data Base
O&M	Operations and Maintenance
OCPD	Overcurrent Protection Devices
PBI	Performance based incentives
PERC	Passive emitter rear contact
PI	Performance Index
PID	Potential-induced degradation
PPA	Power Purchase Agreement
PTO	Permission to Operate
PV	Photovoltaic
QA/QC	Quality Assurance / Quality Control
REC	Renewable Energy Credit
RFQ	Request for qualifications
RMA	Returned Merchandise Authorizations
RSIP	Residential Solar Investment Program
SHREC	Solar Home Renewable Energy Credit
SOP	Standard Operating Procedure
STC	Standard Test Conditions
TMY3	Typical Meteorological Year 3
UI	The United Illuminating Company
UL	Underwriters Laboratory
PBI	Performance Based Incentive
EDC	Electric Distribution Companies

EXECUTIVE SUMMARY

Introduction

At the request of Connecticut Green Bank ("the Green Bank" or "Sponsor") DNV GL has performed a technical due diligence review of the residential photovoltaic (PV) systems in the Sponsor's Solar Home Renewable Energy Credit (SHREC) portfolio, Tranche 3 (the "Portfolio"), representing 4,811 residential-scale solar PV systems.

The purpose of this Report is to summarize Portfolio performance, create a production forecast, and perform an equipment review. Specifically, DNV GL's scope of work includes review of the following:

- Engineering process review
- Major equipment review
- SHREC production forecasting procedures
- Production analysis of operational PV systems
- Major agreements
- Operating system review
- Financial model technical input review.

Engineering process review

DNV GL has reviewed the Request for Qualifications and Program Guidelines for Eligible Contractors and Third-party PV System Owners to participate in the Residential Solar Investment Program (RSIP) document provided by the Sponsor, dated 1 November 2016.

The RSIP document provides the requirements necessary for a PV system to be eligible for CT Green Bank incentives, including requirements for contractors and PV system owners to qualify as approved RSIP-eligible PV system installers.

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
2.1	**Summary:** The Sponsor has issued a request for qualifications (RFQ), which explains the process and requirements PV system installers must follow to qualify as an eligible Installer and later receive incentives through the RSIP. The program requires that PV system installers pass incentives onto the homeowners as a cost reduction during contracting (i.e. system purchase, lease, or power purchase agreement). The PV system installers do not receive the incentives until they have passed the Sponsor's completion requirements, which includes review of a self-inspection report following installation and a potential audit of the installed PV system.

Section	Primary Findings
2.1.1	**PV system eligibility requirements:** Notably, the RSIP document requires the PV system to be in The United Illuminating Company (UI) or Eversource Energy service territories, to be grid-tied, and PV equipment must be new and listed by the California Energy Commission (CEC).
2.1.2	**Installers eligibility requirements:** Installers must first complete an application process to become eligible to participate in the RSIP. The application process requires the installer to demonstrate experience and licensing/certification, as well as provide subcontractor and homeowner contracts and terms, including a five-year workmanship warranty on all components. The Sponsor will review the installer annually or as-needed to ensure compliance with RSIP standards.
2.1.3	**Installer responsibilities**: Once approved, Installers have responsibilities such as completing accurate pre-construction assessment and calculations, completing RSIP applications, receiving approvals for the PV system from authorities, complying with inspection reports and completion documents, and passing required inspections.
2.1.3.1	**Installer completion documents:** Upon completing the PV system installation, Installers are required to submit a project completion certificate, utility approval-to-energize documentation, self-inspection report (including all required photos), energy efficiency audit documents, and performance data provider information (e.g. approved revenue-grade meter ID).
2.1.4	**Sponsor rights:** Under the RSIP rules, the Sponsor is the owner and receives all renewable energy credits (REC)s. The Sponsor reviews completion documents, specifically the self-inspection report submission and will follow-up with the Installer as needed. The Sponsor has the right to perform an audit of the system to confirm completion documentation submitted is accurate. The Sponsor reserves the right to withhold or adjust incentives based on inspection reports or other information.

Major equipment review

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
3.1	**PV Modules:** The module manufacturers in the Portfolio, except for Silfab, are large established manufacturers with some extended-duration test data. These manufacturers are considered to be capable of manufacturing modules without atypical reliability or quality risk as compared to the broader industry. Silfab, with 13% of the modules in the Portfolio, is a smaller and less experienced manufacturer which might present an atypical risk relative to more established suppliers available in the market.
3.2	**PV Inverters**: Over 99% of the Portfolio is represented by SolarEdge, ABB/Power-One, Enphase, SMA, SunPower, and Delta Electronics inverters. Based on past detailed technology reviews of SolarEdge, ABB/Power-One, Enphase, SMA, and SunPower inverters, DNV GL considers these manufacturers to be acceptable suppliers of inverters to the Portfolio. DNV GL has not performed a detailed technology review of Delta Electronics inverters; however, DNV GL considers Delta Electronics to be an acceptable supplier based on DNV GL's limited experiences with the manufacturer and Delta Electronics' reputation in the industry.

Section	Primary Findings
3.3	**Racking:** DNV GL has not reviewed racking used by individual installers in this Portfolio. DNV GL considers residential roof racking commonly installed to be a low risk item.
3.4	**Meter:** The eligible Sponsor approved revenue grade meters include Locus L Gate 101 and 120, Solar Data Systems – Solar-Log 350, 360, 370 and GE I-210+, Enphase Energy – Envoy-S Metered and IQ Envoy, SolarEdge – RWND-3D-240-MB with 100A CT Cellular meter. All the meters provide adequate accuracy. Meter reliability was not evaluated, though the technology used in the meters should provide adequate reliability.

SHREC production forecasting procedure review

DNV GL has reviewed the procedures by which the Sponsor generates energy production forecasts for residential systems with the purpose of evaluating the long-term accuracy of these forecasts and their usefulness for predicting the Portfolio's SHRECs from energy production.

Section	Primary Findings
4.2	**Energy simulation:** Since 2006, PowerClerk has acted as the proposal and system reporting portal for all Sponsor systems, as well as supporting the Sponsor's incentive program. The Sponsor's process requires system information be initial entered in PowerClerk; however, for SHREC forecasting purposes, the Sponsor relies on a parallel calculation in Clean Power Research's (CPR) SolarAnywhere Fleetview.
4.3.1	**Meteorological data:** The Sponsor uses CPR SolarAnywhere data at the site location as the irradiation data input to the energy estimate simulation. The data satellite imagery collected from geosynchronous satellite networks and is applied to 10 x 10 km mesh grids. The data spans 1998 – 2017.
4.3.3	**Loss factors:** The Sponsor applies a 10% loss factor in SolarAnywhere Fleetview to account for all component loss factors except for shading and inverter efficiency. DNV GL finds the 10% loss factor reasonable for this specific Portfolio of systems based on regional weather.
4.3.5	Validating Sponsor energy estimates: DNV GL performed validations of the 20 systems reviewed, DNV GL independently validated 20 of the 20 systems to within ±1%.

Production analysis

DNV GL has analysed a production dataset from the Sponsor's Portfolio (the "Portfolio Data" or the "Portfolio") of deployed systems to confirm the accuracy of the Sponsor's energy production estimates and to set expectations for future production of these systems.

DNV GL has also estimated and presented the uncertainty in its production forecast.

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
5.1	**Production data set:** The Sponsor provided production data and system details for 4,811 systems comprising Tranche 3. DNV GL has used the production history of the Portfolio to forecast future production of the Portfolio.
5.3	**Production Sample results:** The Production Sample systems have overperformed their estimates by 4.0% on average. DNV GL compared the performance of the Production Sample by Installer, PTO date, module manufacturer, and inverter manufacturer.
5.5	**Portfolio forecasting and uncertainty:** DNV GL has calculated a Year 1 portfolio-level P50 correction factor of 102.3% of the Sponsor's first-year energy estimate. DNV GL has calculated a Year 1 P90 correction factor of 95.2% of the Sponsor's first-year P50 energy estimate.

Major agreement review

SHRECs sales to The Connecticut Light and Power Company (dba "Eversource Energy") and UI are provided for using a Master Purchase Agreement (MPA). DNV GL has reviewed the following executed agreements (collectively, "MPAs"), all dated 7 February 2017 with Eversource Energy and UI.

The MPAs provide for the Sponsor to sell SHRECs at firm pricing ($50 per MWh for tranche one, $49/MWh for tranche two, and $48/MWh for tranche three) for 15 years. The Buyer, either Eversource Energy or UI, is obligated to purchase those SHRECs in a tranche associated with the energy generated by the projects assuming the pre-requisites have been met and continue to be met through the term. The main difference between the MPAs provided is the Buyer's Percentage Entitlement ("BPE"); Eversource Energy having a BPE of 80% and UI having a BPE of 20%. DNV GL has not identified other meaningful differences between the individual MPAs.

While the buyer is obligated to purchase all SHRECs from a qualifying tranche, there is not a SHREC guaranty or other performance-based terms that require a minimum amount of electricity be produced from a tranche.

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
6.1.1	**Parties and contract status:** Buyer of SHRECs: Eversource Energy (80%) UI (20%) Contract status: Executed 7 February 2017
6.1.2	**Term:** The tranche delivery term starts on 1 January of a tranche year and continues for 15 years. The Buyer's obligation to purchase tranche SHRECs will end no later than the earlier of when Sponsor achieves deployment of 305.4 MWdc of qualifying residential solar PV installations or 31 December 2022, meaning the final tranche start date would begin 1 January 2022.
6.1.3	**Sale of SHRECs:** The purchase price of each SHREC is $50.00 in the MPAs for Tranche 1, $49/MWh for Tranche 2, and $48/MWh for Tranche 3. The Sponsor establishes the price of each tranche in accordance with Connecticut General Statutes. A SHREC is equal to one megawatt hour (MWh) of electricity generated from a qualifying residential solar PV system. The Buyer is obligated to purchase all SHRECs generated by SHREC projects in a tranche. SHRECs are invoiced quarterly.
6.1.4	**Obligations of Sponsor**: The Sponsor is responsible for ensuring energy generation has begun prior to tranche delivery start date, providing the tranche purchase price and project details, ensuring the SHREC projects qualify as residential solar PV system, executed the tranche confirmation (Exhibit B), and completing delivery of SHRECs to Buyer.
6.1.5	**Obligations of Buyer:** The Buyer is responsible for ensuring it has received regulatory and corporate approval and has received tranche detail and executed the confirmation.
6.1.6	**Energy generation and metering:** SHREC projects must be located behind a qualifying utility revenue meter and must have a separate meter dedicated to measurement of SHREC project's energy output. The meter shall be installed, operated, maintained, and tested to meet applicable requirements and standards of the utility and electric system operator.

Operating system review

DNV GL has completed an electrical design audit for a sample of 20 systems within the Sponsor's Portfolio for the purpose of both confirming consistency with the Sponsor's agreed processes and for identifying any specific issues or risks. In addition, 10 sample systems were selected for an on-site inspection.

A summary of the primary findings identified is provided in the following table.

Section	Primary findings
7.1.1	**Electrical audit:** DNV GL considers the sampled systems to exhibit standard electrical design quality, which is consistent with typical practices in the residential market. DNV GL does not expect that the PV systems in the Portfolio are at above-normal risk of electrical issues.

Section	Primary findings
7.1.2	**Structural audit:** The Sponsor does not require installers to submit structural design drawings as part of project completion. As such, DNV GL was not able to select a sample of structural designs for audit. Site visit inspection results will be later summarized in Section 7.2 in lieu of a structural design audit sample review.
7.2	**Site inspection review summary:** Ten PV systems in Tranche 3 were inspected in February 2020. The systems which were visited represented the top installers in the Portfolio by project volume, and the average Performance Index (PI) for the installers ranged between 0.98 and 1.07. Structural: For the structural issues noted, most of the items observed do not represent a high criticality. The most prevalent issue found in the inspection reports relates to flashing, which represents a low criticality which may lead to long term roof damage if the flashing issues are not resolved and roof leaks develop, leading to increased O&M costs due to roof leak warranty claims. The Sponsor has indicated that they will add the following line on the inspection checklist in the future to remind installers to confirm adequate flashing: "Any roof penetrations are properly flashed and sealed". The two systems where improper clearance for fire access was noted represent a high criticality in the case of a fire, as the clearances are intended to provide access paths for firefighting operations. It is possible that the IFC requirements for these clearances had not yet been adopted in Connecticut at the time of installation. The Sponsor confirmed that the two projects in question were permitted before the new fire code came into play in CT which was Oct.1, 2018. Electrical: DNV GL notes that the issues identified do not impact the immediate performance of the system. However, DNV GL's opinion is that there is low to moderate risk that the issues noted could result in reliability concerns, future downtime, increased O&M costs, reduced project life and safety events. Common issues are typically limited to inadequate wire-management and incorrect labeling. Tracking inspection results could identify reoccurring issues and quality checks to mitigate these issues. Wire management and labeling are on the Sponsor's inspection checklist, though the Sponsor has indicated that it will increase correspondence with installers to reduce these occurrences.

Financial model technical input review

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
8.1	**Revenue:** DNV GL has calculated a Year 1 portfolio-level P50 correction factor of 102.3% of the Sponsor's first-year energy estimate. The Portfolio is forecast to degrade at -0.68% per year at a P50 confidence level. DNV GL expects well-designed, properly installed, and well-maintained PV systems to perform in line with expectations for 25–30 years.
8.2	**O&M:** DNV GL understands that the Sponsor does not have direct responsibility for O&M costs for the Portfolio, as the Sponsor's role is as an asset program administrator. As such, DNV GL has not reviewed either projected Performance Guarantee payout liabilities or inverter replacement cost projections.
8.3	**Stress cases:** DNV GL has provided production stress cases as well as consideration for installer bankruptcy / market exit. The Sponsor has contracted with Locus Energy, an AlsoEnergy Company for Portfolio monitoring, and the Sponsor has contracted with SunSystem Technology as a third-party US residential O&M provider. DNV GL views this as an appropriate risk mitigation step.

1. INTRODUCTION

At the request of Connecticut Green Bank ("the Green Bank" or "Sponsor") DNV GL has performed a technical due diligence review of the residential photovoltaic (PV) systems in the Sponsor's Solar Home Renewable Energy Credit (SHREC) portfolio, Tranche 3 (the "Portfolio"), representing 4,811 residential-scale solar PV systems.

1.1 Objective and scope of review

The scope of work for the review was defined in the agreement resulting from the DNV GL Work Order [1] (the "Agreement"). This Report is provided per the terms and conditions of the Agreement, and disclosure of the Report to other potential investors and/or lenders is subject to provisions of the referenced terms and conditions and the disclaimer at the front of this Report.

The purpose of this Report is to summarize Portfolio performance, create a production forecast, and perform an equipment review. Specifically, DNV GL's scope of work includes review of the following:

- Engineering process review
- Major equipment review
- SHREC production forecasting procedures
- Production analysis of operational PV systems
- Major agreements
- Operating system review
- Financial model technical input review.

Items requiring further clarification or action and identified risks are noted in ***bold italics*** within this Report.

1.2 Assumptions

Some of the information relied upon for this Report is not within the control of DNV GL. DNV GL assumes that the information provided by others is true and correct and reasonable for the purposes of this Report. DNV GL has not been requested to make an independent analysis or verification of the validity of such information. DNV GL does not guarantee the accuracy of the data, information or opinions provided by others.

In preparing this Report and the opinions presented herein, DNV GL has made certain assumptions with respect to conditions that may exist, or events that may occur in the future. DNV GL believes that these assumptions are reasonable for purposes of this Report but actual events or conditions may cause results to differ materially from forward-looking statements.

1.3 Connecticut Green Bank overview

Per the Connecticut Green Bank, "[T]he Green Bank was established by Governor Malloy and Connecticut's General Assembly on July 1, 2011 through Public Act 11-80 as a quasi-public agency that supersedes the former Connecticut Clean Energy Fund. As the nation's first state green bank, the Green Bank leverages public and private funds to drive investment and scale-up clean energy deployment in Connecticut.

The Green Bank's vision is to lead the green bank movement by accelerating private investment in clean energy deployment for Connecticut in order to achieve economic prosperity, create jobs, promote energy security, and address climate change in a world empowered by the renewable energy community. The Green Bank's mission is to support the Governor's and Legislature's energy strategy to achieve cleaner, cheaper, and more reliable sources of energy while creating jobs and supporting local economic development. The Green Bank's mission is to confront climate change and provide all of society a healthier and more prosperous future by increasing and accelerating the flow of private capital into markets that energize the green economy." [2]

1.4 Description of the Portfolio

The Portfolio is composed of 4,811 residential PV systems located in Connecticut as illustrated below in Table 1-1. The total capacity of the Portfolio is approximately 34 MWac[1]. The top 10 installers by system count represent 90.1% of the installed capacity in the Portfolio [3]. The Sponsor has indicated the Tranche 3 portfolio is 74% third-party owned and 26% homeowner owned.

The Green Bank manages the state incentive plan which enables the generation of SHRECs. SHREC production is directly correlated (on a 1:1 basis) with MWh produced by PV systems in the Portfolio. Further details on the SHREC production process are described in Section 2.

Table 1-1 Installed PV capacity of Portfolio, by installer

Installer	Total MWac	Total systems	% MWac per installer
Trinity Solar	13.3	2047	39%
Vivint Solar	4.0	573	12%
PosiGen	2.9	523	9%
Sunrun	2.7	348	8%
SunPower Capital	2.0	245	6%
Ross Solar	1.5	148	4%
C-TEC Solar	1.4	169	4%
Earthlight Technologies	1.3	155	4%
SolarCity	0.8	113	2%
Sunlight Solar Energy	0.7	84	2%
Remaining installers	3.4	406	10%
Total	**34**	**4,811**	**100%**

[1] Based upon the Project Size as listed in EDC approval to Energize.

2. ENGINEERING PROCESS REVIEW

DNV GL has reviewed the Request for Qualifications and Program Guidelines for Eligible Contractors and Third-party PV System Owners to participate in the Residential Solar Investment Program (RSIP) document provided by the Sponsor [4], dated 1 November 2016.

The RSIP document provides the requirements necessary for a PV system to be eligible for CT Green Bank incentives, including requirements for contractors and PV system owners to qualify as approved RSIP-eligible PV system installers. While the document provides information on expected performance-based buy-down incentives (EPBB) and performance-based incentives (PBI), DNV GL review of the RSIP document has focused on PV system installer requirements in ensuring quality PV systems installations.

The RSIP document describes the application and obligations that either contractors or PV system owners, collectively ("Installers"), must meet and maintain to be eligible to receive incentives from the RSIP. The Installers receive EPBB upon successful completion of a PV system purchased by the homeowner or become eligible for PBI payments upon successful completion of a PV system with a lease contract or power purchase agreement (PPA).

2.1 Residential Solar Investment Program

2.1.1 PV system eligibility

Below is a list of PV system requirements to receive incentives under the RSIP:

- The PV system must be installed on a one to four family primary residence so long as the homeowner owns the land on which the home is affixed to a foundation (i.e. mobile homes and some manufactured homes are ineligible)
- The home must be in UI or Eversource Energy service territory (not Connecticut Municipal Electrical Energy Cooperative)
- The home must have an energy efficiency audit completed unless the home is new construction or under rehabilitation, has been ENERGY STAR certified since 2005, or the home has a Home Energy Rating of 85 or lower
- PV equipment must be new and listed by the CEC
- PV system is grid tied
- The equipment and installation must comply with all federal, state, and local laws, codes, and regulations, including Connecticut Building Code and the National Electric Code (NEC).

It should also be noted that for EPBB eligible PV systems, there is a 20 kW_{PTC} limit, limited by homeowner electricity usage, and the system must have a design factor[2] of 75% or greater to receive the full incentive. For PBI systems the design factor must be 60% or greater to receive incentives.

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[2] Defined as the ratio of the summer output of the proposed system to the summer output of a reference optimal system

2.1.2 Installer eligibility requirements

Approved Installers must be used for all RSIP PV systems. The Sponsor approves each Installer through a request for qualifications (RFQ) process. The Installer submits to the Sponsor an application with supporting documentation, including but not limited to[3]:

- Resumes of key staff
- Connecticut E-1, PV-1 or Home Improvement Contractor (HIC) licenses
- North American Board of Certified Energy Practitioners (NABCEP) certification from at least one person
- Subcontractor agreements
- Sales contract and terms
- Bank reference letter
- General liability insurance
- PPA contract and terms (if applicable) including details of any performance guarantee
- References

Workmanship warranty of 5 years (or more) to cover all components against degradation of more than 10% from the original rated electrical output, and full costs of labor for repair or replacement of any defective PV system components. The Sponsor will evaluate the application and documentation for completeness and, if deemed to have met the requirements, will invite the Installer to attend a one-hour training session with a RSIP representative. Upon completion of the training session, the Installer will be added to the "Eligible Contractor" list with either full status or provisional status depending on experience and number of PV installations or equivalent training. Provisional status will be lifted after enough PV installations have been completed and passing Sponsor required PV system inspections.

The Sponsor will review annually or as needed to ensure continued compliance with the RSIP document standards. An Installer may be placed on probation, suspension, or terminated for program violations such as:

- Poor quality or service or false or inaccurate claims, billing, system capabilities or benefits
- Failure to ensure all applicable employees and subcontractors are licensed
- Failure to comply with state and local laws and ordinances
- Improper incentive activity
- Consistent inspection failures
- Failure to respond to requests for information
- Falsifying documents
- Illegal actions

[3] Third Party System Owner requirements were:
- Resumes of key staff
- Bank reference letter
- Agreements with installers
- Lease or PPA contract and terms

2.1.3 Installer responsibilities

To maintain their approval, Installers have primary responsibilities that must be meet. Key responsibilities are summarized below:

- Conduct accurate site evaluations, including shading assessments
- Follow RSIP rules to determine eligibility, size, cost and estimated incentive
- Complete accurate RSIP applications on behalf of the homeowner
- Comply with requirements for inspection reports and completion documents
- Obtain appropriate permits and approvals
- Maintain all required insurance, licenses, and certifications
- Comply with all national, state, and local codes and standards, rules, and regulations
- Coordinate installation of the PV system through direct employees or subcontractors – note Installers are held directly accountable for work performed by all their staff as well as subcontractors
- Complete interconnection process and receive approval to energize
- Collaborate with the Sponsor's third-party inspectors
- Pass required inspections
- Honor five-year workmanship warranty

RSIP applications are not approved until all required documents have been submitted to the Sponsor's satisfaction. In the event of project cancellation, or if cost, component, or system design specifications have changed from the original approved application, a change order or cancellation request shall be sent to the Sponsor within five business days.

2.1.3.1 Installer completion documents

To receive the Expected Performance Based buy-down incentives (EPBB) or Performance Based Incentive (PBI), the Installer must pass inspections and completion documentation must be submitted:

- Project completion certificate
- Utility approval-to-energize documentation
- Self-inspection report (including all required photos)
- Documentation of energy efficiency audit, if not already provided
- Performance data provider information (e.g., approved revenue-grade meter ID)

Representative self-inspection reports have been shared and DNV GL's review is part of Section 7 Operating System Review. The self-inspection reports include pass/fail criteria for the installed system covering:

- Verifying system orientation (tilt and azimuth) and shading
- Verify module and inverter model installed
- Verify system capacity
- PV array, conduits, and cables secured with no visible damage
- Fuses and circuit breakers (dc and ac)
- Disconnects (dc and ac)
- Inverter and interconnection
- Installation consistent with manufacturer specifications
- As-built diagrams and owner's manuals have been supplied
- Monitoring and metering equipment installed correctly

- Methodology for calculating values for labels

DNV GL recommends including more details regarding inspection of the mounting structure in the self-inspection template, for example an inspection of the existing roof framing, verification of positive attachment of lag screws to rafters, inspection of flashing, and verification that the racking, standoffs, and module clips are installed according to the plans and manufacturer's requirements. DNV GL finds the self-inspection report template is lacking in mounting system structural checks, only including one check to ensure the PV modules are secured to the mounting system.

2.1.4 Sponsor rights

RSIP customers and third-party owners (under leases and PPAs) forfeit any ownership of renewable energy credits (RECs) generated by their solar PV systems to the Sponsor. The Sponsor reviews completion documents, specifically the self-inspection report submission and will follow-up with the Installer as needed. The Sponsor may audit the system to confirm documentation. Upon the second instance of a re-inspection at one or more sites, the Installer will be required to pay the cost of the follow-up inspection.

The Sponsor reserves the right to adjust incentive calculations based on inspection reports or other submitted documentation. If the PV system is not installed properly or in accordance with the proposed system specifications, the Sponsor may withhold or recalculate incentives based on actual installed equipment and actual site conditions.

2.2 Monitoring and maintenance activities

The Sponsor has informed DNV GL that it utilizes the production monitoring platform and services of Locus Energy, an AlsoEnergy Company, to monitor Portfolio performance.

As indicated by the Sponsor, the Sponsor utilizes SunSystem Technology (SST) to provide O&M services for systems owned by the Sponsor (none in Tranche 3 but present in the overall program) and is planning to use SST to provide O&M services for other projects where needed. The remaining systems rely on the installer partner and/or third party owners to provide O&M services resulting from warranty claims or other needed system fixes.

2.3 Portfolio installers

Under the RSIP, installation contractors both originate and install systems. Table 2-1 summarizes the installation contractors engaged on system origination within the Portfolio and their respective contribution on a capacity basis. Overall, 46 installation contractors are represented in the Portfolio. The Tranche 3 portfolio is 74% third-party owned and 26% homeowner owned.

Table 2-1 Portfolio composition by installation contractor

Install Partner	System Count	% of Total
Trinity Solar	2,047	43%
Vivint Solar	573	12%
PosiGen	523	11%
Sunrun	348	7%
SunPower Capital	245	5%
Ross Solar	148	3%
C-TEC Solar	169	4%
Earthlight Technologies	155	3%
SolarCity	113	2%
Sunlight Solar Energy	84	2%
Others (36)	406	8%
Total	**4,811**	**100.0%**

Trinity Solar has originated 43% of the Portfolio on a system basis. Vivint Solar, PosiGen, Sunrun, and SunPower Capital have contributed 12%, 11%, 7%, and 5%, respectively. Another 41 contractors have also contributed to the Portfolio.

Brief reviews of Trinity Solar, Vivint Solar, Sunrun Inc, PosiGen, and SunPower Capital are included here.

2.3.1 Trinity Solar

Trinity Solar, based in New Jersey, began installing solar systems in 2004, and the organization now employs over 1,000 personnel serving over 20,000 systems and installing over 218 MW of solar, primarily on the East Coast [5]. Trinity Solar's service areas include New Jersey, New York, Connecticut, Massachusetts, Maryland, and Rhode Island. Though DNV GL's direct experience with Trinity Solar is limited, DNV GL acknowledges the company's strong standing as a national installer and considers them a suitable provider to the Portfolio.

2.3.2 Vivint Solar

Vivint Solar, based in Lehi, UT, began installing solar systems in 2011 and currently employees about 4,000 people operating in 22 states, primarily in the northeastern and southwestern U.S. [6]. As of 31 December 2019, Vivint Solar had installed 1,294 MW of solar PV systems for with 188,291 cumulative installations [7]. Vivint Solar generates sales primarily through direct-to-home model offering homeowners power purchase agreements, leases, or ownership. Vivint Solar offers its customers a 10-year material defect warranty for 10 years. [7].

Though DNV GL's direct experience with Vivint Solar is limited, DNV GL acknowledges the company's strong standing as a national installer and considers them a suitable provider to the Portfolio.

2.3.3 PosiGen

Headquartered in New Orleans, LA, PosiGen was founded in 2011. Now they have offices in New Orleans. Connecticut, and New Jersey [8]. To date, the company has over 14,000 customers in Louisiana, Connecticut, New York, New Jersey and Florida. PosiGen is a residential solar, energy efficiency and energy education provider for low-to-moderate income families. The Sponsor has disclosed to DNV GL that, pursuant to a request for proposal and subsequent strategic partnership agreements dating to 2015, the Green Bank, as of May 2020, has extended credit facilities to PosiGen totaling $19 million [9].

PosiGen has over 220 direct employees and supports more than 120 employees through its contractors in Louisiana, Connecticut, New Jersey, New York, and Florida [10]. DNV GL views PosiGen as a suitable provider to the Portfolio.

2.3.4 Sunrun Inc.

Sunrun Inc., based in San Francisco, CA, began installing solar systems in 2007, and as of 31 December 2017, operated the second largest fleet of residential solar energy systems, with approximately 180,000 customers in 22 states [11]. In February 2014, Sunrun acquired the residential division of REC Solar, including AEE Solar and mounting company SnapNrack, while the commercial and utility divisions remained under REC Solar.

In 2019, Sunrun had total deployments of 413 MW an increase of 11% year-over-year [12]. DNV GL views Sunrun as a top solar installer indicating good quality and strong installation practice. In light of these considerations, DNV GL views Sunrun, Inc. favorably and as a suitable provider to the Portfolio.

2.3.5 SunPower Capital

SunPower Capital's global headquarters is based in San Jose, CA since 1985. SunPower has a global portfolio in residential, commercial and utility solar energy markets. SunPower is a PV module manufacturer as well [13].

SunPower has a team of about 6,600 employees in Africa, Asia, Australia, Europe, North and South America. SunPower is publicly listed in NASDAQ: SPWR. The company has two separate business units: SunPower Technologies (SPT) for manufacturing and global DG sales, and SunPower Energy Services (SPES) for North America residential and commercial. The company's recent P-series module was a Top Performer in the DNV GL 2017 Module Reliability Scorecard. SunPower is a leading North American residential solar panel supplier, seeing 15% growth and 278 MW's installed in 2018 [14].

2.3.6 Installation performance

2.3.6.1 Inspection scoring

The Sponsor does not maintain a database of pass/fail inspection results with inspection criteria fields for all RSIP projects but does retain all inspection reports in the PowerClerk system. The program's self-inspection process, required for all systems, is to provide a completed checklist and a list of required photographs of the system and key components to ensure installation quality and safety. The purpose of the checklist is to provide contractors with quality control guidance and documentation to the Green Bank that systems meet program criteria. The Sponsor notes that it has yet to have an installer fail a “self-inspection” report [9].

Similarly, the Sponsor provided some anecdotal details of installer performance and disciplinary actions:

- If installer fails more than twice on same project (i.e., two times out for inspector to same site), then installer would need to pay equivalent for 3rd inspection.
  - The Sponsor can only recall this happening once with installer, Today Electronics, which only installed one project, and is no longer an eligible contractor. The Sponsor took the cost of inspection from final rebate payment.
- Installers that have been removed from the program, all related to contracting issues: BeFree, Catchin Rays, and Sunergy. Additionally, 1st Light Energy was suspended from the program due to alleged violations related to improper incentive activity. [15].
- The installer Skyline was previously suspended from the program but this suspension has been lifted at the recommendation of the Connecticut Department of Consumer Protection, having reached a settlement on customer issues. [15].
- Installers with no prior experience installing PV systems will become eligible contractors once three PV installations pass Sponsor inspections. There have been several installers with ongoing QA/QC concerns that needed to be inspected well beyond the requisite three inspections.
- Inspectors: The Sponsor has always and continues to encourage inspectors to work with installers on issue(s) found in the field; the goal is for the homeowner to ultimately be satisfied. The Sponsor has worked with installers to adjust practices and help them better understand electrical aspects to ensure system longevity.

3. MAJOR EQUIPMENT REVIEW

This section includes a review of the major equipment manufacturers used in the Tranche 3 Portfolio.

3.1 Modules

Based upon review of the Tranche 3 Composition [3] data provided by CT Green Bank, the following manufacturers represent over 95% of the PV modules deployed in the Portfolio: Hanwha Q-cells, Silfab, LG Electronics Solar Cell division, Jinko Solar, SunPower, Trina Solar, REC Solar, and SolarCity/Panasonic. As noted in Section 5.1, the dataset consists of 4,811 systems with Approval to Energize dates between 3 February 2015 and 17 January 2019. As such DNV GL's has focused the manufacturer level review on 2015 – 2018 manufacturer capabilities and quality.

Table 3-1 Portfolio composition by module manufacturer

Module manufacturer	System count	% of total
Hanwha Q-Cells	1762	37%
Silfab	624	13%
LG Electronics Solar Cell Division	561	12%
Jinko Solar	545	11%
SunPower	497	10%
Trina Solar	348	7%
REC Solar	170	4%
SolarCity/Panasonic	47	1%
Remaining (17)	257	5%
Total	**4,811**	**100.0%**

DNV GL's review was conducted primarily at the manufacturer level, rather than the product level. These manufacturer-level reviews are based on publicly available documents to assess the capability of the manufacturer to supply modules that do not pose atypical risks. DNV GL notes that these reviews do not include an evaluation of the performance or reliability of any specific products or technologies.

Product level reviews were not performed within this scope due to lack of available data for the Portfolio. Specifically, warranties and extended reliability test data were not reviewed for systems in the Portfolio. Manufacturer-level results from the DNV GL PV Module Reliability Scorecard [16] are referenced, where pertinent.

3.1.1 Hanwha Q-Cells

Hanwha Q CELLS is a global PV manufacturer and part of the South Korean Hanwha Group. Hanwha Group is a diversified company with several major divisions: Aerospace & Mechatronics, Chemicals & Materials, Construction, Financial Services, Leisure & Lifestyle, and Solar Energy. The Solar Energy division is Hanwha Q CELLS. Hanwha Q CELLS is the result of first the acquisition of Q CELLS in 2012, and then the merger of Hanwha Q CELLS and Hanwha SolarOne (formerly Solarfun) in 2015. The combined company is listed on NASDAQ under the trading symbol of HQCL. It is headquartered in Seoul, South Korea, (Global Executive Headquarters) and Thalheim, Germany (Technology & Innovation Headquarters). The company is one of the world's leading PV cell producers and was the 6th largest module supplier in 2019.

Q CELLS was founded in Berlin, Germany in 1999 and entered the PV market in 2000 as a supplier of crystalline silicon PV cells. Module production began in 2010. Hanwha acquired Q-Cells in 2012, rebranding the company Hanwha Q-Cells. The company currently has manufacturing sites in Korea, China, and Malaysia.

Hanwha SolarOne, formerly known as Solarfun Power Holdings, was founded in 2004 and commenced production in 2005. Solarfun joined the Hanwha group in 2010.

Hanwha Q-Cells modules have received the VDE Quality Tested certificate. The program requires mandatory quarterly testing of Q-Cells production modules as well as mandatory quality controls in production, such as 100% EL imaging, and wet leakage current testing for 1% of all modules produced. The quarterly testing program requires 400 thermal cycles, 2 x the IEC 61215 standard, and 1,500 hours' damp heat, which is 1.5 times the IEC 61215 standard. Also of note is that the testing includes a dynamic mechanical load test, which is not required for IEC 61215 testing but does test the physical construction of the module for field use. DNV GL views this certificate favorably. The test programs are stringent, and mandatory testing on a quarterly basis provides confidence in the consistency of the manufacturing.

Hanwha Q-Cells offers modules containing mono or multicrystalline cells, PERC cell, or half-cell technology.

Hanwha Q-Cells' website indicates that the Hanwha Q-Cells factories have the ISO 9001 Quality Management System certification.

Hanwha Q CELLS has a long history in the PV business. DNV GL views Hanwha Q CELLS to be capable of suppling PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL's view are presented in the table below.

Table 3-2 Hanwha Q CELLS module manufacturing summary

Years in manufacturing	Q-Cells began in 2000, and SolarOne in 2005	Company website
Manufacturing	9 GW cells & modules	Company website
Manufacturing locations	Korea, Malaysia, China, USA	Company website
Market standing	Fourth largest manufacturer	PVtech.org
Technologies offered	Mono, multi, black module, PERC, half-cell	Company website
Factory certifications	ISO 9001 Quality Management System	Company website
Extended durability tests	Top performer, in-house testing >2x IEC	DNV GL PV Module Reliability Scorecard, Company website
DNV GL view	Capable of suppling PV modules that do not pose atypical risks	

3.1.2 Silfab

Silfab Solar was founded in 2011 in Mississauga, Canada, and manufactures monocrystalline modules. Silfab Solar also serves as a contract manufacturer and assembler to companies looking to have operations in Ontario, in order to comply with the Ontario Power Authority's FIT domestic content requirements. Silfab Ontario has a 110,000-square foot, ISO 9001-2008 quality certified, production facility. In Toronto, Silfab says it has a manufacturing capacity of 700 MW/year. SilFab additionally has a 150MW/year manufacturing site in Bellingham, Washington, after its recent investment in ITEK Solar.

Silfab claims its module manufacturing line is among the most automated in the world. DNV GL notes that automation generally improves repeatability of the module build.

Silfab offers modules with monocrystalline cells and has recently begun offering modules with n-type cells as well as bifacial modules. Additionally, Silfab has partnered with DSM to develop high efficiency modules based on back contact cells and has developed supply agreements with multiple companies for residential systems including roofing companies GAF and PetersonDean, and Titan Solar Power.

While Silfab is not a large manufacturer, Silfab has been making modules for more than 7 years and claims to have a fully automated production line. DNV GL views Silfab to be capable of supplying PV modules that do not pose atypical risks compared to generally available modules in the market. Silfab is developing and commercializing new and innovative PV technologies, some of which may have a short or unproven field history. DNV GL recommends selecting products with a proven history of successful field deployments. A summary of selected details as well as DNV GL's view are presented in the table below.

Table 3-3 Silfab PV module manufacturing summary

Years in manufacturing	Since 2011	Company website
Manufacturing	~350MW	Press release
Manufacturing locations	Toronto Canada	Company website
Market standing	Not in the top 10	PVtech.org
Technologies offered	Mono, black module, bifacial, n-type	Company website
Factory certifications	Unable to verify	
Extended durability tests	Silfab was not a top performer except on the PID test	DNV GL Module Reliability Scorecard
DNV GL view	Less manufacturing experience than leading PV manufacturers may pose atypical risks	

3.1.3 LG Electronics

Founded in 1958, LG Electronics Inc., based in South Korea, is a large multinational producer of consumer electronics, mobile communications devices, and home appliances. It is part of LG group which employs 75,000 people and had 2016 sales of USD ~50 billion. While being involved with PV as far back as 1985, the company entered the PV module industry in earnest in 2009. In that year, LG Electronics constructed PV cell and module factories in Gumi, Korea. A Solar Test Lab was certified by TÜV and UL, and LG began initial mass production of solar panels in 2010. In January 2016, LG began a fabrication expansion increasing its capacity from 1 GW to 1.8 GW by 2018 and plans to expand to 3 GW by 2020.

LG is a vertically integrated manufacturer producing their own solar cells and assembling their own modules. LG only offers modules with monocrystalline cells. Additionally, LG offers new and innovative PV technologies including n-type cells, back-contact cells, and multi-wire cell interconnections.

The firm states that it performs electroluminescence (EL) tests on 100% of modules coming off their manufacturing line, which DNV GL considers to represent industry best practice. LG maintains their own PV module test laboratory certified by Underwriters Laboratories (UL) in the U.S. and TÜV Rhineland in Germany to carry out a suite of customary UL and International Electrotechnical Commission (IEC) tests applied to solar modules. Presently, the firm produces PV modules with module efficiencies exceeding 21%, which is above industry averages for crystalline silicon (except SunPower and Panasonic).

LG’s website indicates that the LG factories have the ISO 9001 Quality Management System certification, the ISO 14001 Environmental Management System certification, and the OHSAS 18001 Occupational Health and Safety certification.

DNV GL views LG to be capable of suppling PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL’s view are presented in the table below.

Table 3-4 LG PV module manufacturing summary

Years in manufacturing	Since 2010	Company website
Manufacturing	1.8 GW 2018 (est)	Company website
Manufacturing locations	Korea	Company website
Market standing	Not in the top ten.	PVtech.org
Technologies offered	Mono, PERC, black modules, multi-wire, n-type cells, back-contact, bifacial	Company website
Factory certifications	ISO 9001 Quality Management System, ISO 14001 Environmental Management System OHSAS 18001 Occupational Health and Safety	Company website
Extended durability tests	No public reports available	
DNV GL view	Capable of suppling PV modules that do not pose atypical risks	

3.1.4 Jinko Solar

Jinko Solar started operations in 2006 with first modules sold in 2009. It is a vertically integrated manufacturer producing silicon ingots, wafers, PV cells, modules and mounting systems. Jinko states it has a global customer base for its utility, commercial, and residential solutions and services spanning China, the United States, Japan, Germany, the United Kingdom, Chile, South Africa, India, Mexico, Brazil, the United Arab Emirates, Italy, Spain, France, Belgium, and other countries.

Jinko Solar has five manufacturing facilities in Jiangxi and Zhejiang Provinces in China where the majority of the production capacity is concentrated, and other minor production lines in Malaysia, Portugal, and South Africa. In February 2019, Jinko officially opened its new state-of-the-art 400MW/year solar panel manufacturing facility in Jacksonville, FL, USA.

The manufacturer reported an integrated annual capacity of 14.5 GW for silicon wafers, 9.2 GW for solar cells, and 15 GW for solar modules (late 2019). Jinko Solar is ranked 1st according to shipments in a worldwide list of module suppliers in 2019. Jinko Solar has over 15,000 employees worldwide.

Jinko Solar has a long history in the PV business. DNV GL views Jinko Solar to be capable of supplying PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL’s view are presented in the table below.

Table 3-5 Jinko Solar PV module manufacturing summary

Years in manufacturing	Since 2006	Company website
Manufacturing	15 GW/year capacity 2018, over 29GW deployed	Company website
Manufacturing locations	primarily Jiangxi and Zhejiang Provinces in China	Company website
Market standing	1st by shipments	PV-Magazine.com
Technologies offered	Mono, multi, black module, PERC	Company website
Factory certifications	ISO 9001 Quality Management System ISO 14001 Environmental Management System OHSAS 18001 Occupational Health and Safety	Company website
Extended durability tests	Top Performer DNV GL Module Reliability Scorecard	DNV GL PV Module Scorecard
DNV GL view	Capable of supplying PV modules that do not pose atypical risks	

3.1.5 SunPower

U.S.-based SunPower (NASDAQ: SPWR) was founded in 1985. In the early 1990s, SunPower developed and patented the Interdigitated Back-Contact (IBC) cell which has been used to construct the industry's most efficient modules based on silicon. The IBC cell features numerous efficiency-enhancing features including all rear side metallization, eliminating front metal-contact shadowing effects and resulting in higher efficiencies. SunPower calls the highest performing of these cells "Maxeon" cells with efficiencies exceeding 25%, which enable modules that operate above 22% efficiency.

In 2011, the French oil giant Total purchased a controlling interest in SunPower. As of 2018, SunPower's annual production capacity was approximately 1.2 GW. In April 2018, SunPower purchased the SolarWorld Portland, Oregon, facility and is ramping 200MW/year of P-Series production which is a p-type PERC shingled cell module.

SunPower was a vertically integrated manufacturer covering cell manufacturing, module manufacturing, systems design and integration as well as installation, with offices and facilities located worldwide. However, in November 2019, SunPower spun off its IBC-based module manufacturing into a new company, Maxeon Solar, that will be based in Singapore with factories in France, Malaysia, Mexico and the Philippines. SunPower will continue to manufacture its shingled cell modules in the Portland facility, but will focus on installing residential and commercial rooftop solar projects.

SunPower/Maxeon has nearly two decades' experience in manufacturing IBC modules, and have published field data demonstrating very low degradation rates. The company's recent P-series module was a Top Performer in the DNV GL 2017 Module Reliability Scorecard.

Table 3-6 SunPower PV module manufacturing summary

Years in manufacturing	Since 1985	Company website
Manufacturing	~1.9 GW	2017 Annual Report
Manufacturing locations	Philippines and Malaysia	2017 Annual Report
Market standing	Not in the top 10	PVtech.org
Technologies offered	IBC, shingled, black module	Company website
Factory certifications	ISO 9001 Quality Management System ISO 14001 Environmental Management System	Company website
Extended durability tests	Top Performer 2017	DNV GL PV Module Reliability Scorecard
DNV GL view	Capable of suppling PV modules that do not pose atypical risks	

3.1.6 Trina Solar

Trina Solar, founded in 1997, produces silicon wafers, cells, and modules and includes a system integration group. The company's corporate headquarters and main factory are located in Changzhou, China. They have over 15,000 employees in 20 offices worldwide. Trina's production capacity is estimated at greater than 9 GW/year and has produced a cumulative 40 GW. Trina Solar offers modules with mono and multicrystalline cells, PERC cells, and half-cut cells, as well as dual-glass modules. In addition, Trina's downstream businesses includes solar PV project development, financing, design, construction, and operations & management.

Trina had entered the listings on the New York Stock Exchange (NYSE) under TSL in 2006, but went private in an acquisition by Fortune Solar Holdings Ltd in 2016 and delisted from NYSE. According to the company's website, Trina's State Key Laboratory of PV Science and Technology has broken 18 world records on solar cell efficiency and module power. Additionally, Trina's average p-type mono-PERC cell efficiency is 22.6%.

Trina claims to use 36 in-house quality tests to ensure product reliability throughout the manufacturing chain from incoming silicon and wafer quality, through cell and module assembly.

Trina has been a Top Performer in all four DNV GL Module Reliability Scorecard Reports.

Trina Solar has a long history in the PV business. DNV GL views Trina Solar to be capable of suppling PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL's view are presented in the table below.

Table 3-7 Trina Solar PV module manufacturing summary

Years in manufacturing	Approximately 20 years	Company website
Manufacturing	>9 GW, > 32 GW produced in total	PV-Magazine.com and Company website
Manufacturing locations	China	Company website
Market standing	Third largest manufacturer 2019	Solarquotes.com
Technologies offered	Mono & multicrystalline, dual glass, half-cell, PERC	Company website
Factory certifications	ISO 9001 Quality Management System ISO 14001 Environmental Management System OHSAS 18001 Occupational Health and Safety	Company website
Extended durability tests	Several modules are top performers in all reports	DNV GL PV Module Scorecard
DNV GL view	Capable of suppling PV modules that do not pose atypical risks	

3.1.7 REC Solar

REC (Renewable Energy Corporation) was originally founded in 1994 in Norway as a silicon wafer manufacturer, ScanWafer. The company changed its name to REC in 1999. The former Renewable Energy Corporation ASA had two divisions: REC Silicon and REC Solar. In October 2013, these were split into two entirely separate entities, each focusing on its own core business. For REC Silicon, this was polysilicon and silane gas for the solar and electronics industries with manufacturing facilities in Moses Lake, Washington and Butte, Montana, USA. REC Solar has been sold to Elkem, a large Norwegian conglomerate and continues as "REC" to manufacture wafers, solar cells, and solar panels at its fully automated integrated manufacturing facility in Singapore, plus EPC services and solutions in select markets. REC is a Bluestar Elkem company with headquarters in Norway and operational headquarters in Singapore.

REC employs more than 2,000 people worldwide, producing 1.4 GW/year of solar panels with an estimated cumulative production of 8 GW. REC offers a variety of module technologies including modules with mono and multicrystalline standard and PERC cells. REC is now also offering modules with n-type cells for higher efficiencies.

REC’s website indicates that the REC factories have the ISO 9001 Quality Management System certification, the ISO 14001 Environmental Management System certification, and the OHSAS 18001 Occupational Health and Safety certification.

REC has a long history in the PV business. DNV GL views REC Solar to be capable of suppling PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL’s view are presented in the table below.

Table 3-8 REC PV module manufacturing summary

Years in manufacturing	Over 20 years	Company website
Manufacturing	1.4 GW 2018 (est.) and >8GW produced in total	Company website
Manufacturing locations	Singapore	Company website
Market standing	While over 1 GW of production, REC is not in top 10	PVtech.org
Technologies offered	Mono & multicrystalline, half-cell, PERC, black modules, n-type cells	Company website
Factory certifications	ISO 9001 Quality Management System ISO 14001 Environmental Management System OHSAS 18001 Occupational Health and Safety	Company website
Extended durability tests	REC Twin Peak module is a top performer	DNV GL PV Module Reliability Scorecard
DNV GL view	Capable of suppling PV modules that do not pose atypical risks	

3.1.8 SolarCity/Panasonic

The modules branded as SolarCity SC315B2 AND SC310B2 are manufactured by Panasonic to SolarCity's specifications. Thus, Panasonic is reviewed.

SANYO started the development of the Heterojunction with Intrinsic Thin-layer (HIT) silicon solar cells in 1990. SANYO became a full subsidiary of the Panasonic Group in 2011 and adopted the Panasonic brand name in 2012. The change applied to the brand name only, the modules continued to be manufactured at the same production facilities. At that time, Panasonic produced solar cells at two plants and had three module assembly bases—two in Japan and one in Hungary—with an annual production capacity of 600 MW. In 2012, Panasonic also built a new plant in Kedah, Malaysia to serve as the new solar manufacturing base for Asia, adding 300 MW of production capacity, and increasing Panasonic's overall module production capacity to 900 MW. In June 2015, in view of the rapidly developing solar power market in Japan, Panasonic announced plans to add an additional 150 MW to its solar photovoltaic modules production capacity.

Panasonic HIT technology is among the top modules with respect to module efficiency. Panasonic modules feature module efficiencies over 19%, and low temperature coefficients below -0.26%/°C. Panasonic is considered a Tier 1 manufacturer in the 2017 Bloomberg New Energy Finance survey.

Panasonic has a long history in the PV business. DNV GL views Panasonic to be capable of supplying PV modules that do not pose atypical risks compared to generally available modules in the market. A summary of selected details as well as DNV GL's view are presented in the table below.

Table 3-9 Panasonic PV summary

PV Production Experience	20 years of HIT manufacturing	Company website
Manufacturing capacity	Approximately 1 GW	Various news reports
Manufacturing locations	Japan, Hungary, Malaysia, soon Buffalo NY	Company website
Manufacturing chain	Cells and modules	Company website
Market Standing	Not in the top ten.	PVtech.org
Technologies offered	Mono heterojunction	Company website
Factory certifications	ISO 9001 Quality Management System, ISO 14001 Environmental Management System OHSAS 18001 Occupational Health and Safety	Company website
Extended duration tests	Top Performer DNV GL Module Reliability Scorecard 2018	DNV GL
DNV GL view	Capable of supplying PV modules that do not pose atypical risks	

3.2 Inverters

Based upon review of the Tranche 3 Composition data [3] provided by CT Green Bank, the following manufacturers represent over 99% of the inverters deployed in the Portfolio. Manufacturers included in the review include SolarEdge, ABB/Power-One, Enphase, SMA, SunPower, and Delta Electronics.

Table 3-10 Portfolio composition by inverter manufacturer

Inverter manufacturer	System count	% of total
SolarEdge Technologies	3163	66%
Enphase Energy	926	19%
SunPower	468	10%
SMA America	80	2%
ABB/Power-One	71	1%
Delta Electronics	54	1%
Remaining (6)	49	1%
Total	**4,811**	**100.0%**

DNV GL has utilized its experience in the inverter industry, including that related to performing detailed technology reviews of SolarEdge, ABB, Enphase, SMA, and SunPower inverters, to inform the manufacturer level summaries provided herein. Where available, DNV GL relied on additional manufacturer-provided reliability data.

3.2.1 SolarEdge

SolarEdge (NASDAQ: SEDG, with a March 2015 initial public offering) is a solar electronics manufacturer which was founded in 2006 and began mass production of module-level power optimizers and inverters in 2009. As of December 2016, SolarEdge documentation indicates that it has shipped approximately 15.4 million power optimizers and 663,000 inverters as well as an unspecified number of three-phase inverters. In 2017, SolarEdge was ranked number 10 in global PV inverter market share by shipments, per GTM Research.

SolarEdge provides both module level electronics (optimizers) and inverters. SolarEdge is best known for its power optimizers, which are small electronic devices attached to each PV module which operate under the principal of implementing Maximum Power Point Tracking (MPPT) at the individual module level. An additional benefit of this setup is real-time performance monitoring of each PV module. These devices are commonly deployed in situations where a PV array may consist of two or more azimuths and/or complex shading conditions where part of the module or array may be wholly or partially shaded while another part has a clear view of the sun. SolarEdge was one of the first market entrants for this type of component. The systems with SolarEdge optimizers almost always employ SolarEdge inverters as the inverters are designed to work as a system with optimal performance and cost.

DNV GL is very familiar with SolarEdge's residential product lines, and has reviewed the design for reliability, highly accelerated life testing (HALT), and field track record since the optimizer's introduction. In 2016, SolarEdge also provided DNV GL up-to-date track record summaries for inverters and power optimizers.

SolarEdge has seen a decline in failure rates for its installed bases of both inverters and power optimizers over time as product improvements have been implemented.

Table 3-11 SolarEdge inverter manufacturing summary

Manufacturing experience	9 years
Size and diversification of parent company	None: Pure Play PV electronics manufacturer
Country of origin: **Manufacturing facilities:**	Israel Contract manufacturers in China and Hungary

Power Optimizers

The documentation provided to DNV GL indicates that the field reliability of the power optimizers is high. Each power optimizer device contains a relatively low discrete component count (compared to solar inverters), utilizes existing mature electronic technologies and fabrication methods, and is subject to rigorous product testing. Short of longer duration field reliability data, SolarEdge has applied established QA/QC and production methods which in their view allow them to warrant the devices for 25 years of operation, based upon a daily duty cycle of 12 hours on, 12 hours off.

Inverters

The single-phase and three-phase inverter data supplied by SolarEdge in 2015 (as well as single-phase inverter data from other fleets DNV GL has reviewed) all indicate that SolarEdge inverters have a good track record and are on par with other leading inverter suppliers in terms of performance and failure rates.

DNV GL considers SolarEdge to be an acceptable supplier of solar inverter systems with power optimizers. SolarEdge is the leader in module level optimizer technology.

3.2.2 ABB/Power-One

Founded in 1973, Power-One was originally a United States-based manufacturer of alternating current/direct current (AC/DC) and direct current/direct current (DC/DC) power conversion and management equipment. The company was arranged into separate divisions for power solutions and renewable energy solutions. Power-One's power solutions products are used in computer servers, data centers, network power systems and industrial markets. The renewable energy solutions business produced power conversion equipment for the solar and wind energy markets, including both residential scale and utility scale solar inverters.

Power-One was acquired by the Swiss engineering and manufacturing conglomerate ASEA Brown Boveri (ABB) in July 2013. Their inverter products have adopted the ABB brand as of May 2014. The company was listed as the 4th largest global PV inverter supplier by shipments for 2017 by GTM Research.

ABB has provided a variety of additional documentation regarding company background and testing of their inverters to DNV GL in Q2 2013, including sales and product failure rate data. These documents provide a synopsis of ABB production to date of various inverter model families. Generic inverter failure modes are presented via Pareto charts. These rates have been reduced since 2009 across greatly expanded production, and present a positive picture of Power-One's efforts to track and measure inverter failures and to implement various corrective actions so as to reduce product returns and/or service calls.

DNV GL has reviewed ABB's capabilities in detail and has been positively impressed with both the PV inverter products and the company.

DNV GL considers ABB to be an acceptable supplier of inverters due to its significant manufacturing history and track record of designing and manufacturing power control equipment.

Table 3-12 ABB (Power-One) string inverter manufacturing summary

Manufacturing experience	10 years[1]
Size and diversification of parent company	Parent company is a diversified engineering and manufacturing conglomerate
County of origin	Italy [2]

1. DNV GL was not able to determine when the first string inverter was manufactured; however, the renewable energy products division was initiated in 2006. Power-One's broader manufacturing experience dates back over 40 years.
2. Power-One also has manufacturing facilities in the U.S. It has advised DNV GL in December 2013 that Italy is the relevant country of origin for its string inverters.

3.2.3 Enphase

Enphase Energy (NASDAQ: ENPH) is a publicly-held company based in Petaluma, California, and is the world's leading microinverter manufacturer.

Table 3-13 Enphase inverter manufacturing summary

Manufacturing experience	2008
Size and diversification of parent company	Pure-play microinverter manufacturer + related monitoring services
County of origin	Germany (Phoenix Contact), China (Flextronics), and Canada (Flextronics)

As of Q1 2017, Enphase reported that it has sold approximately 13-14 million of its microinverters since their introduction in 2008 and is currently on its seventh generation design. The devices have thus far been well-received by the solar industry and no substantial failures (e.g., serial defects) have been reported in industry press. The use of module-level electronics like Enphase can be particularly beneficial for systems with partial shading or complex roof designs, as the microinverters help reduce mismatch losses (as are incurred with string inverters). Enphase's microinverters are also favored by certain installers due to the simplicity (relative to a string inverter) of installing them and module level performance monitoring, among other reasons.

DNV GL has reviewed reliability information for Enphase M215 integrated ground (IG) and M250 microinverters which support a 25-year design lifetime, although some proportion will likely fail over this period. DNV GL has recently completed an updated Technology Review of Enphase's product lines (Q2 2015), and such report may be available via Enphase. This report includes a significant reliability discussion including failure rate projections. DNV GL views the overall Enphase activities to ensure product reliability very positively. These include:

- Design for Reliability
- Reliability testing (HALT)
- Actual field performance monitoring with low field failure rates.

The approaches used by Enphase are state-of-the-art in these areas.

DNV GL views Enphase to be the leading microinverter supplier and an acceptable supplier based on our thorough Technology Review.

3.2.4 SMA

Once the largest PV inverter manufacturer in the world, SMA was ranked 6th in the US residential PV inverter market share for 2018. [17] SMA was founded in 1981,and is based in Germany. SMA was listed on the Frankfurt Stock Exchange (S92) in 2008. The SMA Americas division is based in Rocklin, California. SMA Solar Technology AG is the global leader in the development, production, and sales of PV inverters. SMA is represented in all important PV markets, including 21 countries on four continents. Note that SMA has downsized in the more competitive recent market. SMA produces a wide range of inverters from the smaller string inverters to the larger commercial and utility scale products. While their market share has eroded as other top tier manufacturers have consolidated and entered the North American markets, SMA remains a leading PV inverter manufacturer.

DNV GL considers SMA to be a top-tier supplier of inverters due to its significant manufacturing history and reliability track record. DNV GL has performed a detailed technology review of SMA's string inverter products.

Table 3-14 SMA inverter manufacturing summary

Manufacturing experience	30+ years
Size and diversification of parent company	Pure-play solar inverter supplier
Country of origin	Germany

3.2.5 SunPower

The SunPower inverters used in this portfolio are a mixture of string inverters and microinverters. The 5kW and 6 kW string inverters are rebranded SMA inverters. The microinverters used in the AC modules are all the 3rd generation SunPower MI-C-320 microinverters and are the product results of SunPower acquiring SolarBridge in 2014. DNV GL has performed a detailed technology review of SunPower's microinverters including the MI-C-320 in 2017 and such report may be available via SunPower.

U.S. based SunPower (NASDAQ: SPWR) was founded in 1985. Since their first introduction in 1993, SunPower' s back contact solar cells have been used to construct the industry's most efficient solar systems based on silicon. In 2011, the French oil giant Total purchased a controlling interest in SunPower. SunPower's annual production capacity exceeds 1 GW.

To expand their business and maintain their competitive position, SunPower acquired a number of other companies and entered into several joint ventures over the past several years. For example, in July 2010, SunPower formed AUOSP as a joint venture with AUO. In January 2012, SunPower acquired Tenesol, and in November 2013, acquired Greenbotics, Inc. In November 2014, SunPower acquired SolarBridge Technologies, a developer of integrated microinverter technologies for the solar industry.

SunPower employs a contract manufacturer, Celestica Technology Limited, located in Dongguan, China for their microinverter products. The company operates approximately 20 manufacturing and design centers worldwide. With over 25,000 employees, Celestica's reported 2014 revenues of US $5.6 billion. The Song Shun Lake facility in Dongguan provides printed circuit assemblies and a variety of services in system final fabrication and test.

Table 3-15 SunPower inverter manufacturing summary

Manufacturing Experience	20 years (7 years for solar microinverters)
Size and diversification of parent company	None: pure-play PV manufacturer
County of origin	United States Dongguan, China (ISO 9001), Mexico (Assembly)

SunPower worked with SolarBridge Technologies to develop AC Modules starting in 2010 and sold AC Modules incorporating SolarBridge microinverters starting in 2011. SunPower's acquisition of SolarBridge Technologies in 2014 gave SunPower the capability to deliver ac panels with factory-integrated microinverters, all manufactured under SunPower's control. Through 2016, SunPower has deployed over 235,000 gen 3 ac modules and has a reported annual failure rate of less than 0.2%.

DNV GL considers SunPower to be an acceptable supplier of microinverters although the deployment history is limited on the presently produced products.

3.2.6 Delta

Delta Energy Systems ("Delta") develops, manufactures, and markets worldwide, innovative customized and standard power supplies for a variety of different industries, including renewable energies. Delta provides solar inverters and monitoring for residential, commercial, and utility installations.

Delta Electronics Group (founded 1971) is the world's largest provider of switching power supplies and DC brushless fans, as well as a major source for power management solutions, components, visual displays, industrial automation, networking products, and renewable energy solutions. Delta Group has sales offices worldwide and manufacturing plants in Taiwan, China, Thailand, Mexico, India and Europe. The Delta Group is a large company with substantial resources and 80,000 employees in 40 countries. Delta was ranked 15th in the US PV inverter market in 2017, by GTM Research, "The Global PV Inverter and MLPE Landscape, H2 2017." Annual inverter shipments for 2017were stated at 1,300 MWac worldwide per GTM Research. Wood Mackenzie Power Renewables had Delta ranked number 5 in the national residential market share for 2018.

Table 3-16 Delta inverter manufacturing summary

Manufacturing Experience	40 years
Size and diversification of parent company	Parent company is a global provider of power and thermal management solutions
County of origin	Worldwide manufacturing, R&D Labs, and sales offices

The inverters used in this portfolio are the Solivia string inverters ranging in size from 3.8kW to 7.6kW. They are 600Vdc input, single phase inverters ideally suited for the residential market. They also can produce power at 208Vac making them applicable to the commercial market.

DNV GL has reviewed Delta and its solar inverters in detail and considers Delta to be an acceptable supplier of inverters due to its long history of designing and manufacturing power supply solutions, combined with its growing families of PV and energy storage inverters.

3.3 Racking

DNV GL has not reviewed racking used by individual installers in this Portfolio. DNV GL considers residential roof racking commonly installed to be a low risk item. Most residential roof racking systems consist of extruded aluminum rails to support modules, spanning between aluminum or steel mounting standoffs which are bolted to the existing roof structure. The systems are inherently simple, with relatively simple wind loading and structural analysis required. Issues related to residential racking tend to be related to installation errors rather than problems with the racking design. In addition, the relative risk of a structural failure of a roof due to the installation of solar PV module racking is considered by DNV GL to be low. This is due to the relatively low weight of the PV system (typically 3 or 4 psf) in comparison to typical code required design live loads (16 to 20 psf) which are effectively replaced when solar is installed.

3.4 Metering and communication equipment

The RSIP states that the contractor and/or system owner and homeowner is responsible for installing a Sponsor approved revenue grade performance monitoring meter and for maintaining a working connection over the useful life of the PV system. For all RSIP projects, system performance data shall be made available to the Sponsor for incentive payments and REC monetization. For PBI projects, incentive payments are made quarterly over six years based on actual production data.

The following eligible Sponsor-approved revenue grade meter manufacturers are represented in the Portfolio and reviewed herein:

- Locus meter – LGate 101 or LGate 120
- Enphase Envoy S Metered & IQ Envoy
- SolarEdge meter- RWND-3D-240-MB with 100A CT Cellular meter
- Solar Data Systems – Solar-Log (plus GE meter) 350, 360, 370 & GE I-210+

The revenue grade energy meters for remote monitoring of PV energy are similar in topology, in that inverter manufacturers use electronic devices, external to the inverter, with wired or wireless communications connections to the inverter, or to a wireless network. The metering is built around the GE revenue meter, or a similar device manufactured by Locus Energy. An exception to this is the SolarEdge solution using a revenue grade energy meter designed by SolarEdge, which carries an efficiency rating that varies from the GE and Locus devices.

3.4.1 Locus meter - LGate 101 or LGate 120

LGate 120 is a single-phase electronic watt-hour, revenue grade meter for remote monitoring of solar PV systems. Installation is between the PV inverter and the electrical service, with a communications connection to the inverter.

Figure 3-1 Locus Energy LGate 120 revenue grade meter

LGate 120 specifications:

Accuracy: ANSI 12.20 (Class 0.2%)
Enclosure type: NEMA 3R
Temperature range: -20°C to +60°C
Third-party compliance: not indicated in specification

3.4.2 Enphase Envoy S

The Enphase Metering and Management Solution (MMS) manages microinverter operation and gathers revenue-graded energy data. The Revenue Grade Meter is manufactured by GE, and communicates across to the Enphase Envoy Communications Gateway, providing data from review using the Enphase Enlighten software.

Figure 3-2 Enphase revenue grade meter with Envoy

Specification:

Accuracy: ANSI 12.20 (Class 0.2%)
Enclosure type: NEMA 3R
Temperature range: -40°C to +85°C
Third-party compliance: not indicated in specification

3.4.3 Solar-Log plus GE 210 meter

The Solar-Log PV monitoring technology combines the GE 210 revenue grade meter with proprietary wireless, online energy monitoring.

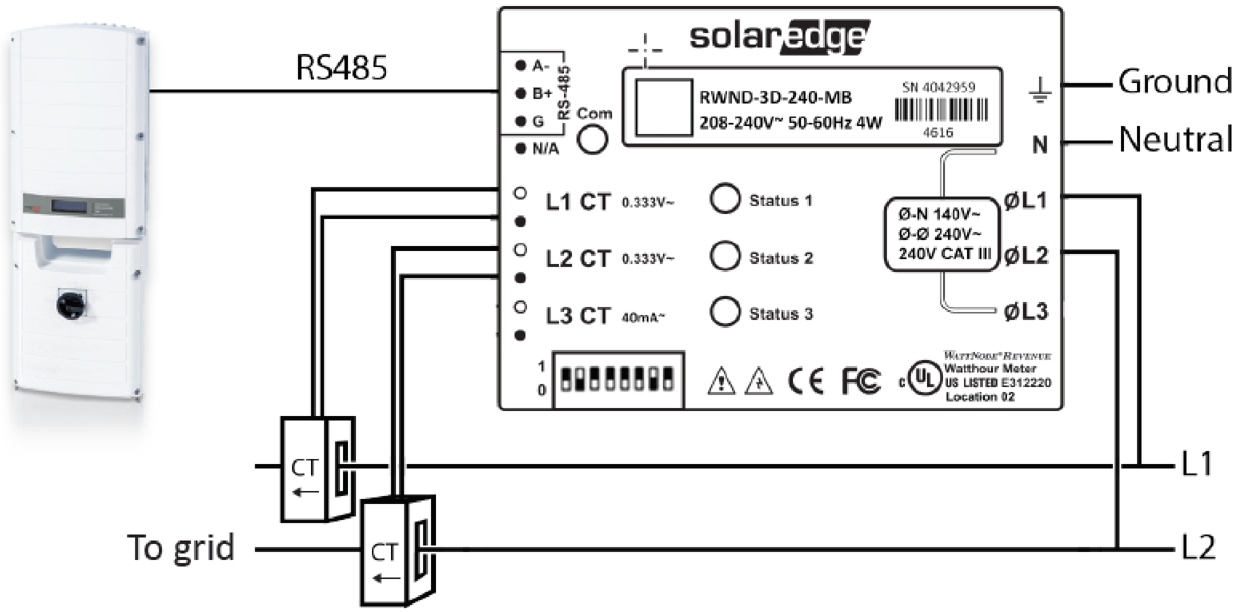
Figure 3-3 Solar-Log PV monitoring meter

Specification:

Accuracy: ANSI 12.20 (Class 0.2%)
Enclosure type: NEMA 3R
Temperature range: -40°C to +85°C
Third-party compliance: not indicated in specification

3.4.4 SolarEdge meter – external to inverter

SolarEdge proprietary revenue grade energy meter is listed by UL to UL 508A, for electrical safety. Meter accuracy of 1% at full load rating of current transformers, 25°C, and power factor of 0.7 to 1.0.



Specification:

Accuracy: ±1% at full Current Transformer load, 25°C, and power factor of 0.7 to 1.0.
Enclosure type: NEMA 3R
Temperature range: -40°C to +55°C
Third-party compliance: UL 508A

3.4.5 Metering and communication equipment conclusions

Communications hardware varies somewhat from manufacturer to manufacturer, with RS-485 or Zigbee connections generally provided. The meter hardware in use is for a low-cost revenue-grade energy metering with adequate accuracy. The revenue grade meters have not been evaluated by DNV GL regarding reliability and useful life; however, the technology in use should provide adequate reliability. Typically, the primary issue with metering is getting the initial settings correct and current transformers properly installed. Once the equipment is operating properly, the reliability of the communications equipment affects the availability of the data, while the revenue grade meters continue to log energy data, with or without functioning communications. RSIP began requiring all meters to communicate using a cellular connection (since it was more reliable in the majority of cases). This requirement was put in place 8 August 2015: Starting with Step 8, which began 8 August 2015, Revenue-Grade Meters were required to be cellular and include a five-year cellular plan provided to the customer incorporated into the price of the meter. The Green Bank covers the cost of the cellular plans after the 5-year period [4].

4. SHREC PRODUCTION FORECASTING PROCEDURES REVIEW

DNV GL has reviewed the procedures by which the Sponsor generates energy production forecasts for residential systems with the purpose of evaluating the long-term accuracy of these forecasts and their usefulness for predicting the Portfolio's SHRECs from energy production.

4.1 Review methodology

DNV GL has reviewed the procedure by which the Sponsor generates energy production forecasts for each PV system with the purpose of evaluating the long-term accuracy of these forecasts and their usefulness for predicting the Portfolio's revenue from energy production, and thereby the Portfolio's ability to generate SHRECs. The review has focused on the following areas:

- Quality of data used to establish long-term irradiation and temperature
- Method employed to determine irradiation on the collector plane
- Simulation of physical plant
- Reasonableness of loss factor assumptions.

This section provides a qualitative review of the Sponsor's energy production forecasting procedure, whereas Section 5 provides a comparison between the Sponsor's forecasts and the actual production data.

4.2 Energy simulation

Since 2006, PowerClerk has acted as the proposal and system reporting portal for all Sponsor systems, as well as supporting the Sponsor's incentive program. The Sponsor's process requires system information be initially entered in PowerClerk, however, for SHREC forecasting purposes, the Sponsor relies on a parallel calculation in Clean Power Research's (CPR) SolarAnywhere Fleetview. The only difference between PowerClerk and SolarAnywhere Fleetview is the choice of weather data used in the simulation. PowerClerk relies on National Solar Radiation Database (NSRDB) Typical Meteorological Year 3 (TMY3) weather files whereas the CPR SolarAnywhere Fleetview estimate is based on SolarAnywhere typical global horizontal irradiation year (TGY) weather files. All PowerClerk system entries are transferred to CPR SolarAnywhere Fleetview automatically and the underlying PVForm code is the same between PowerClerk and SolarAnywhere Fleetview. The remainder of this section and report focuses on SolarAnywhere Fleetview as the SHREC forecast source.

SolarAnywhere Fleetview is able to access Clean Power Research's (CPR) SolarAnywhere irradiance data through a web-based RESTful API to calculate solar energy production. CPR's SolarAnywhere Fleetview tool incorporates a modified version of Sandia National Labs PVForm Power Output Model. NREL's PVWatts is also based on PVForm, but the SolarAnywhere Fleetview API implements the model differently in several ways. DNV GL understands some of the major differences include reference cell temperature, PV module temperature equations, radiation transmitted though module covers, and module nonlinearity. DNV GL does not have access to the underlying API code and therefore has not independently verified the SolarAnywhere Fleetview API model. DNV GL requested access to PowerClerk and SolarAnywhere Fleetview to validate a number of sample systems.

The inputs into PowerClerk and later transferred to SolarAnywhere Fleetview include the following system parameters:

- Location
- Number of arrays, inverters per array
- PV module manufacturer, model, quantity, and cost
- Inverter manufacturer, model, quantity, and cost
- Fixed tilt or tracking array type
- Azimuth and tilt for each array
- Solar obstruction (shading) angles or monthly (solar access) percentages for each array.

4.2.1 Calculation procedure for the continental United States

The Sponsor uses PVForm code to produce an hourly production time series and SolarAnywhere Fleetview sums the hourly simulation results to output year 1 monthly energy estimates that can be summed to an annual value.

The following is a description of the calculation procedure after drawings are completed:

1 CPR SolarAnwhere Fleetview maintains a database of satellite irradiation data. Address, zip code, and state are used to find the irradiance tile over the site.

2 The inputs entered into PowerClerk are transferred to SolarAnywhere Fleetview and are translated into the PVForm-required inputs of dc rating, array type, array tilt, and array azimuth.

3 The Perez irradiance model is used and plane of array calculations are performed based on the PV array orientation parameters input by the user.

4 A shading model is applied based on the shading obstruction angles or monthly (solar access) percentages input by the user. DNV GL notes that the shade loss is calculated based on the percent of shaded area which is not directly correlated to actual module shade losses. Actual shading losses depend on system variables such as module architecture (e.g., bypass diodes) and orientation, string configuration, and severity of shade. As shown in various studies [18], this assumption underestimates the impact of shading losses on the string of modules for string inverters.

5 The PVForm Power Output Model is used to calculate production from irradiance, based on the inverter and module specifications of the system. PowerClerk has a drop down of inverter and module models selected by the user and can look up hardware specifications including inverter efficiency values from the California Energy Commission (CEC). These specifications are transferred to SolarAnywhere Fleetview for use in the PVForm Power Output Model.

6 The Sponsor uses a fixed 10% de-rate factor, with the exception of inverter and PV module specifications as noted above. A comparison of the Sponsor's de-rate factor vs. the standard de-rate factors for PVWatts v4 is provided in Table 4-1 below.

7 The hourly production time series is summed by SolarAnywhere Fleetview to obtain year 1 monthly energy estimates and an annual energy estimate.

8 The Sponsor applies a 0.5% annual degradation to the year 1 energy estimates. DNV GL comments on portfolio degradation in Section5.5.3.

4.3 Commentary on the Sponsor's residential methodology

The commentary here regarding the Sponsor's methodology for generating production estimates provides context to the Section 5 discussion of forecast accuracy, where estimates are compared to Portfolio production data.

4.3.1 Accuracy and reliability of meteorological data

The Sponsor uses CPR SolarAnywhere TGY data at the site location as the irradiation data input to the energy estimate simulation. Irradiation inputs are a high impact variable within a solar energy production assessment and have the potential to significantly impact the production results. DNV GL discusses the effect of weather data selection throughout this section.

CPR SolarAnywhere data is derived from the SolarAnywhere satellite imagery collected from geosynchronous satellite networks and is applied to 10 x 10 km mesh grids. The data spans 1998 – 2017. DNV GL has reviewed discussions of uncertainty supplied by CPR and has found them insufficient to provide a clear picture of the spatial and temporal uncertainty of this dataset. DNV GL considers the data to be acceptable for use in solar energy estimate production estimates based on endorsements from NREL and the data's general agreement with other, peer reviewed datasets. Also, production index analysis produces correction factors that can compensate for bias error in the weather data among other sources of bias.

DNV GL considers the CPR SolarAnywhere data sets to be suitable for use in PVForm model simulations assuming the localized 10x10 km gridded data is selected as the weather file. DNV GL recommends comparing nearby irradiance resource files to lower the risk of outliers, especially in climatically diverse zones such as coastal or mountainous regions. DNV GL expects the localized 10 x 10 km gridded data from SolarAnywhere to be reasonable, especially given the nature of the spatial coverage needed for residential energy estimates.

Given the background with CPR SolarAnywhere data, DNV GL considers the uncertainty of the Sponsor's solar radiation to be relatively high and higher than a well-calibrated ground measurement station. Nonetheless, DNV GL considers such an approach to be among the best available methods for residential solar applications given the need to have rapid and algorithmic energy estimates. Other meteorological data could potentially have a lower uncertainty if it were site-specific, well-calibrated, well-maintained and consistent between all sites, however the cost of such an approach makes it impractical in most cases with such a large number of systems and the time required to record the measurements. DNV GL considers the use of CPR SolarAnywhere data as a meteorological source to be acceptable for use in the Sponsor's energy forecasts.

4.3.2 Accuracy and reliability of energy simulation process

DNV GL has reviewed SolarAnywhere PV Simulation Product Documentation [19] to inform its understanding of the modifications performed to the PVForm Power Output Model, as discussed in Section 4.2. This document provides a comparison of the PVForm model used by PVWatts and SolarAnywhere for a representative system in Boulder, CO, using the same weather data in the simulation. The difference in AC power is 6% with the largest source of discrepancy being the PTC versus STC reference temperature. The full list of discrepancies are summarized within the document.

While this comparison is useful for highlighting the differences between the two PVForm-based models it does not provide information on the accuracy of the model's energy estimates. The PVWatts v5 Manual [20] lists the PVForm-based energy estimate error as high as +/- 10% on an annual basis. DNV GL does not have access to the underlying API code and therefore has not independently verified the SolarAnywhere Fleetview API model.

As an engine for generating energy production forecasts, SolarAnywhere Fleetview is able to achieve usability and speed and adequately provides meteorological data spatially and geographically for the various systems considered in this portfolio. Therefore, DNV GL considers the use of SolarAnywhere Fleetview to be a reliable method and the selection of such a tool seems appropriate given the Sponsor's business model. Aggregating a large number of PV systems into a portfolio results in a portfolio-wide uncertainty that is lower than the uncertainty for a given rooftop PV system, an effect that is discussed in further detail in Section 5.5.

4.3.3 Accuracy and reliability of energy loss factor assumptions

Table 4-1 below summarizes the losses used to determine DNV GL's standard loss assumptions compared to SolarAnywhere Fleetview's default loss value.

Table 4-1 default loss factors

Component loss factors	Sponsor default loss factors	DNV GL recommended values in CT
Soiling + Snow		3.5%
Shading	Defined per system outside of this value	Define per system
Mismatch		1%
Wiring		2%
Connections		0%
Light-induced degradation		2%
Nameplate rating		0%
Age		0%
Availability		2%
Total loss factor	**10%**	**10%**

While DNV GL does not have information on the breakdown of the 10% loss factor applied in SolarAnywhere Fleetview, DNV GL finds the 10% loss factor reasonable for this specific Portfolio of systems based on regional weather and assuming aggregation of many thousands of systems. Recommended loss values for each component loss factor are presented herein. DNV GL notes that in SolarAnywhere Fleetview, shade losses are considered outside of the 10% loss factor and agrees with this approach. DNV GL notes that the shade loss is calculated based on the percent of shaded area and may underestimate the impact of shading losses on the string of modules for string inverters. DNV GL notes that actual soiling losses can change based on the geographical region and environment and recommends regional dust and snow soiling losses be calculated. A standard loss factor in all regions would not account for this variability. DNV GL calculated typical snow loss factors in Connecticut since the regional distribution of this Portfolio is small.

A discussion of selected loss factor assumptions follows:

- **PV module nameplate dc rating:** Nameplate variation (also referred to as module binning tolerances) is listed as 0%/+3% (or -0 W to +5 W) on most PV module datasheets. DNV GL also accounts for MPPT non-ideality with an additional 0.5% loss. When considering all module nameplate power losses, DNV GL recommends a value of 0% be used for this loss.
- **Inverter and Transformer:** The inverter efficiency is obtained from a look-up table which is updated using values published by the CEC. DNV GL finds this approach reasonable.
- **Mismatch:** The electrical losses resulting from the performance variation of individual electrically-connected modules. DNV GL recommends a 1% loss for default residential systems using string inverters. DNV GL notes that this loss is lower when using dc optimizer or microinverters.
- **DC and AC wiring:** DNV GL recommends a 2.0% loss for dc wiring loss and ac wiring loss for generic systems. DNV GL notes that for string inverter systems dc wiring losses will be higher than for module-level microinverters. The opposite is true of ac wiring losses when comparing string and microinverter systems. In total, dc and ac wiring losses are typically 1.5% to 2.5% for most residential systems. DNV GL notes that the Sponsor can control this loss by altering the system design and wire selection.
- **LID:** Most conventional silicon modules stabilize with a 1-3% loss within the first few hours/days of exposure.
- **Shading:** As part of the design process, installers must take either manual or satellite-based shade measurements. The shade obstruction angles or monthly solar access percentages are entered into PowerClerk (and subsequently transferred to SolarAnywhere Fleetview) and incorporated into the production estimate. DNV GL notes that the shade loss is calculated based on the percent of shaded area and may underestimate the impact of shading losses on the string of modules for string inverters.
- **Soiling/Snow:** DNV GL notes that actual soiling/snow losses can change based on the geographical region and environment. DNV GL independently calculated soiling/snow losses using precipitation data and snowfall data for a generic residential system in CT and determined that 3.5% is a reasonable estimate of soiling/snow losses as presented in Table 4-1. In order to account for potential error caused by soiling/snow losses, DNV GL considers variance in production expectations in the uncertainty analysis as presented in Section 5.5.
- **System Availability:** DNV GL notes that, to some extent, the Sponsor has visibility into the downtime of systems by monitoring system production data. The Sponsor is able to inform third-party owners and installers when systems are down so that those systems can be brought back

online. For project monitoring issues that are not addressable by owners and installers, the Green Bank will rely on SunSystem Technology (SST) to assist with troubleshooting and repair.

DNV GL notes that industry-wide practices for controlling system downtime ainclude employing good monitoring techniques, active maintenance, and responsive repairs. DNV GL generally considers a portfolio-wide availability 98% as an achievable target for a well-maintained residential system portfolio of thousands of systems. An estimate of the Sponsor's Portfolio availability is provided in Section 5.2.4.

To obtain an estimate of PV system degradation, DNV GL has relied on its review of the Jordan and Kurtz 2016 Compendium of photovoltaic degradation rates [21]. DNV GL notes that degradation rates used in non-recourse project finance transactions for PV systems are typically in the range of 0.5-0.75% per annum. This range is supported by extensive industry literature [21]. Based on DNV GL's review of available studies, the median system-level degradation rate is reported to be 0.64%, and the interquartile range (P25-P75) is 0.2%-1.2% per annum.

4.3.4 Uncertainty calculations

Uncertainty analyses are not typically performed or considered on individual residential system energy estimates. Therefore, no project level uncertainly calculations were provided for review by the Sponsor.

- However, DNV GL has used the production data set to draw conclusions regarding the uncertainty of the Sponsor's Portfolio production forecasts. These results are provided in Section 5.5.

4.3.5 Validating Sponsor energy estimate process consistency

DNV GL has attempted to replicate the Sponsor's energy forecasting process by manually entering PV system specifications directly into SolarAnywhere Fleetview for 20 systems randomly selected by DNV GL. The inputs used were determined from system drawings and shading reports provided by the Sponsor.

The estimate made by DNV GL for each system was then compared to the annual as-built production estimate provided by the Sponsor for that system. The summary of the validation results including model inputs are provided in Appendix B, as well as in Table 4-2 below. DNV GL notes continued process consistency from the results of these validations.

Table 4-2 Methodology validation summary

System	Capacity (kWp)	Installer	Module	Inverter	Estimated Deviation (%)
RPV-28389	2.85	Vivint Solar	Jinko Solar	SolarEdge Technologies	0.00%
RPV-28957	4.48	C-TEC Solar	LG Electronics Solar Cell Division	Enphase Energy	0.00%
RPV-29044	4.06	Vivint Solar	Jinko Solar	SolarEdge Technologies	0.00%
RPV-29047	8.64	Earthlight Technologies	SunPower	SunPower	-0.27%
RPV-29426	13.02	Ross Solar	Silfab	SolarEdge Technologies	0.11%
RPV-29623	8.70	PosiGen	Silfab	SolarEdge Technologies	0.00%
RPV-29687	5.40	SolarCity	Hanwha Q-Cells	ABB	0.00%
RPV-29825	5.12	C-TEC Solar	LG Electronics Solar Cell Division	Enphase Energy	0.00%
RPV-30020	14.88	Ross Solar	Silfab	SolarEdge Technologies	0.00%
RPV-30047	13.40	Sunlight Solar Energy	LG Electronics Solar Cell Division	SolarEdge Technologies	0.05%
RPV-30543	6.38	PosiGen	Silfab	SolarEdge Technologies	0.00%
RPV-30631	4.23	SolarCity	SolarCity	Delta Electronics	0.00%
RPV-31451	15.34	Trinity Solar	Hanwha Q-Cells	SolarEdge Technologies	0.00%
RPV-32507	9.44	Trinity Solar	Hanwha Q-Cells	SolarEdge Technologies	0.00%
RPV-32856	4.90	SunPower Capital	SunPower	SunPower	0.00%
RPV-33291	8.40	Sunrun	LG Electronics Solar Cell Division	SolarEdge Technologies	0.00%
RPV-34118	10.44	SunPower Capital	SunPower	SunPower	0.00%
RPV-36370	9.28	Sunrun	REC Solar	SolarEdge Technologies	0.00%
RPV-36462	10.22	Sunlight Solar Energy	LG Electronics Solar Cell Division	Enphase Energy	0.00%
RPV-37248	5.52	Earthlight Technologies	SunPower	SunPower	0.00%

For validation, DNV GL attempts to replicate the Sponsor's energy estimates to a ±1% threshold based upon initial data provided by the Sponsor. If DNV GL's initial validation efforts result in agreement with the Sponsor's estimate outside of the ±1% range, DNV GL requests further details on the Sponsor's inputs to reconcile the deviation.

DNV GL notes that none of the energy estimates exceed the threshold range, though the following systems' electrical drawings differ from the specifications used in SolarAnywhere FleetView:

- System RPV – 29047: System drawings indicate one array with a tilt angle of 14 degrees. System details within SolarAnywhere FleetView indicate a tilt angle of 16 degrees. DNV GL considers this discrepancy to have a negligible impact on the energy estimate.
- System RPV – 30020: System drawings indicate one array with a tilt angle of 48 degrees. System details within SolarAnywhere FleetView indicate a tilt angle of 45 degrees. DNV GL considers this discrepancy to have a negligible impact on the energy estimate.
- System RPV – 31451: System drawings show a total of 2 inverters. System details within SolarAnywhere FleetView indicate only 1 inverter. The Sponsor and CPR have confirmed that there are 2 inverters in the as-built system records and that this discrepancy was a reporting error in SolarAnywhere FleetView that was resolved as of 3 April 2020 [22].
- System RPV – 32507: System drawings indicate one array with a tilt angle of 30 degrees. System details within SolarAnywhere FleetView indicate a tilt angle of 28 degrees. DNV GL considers this discrepancy to have a negligible impact on the energy estimate.
- System RPV – 34118: System drawings indicate one array with a tilt angle of 23 degrees. System details within SolarAnywhere FleetView indicate a tilt angle of 20 degrees. DNV GL considers this discrepancy to have a negligible impact on the energy estimate.
- System RPV – 36462: System drawings show a total of 2 inverters. System details within SolarAnywhere FleetView indicate only 1 inverter. The Sponsor and CPR have confirmed that there are 2 inverters in the as-built system records and that this discrepancy was a reporting error in SolarAnywhere FleetView that was resolved as of 3 April 2020 [22].

Of the 20 systems reviewed, DNV GL independently validated 20 of the 20 systems to within ±1%. The systems with specification discrepancies were examined by the Sponsor who confirmed that the discrepancies were all within their margin of error. The uncertainty in the portfolio forecast is dependent on sufficient information being provided by the Sponsor.

5. PRODUCTION ANALYSIS

DNV GL has analyzed a production dataset [23] from the Sponsor's Portfolio (the "Portfolio Data" or the "Portfolio") of deployed systems to confirm the accuracy of the Sponsor's energy production estimates and to set expectations for future production of these systems.

DNV GL has also estimated and presented the uncertainty in its production forecast.

5.1 Description of the production data set

The Sponsor has provided DNV GL with a dataset consisting of 4,811 systems with Approval to Energize dates between 3 February 2015 and 17 January 2019 [23] [3]. The Sponsor has provided system information for the systems in the Portfolio, including location, system size, estimated monthly production, installer, and inverter and module information. DNV GL understands from the Sponsor that all Year-1 monthly estimates were generated using SolarAnywhere Fleetview, the Sponsor's current energy estimate methodology.

The monthly energy estimates for subsequent years were generated by applying the Sponsor's 0.5% degradation rate to the Year-1 values. DNV GL notes that its recommendations for degradation rates for the portfolio are addressed in Section 5.5.3.

5.2 Methodology for arriving at production estimates

DNV GL has analyzed the Sponsor's operational data. This process involved the following steps:

- Clean the production data to remove erroneous values
- Adjust system production to be more representative of the long-term period
- Derive performance indexes based on the past accuracy of the Sponsor's forecasts.

DNV GL assessed all PV systems with available historical data to gain insight on the performance of the Sponsor's entire operational Portfolio. Each of these steps is described in detail in the following sections.

5.2.1 Data cleaning and processing

The analysis of the systems in the production dataset first began with a data QA/QC procedure. The data QA/QC procedure consisted of the following steps:

1. Any months where the meter was running but the system had not begun to operate have been removed from the data set. For each system, the first month of production were removed to account for typical issues associated with project startup.

2. Any system with a monthly energy estimate of zero, or more than three summer months with production greater than 200% of the energy estimate, were classified as erroneous and were removed from the analysis. Ten systems have been removed as a result of this qualification.

3. Systems in the Portfolio are occasionally unable to communicate production data due to communication errors. In such cases, the meter will continue registering production while it is offline

and sync data with the server when the communication is corrected and the meter is back online. When such a communication error spans multiple months, data spikes result, where a month of low or zero production is followed by an unrealistically high measurement for the month. DNV GL has identified such data spikes, including the preceding months of zero production, and removed these months from the analysis.

4. DNV GL has identified data surges where normal production months are followed by unrealistically high production months. These data surges are defined as any month where the measured production is more than 500 kWh overestimated and more than 200% greater than estimated. These months have been removed from the analysis.
5. Systems without 12 months or more of production data with at least one valid data point for each calendar month have been removed from the analysis.

DNV GL finds the Portfolio data set supplied to be reasonable and to contain a low proportion of erroneous data. Table 5-1 summarizes the results of the QA/QC process, finding 2,551 systems (the "Production Sample") as valid for the analysis. The Production Sample forms the basis of the rest of the analysis.

Table 5-1 Data QA/QC Summary

Tranche 3 Portfolio Systems	Production Sample Systems
4,811	2,551

5.2.2 Solar resource comparison to long-term irradiation

To adjust production data for differences caused by irradiance above or below long-term average, the Sponsor has provided DNV GL with monthly ratios of historical GHI to long-term average GHI for each of the systems in the Portfolio [24]. These ratios were calculated for each system using SolarAnywhere data from a tile located near the system. DNV GL has used these ratios to adjust the production data to what would have occurred in long-term average irradiance conditions. This analysis resulted in an average system-level adjustment of 107.5% of the reported production.

The significant system-level adjustment resulting from the solar resource comparison to the long-term radiation is further bolstered by CPR analysis and an article [25] and separate DNV GL work calculating below average solar insolation in 2018 and 2019 in many parts of the eastern U.S.

5.2.3 Additional weather considerations

DNV GL acknowledges that, in addition to GHI, other meteorological variability can impact the production of a PV system; however, in this case, only irradiance variability was considered in this analysis.

DNV GL understands that the East Coast received higher-than-average amounts of snowfall in 2015. This suggests that the production of the Sponsor's systems in the Northeast may have been negatively impacted during these winter months and is therefore not necessarily reflective of long-term production. DNV GL has not reviewed snowfall levels during the period of operation of the Production Sample systems. DNV GL also notes that the number of systems operational starting in 2015 is relatively small, and therefore the impacts of this higher-than-average snowfall is likely relatively minimal on the portfolio level.

While DNV GL is of the view that inclusion of the solar resource analysis results in more certain forecasts, it does not completely consider all weather events that may cause the average observed performance of the Portfolio to deviate from long-term average behavior.

5.2.4 System availability

For purposes of assessing availability, DNV GL defines availability as system downtime where production losses are attributable to a downtime event. DNV GL employs the following approach:

- DNV GL estimates lost production by comparing the actual production to the expected production for each month of operation for each system, ignoring months affected by communication issues.
- Any month where actual to expected production is less than 50% is flagged as a potential downtime event and lost production is approximated as the difference between expected and actual.
- System availability is calculated as the ratio of the total actual production to the sum of the total actual production and the total lost production.

This analysis showed that the production data set system availability has been moderate, with approximately 60.3% of the systems having less than 0.5% downtime. DNV GL has confirmed the Production Sample's average availability is 96.4%. Table 5-2 summarizes the distribution of system availability for the Production Sample.

Table 5-2 System availability frequency distribution

Availability Bin Floor	% of Total	Availability Bin Floor	% of Total
0.995	60.3%	0.865	0.5%
0.985	1.7%	0.855	0.5%
0.975	6.6%	0.845	0.4%
0.965	6.6%	0.835	0.4%
0.955	5.2%	0.825	0.3%
0.945	4.1%	0.815	0.3%
0.935	2.7%	0.805	0.2%
0.925	1.4%	0.795	0.2%
0.915	1.2%	0.785	0.3%
0.905	1.0%	0.775	0.2%
0.895	0.9%	0.765	0.2%
0.885	0.7%	0.755	0.2%
0.875	0.7%	<0.755	3.2%

5.3 Production analysis results

5.3.1 Accuracy of Sponsor's energy estimation

Figure 5-1 below summarizes key attributes of the Production Sample.

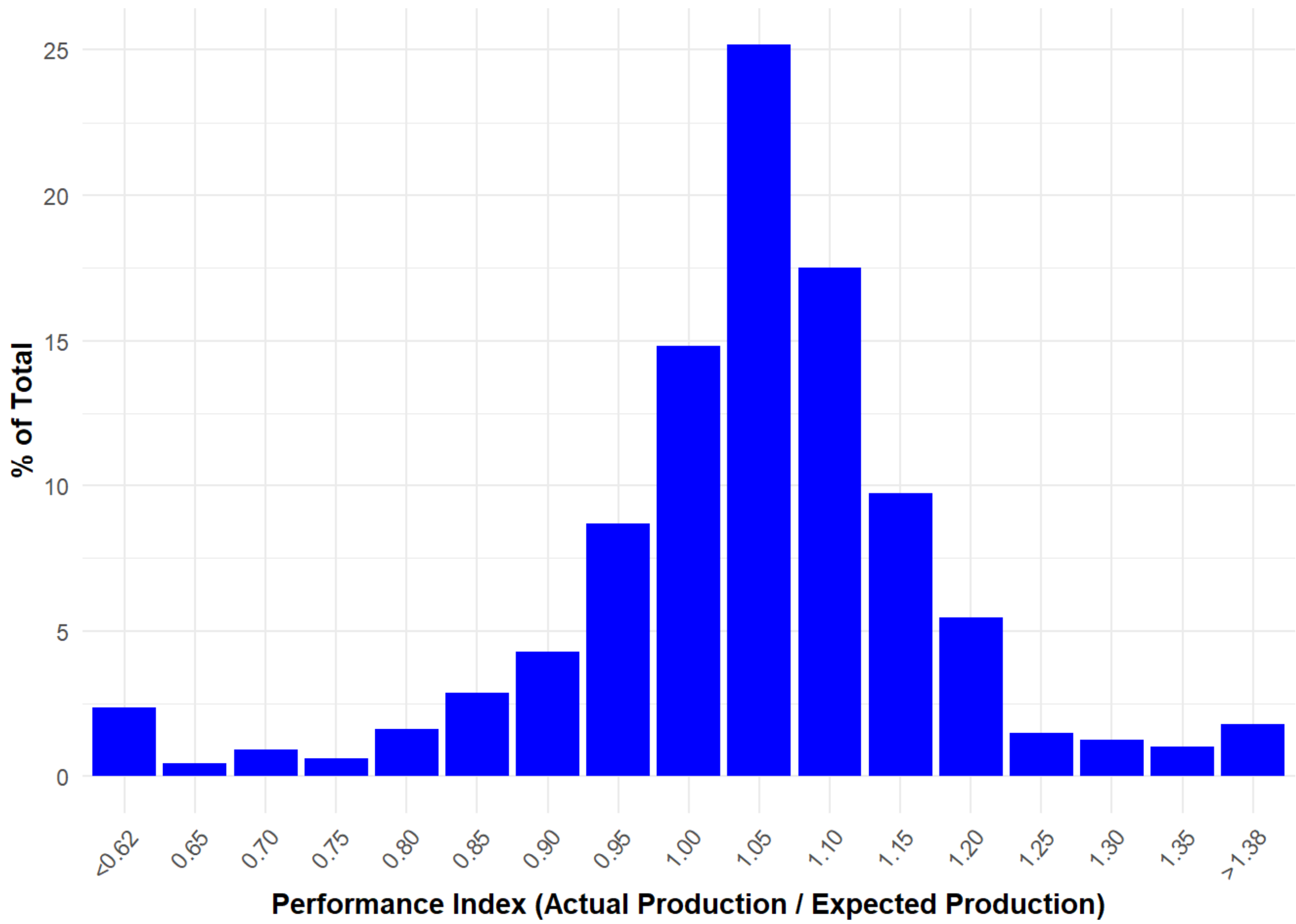


Figure 5-1 Production sample summary

Table 5-3 Summary statistics of energy production of the Production Sample

System Count	2,551
Average Performance index	1.04
Median Performance index	1.05
Performance index Standard Deviation	15.4%
Minimum Performance index	0.01
Maximum Performance index	1.64
Performance index < 0.95	16.3%

The Sponsor's operating systems have overperformed their current modeled as-built estimates on average by 4.0%. The Performance Index standard deviation is 15.4%.

5.3.2 Accuracy by Installer

DNV GL has presented system performance for the top ten install partners that appear in the Portfolio, as summarized in Figure 5-2.

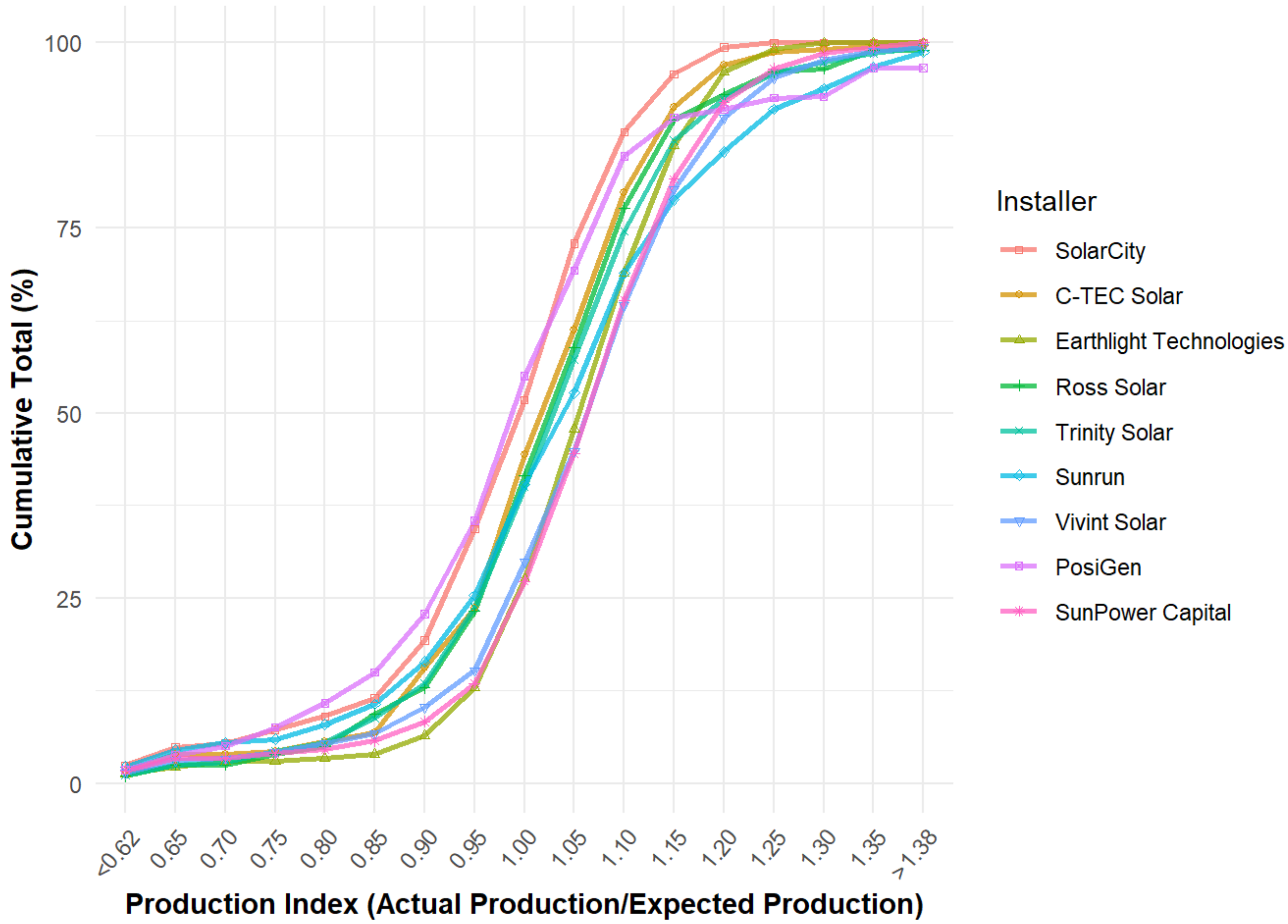


Figure 5-2 Cumulative distribution functions of performance index by Install Partner

Table 5-4 Summary statistics for energy production by Install Partner

Installer	Count	Mean	Median	Standard Deviation	Minimum	Maximum	< 0.95	> 1.05
Trinity Solar	684	1.05	1.06	13.72	0.16	1.6	14.8%	54.1%
Vivint Solar	390	1.07	1.08	14.14	0.17	1.62	9.7%	67.7%
PosiGen	337	1.02	1.02	18.57	0.17	1.64	24.3%	33.5%
Sunrun	201	1.05	1.06	18.39	0.02	1.53	18.9%	52.7%
SunPower Capital	174	1.06	1.09	15.75	0.07	1.36	8.1%	67.8%
C-TEC Solar	116	1.02	1.05	15.18	0.13	1.41	17.2%	48.3%
Earthlight Technologies	116	1.07	1.08	10.6	0.41	1.27	6.0%	67.2%
Ross Solar	101	1.04	1.06	15.87	0.1	1.39	13.9%	54.5%
SolarCity	83	0.98	1.01	19.66	0.06	1.19	19.3%	33.7%
EcoSmart Home Services	67	0.99	1.01	16.01	0.01	1.3	23.9%	29.9%

5.3.3 Accuracy by system age

Figure 5-3 illustrates the cumulative distribution of the PI by the age of the system. Each curve represents systems of various ages.

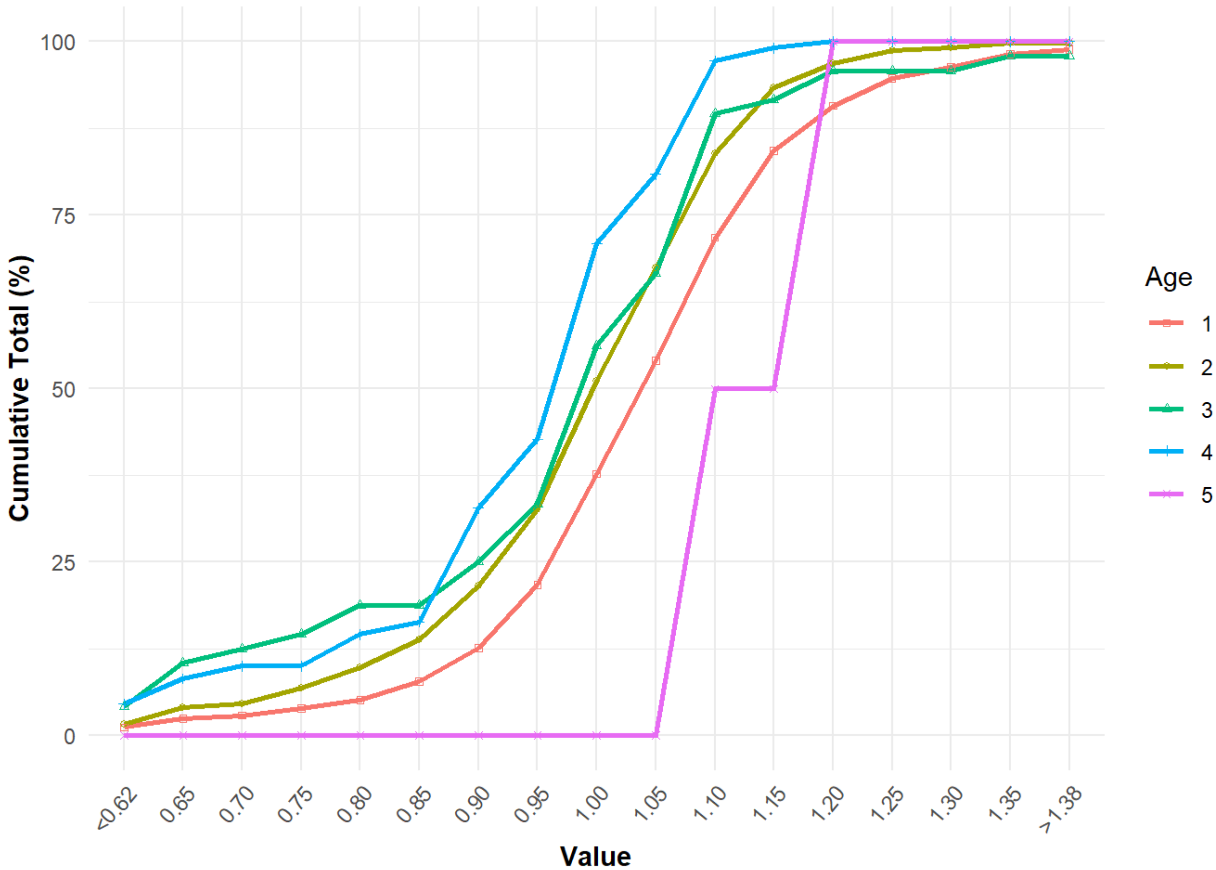


Figure 5-3 Cumulative distribution functions of Performance Index by PTO date

Table 5-5 Summary statistics of energy production by system age

Age [Years]	1	2	3	4	5
Systems	1,862	609	24	55	1
Average PI	1.06	1.00	0.98	0.92	1.17
Maximum PI	1.64	1.44	1.52	1.13	1.17
PI Std. Deviation	14.7	15.06	21.68	25.77	NA
Minimum PI	1.64	1.44	1.52	1.13	1.17

The PI is seen to generally decrease after one year of operation, from a high of 1.06 for systems one year old to a low of 0.92 for systems four years old. However, the sample size for systems for ages 3, 4, and 5 is generally low and may not necessarily be representative of longer operating systems. DNV GL notes that the

Portfolio is primarily composed of relatively new systems under 2 years and that performance over time will be monitored by the Sponsor as described in Section 4.3.3. DNV GL notes the performance difference between systems one, two, and three years old may be attributed to factors outside of the analyzed irradiance variability. See Section 5.2.3 for additional discussion on possible performance factors.

5.3.4 Accuracy by module manufacturer

DNV GL has presented system performance for the top ten module manufacturers that appear in the Portfolio, as summarized in Figure 5-4.

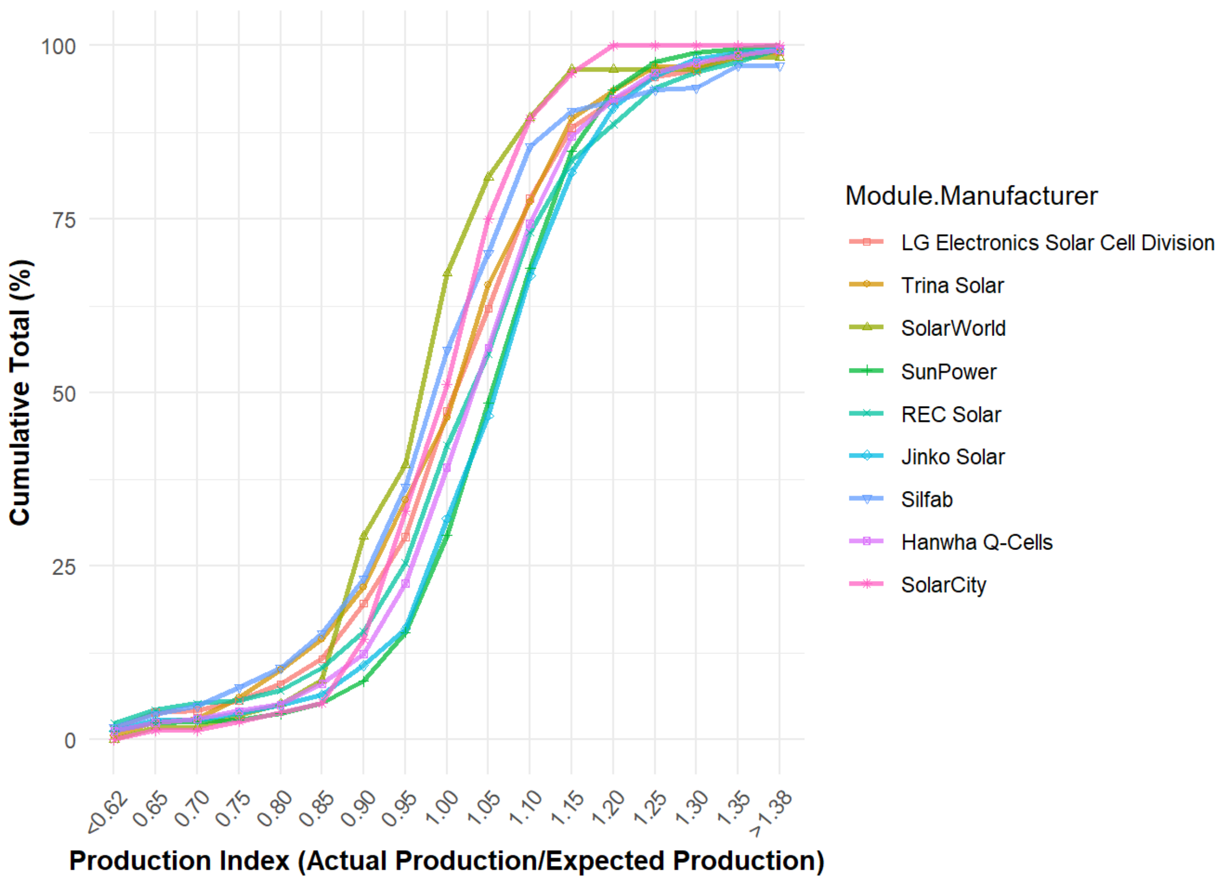


Figure 5-4 Cumulative distribution functions of Performance Index by module manufacturer

Table 5-6 Summary statistics of energy production by module manufacturer

Module manufacturer	Count	Mean	Median	Standard deviation	Minimum	Maximum	< 0.95	> 1.05
Hanwha Q-Cells	583	1.05	1.06	13.84	0.06	1.56	13.6%	55.2%
Silfab	407	1.01	1.02	17.75	0.17	1.64	25.6%	32.2%
Jinko Solar	397	1.07	1.08	13.84	0.17	1.62	9.8%	65.7%
LG Electronics Solar Cell Division	375	1.02	1.04	16.7	0.01	1.53	21.9%	45.1%
SunPower	362	1.06	1.08	13.56	0.07	1.37	8.6%	64.9%
REC Solar	106	1.04	1.05	18.22	0.1	1.44	17.9%	50.9%
Trina Solar	100	1.02	1.03	15.91	0.2	1.54	26.0%	45.0%
SolarCity	38	1.01	1.00	8.7	0.69	1.17	13.2%	31.6%
SolarWorld	29	1.00	0.97	12.57	0.7	1.49	24.1%	24.1%
JA Solar Holding	27	1.05	1.06	15.78	0.57	1.37	11.1%	59.3%

Within these results, SolarWorld systems present the lowest PI at 1.00. Jinko systems outperformed the estimated production with a PI of 1.07.

5.3.5 Accuracy by inverter manufacturer

Figure 5-5 presents a summary of system performance for the Production Sample binned by inverter manufacturer.

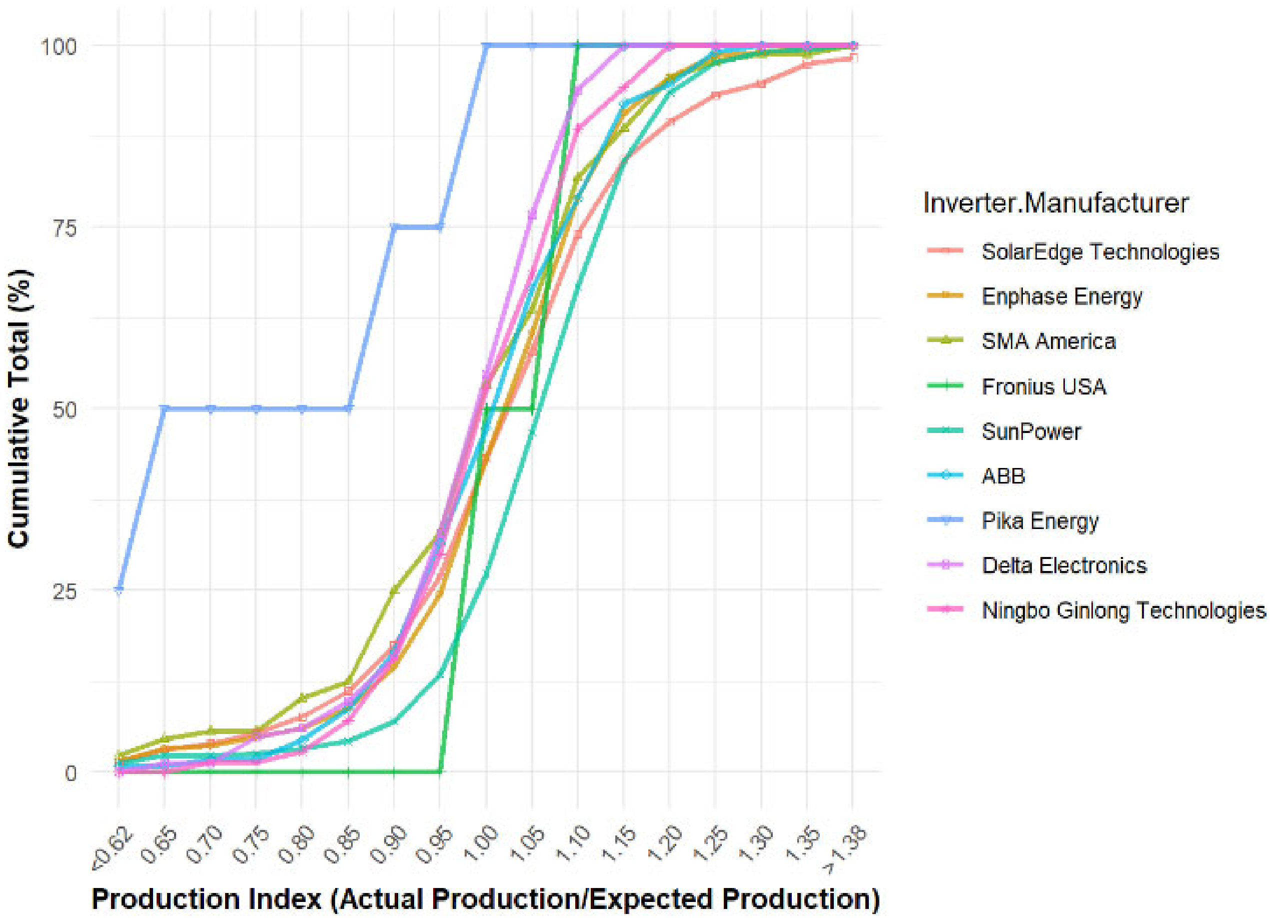


Figure 5-5 Cumulative distribution function for performance indexes by inverter manufacturer

Table 5-7 Summary statistics for energy production by inverter manufacturer

Inverter manufacturer	Count	Mean	Median	Standard deviation	Minimum	Maximum	< 0.95	> 1.05
SolarEdge Technologies	1270	1.04	1.05	16.89	0.02	1.64	18.8%	49.9%
Enphase Energy	756	1.03	1.05	14.03	0.01	1.44	15.5%	49.9%
SunPower	342	1.07	1.08	12.95	0.07	1.37	7.0%	67.3%
ABB	57	1.03	1.03	10.25	0.67	1.25	19.3%	40.4%
SMA America	44	1.00	1.03	17.25	0.29	1.35	25.0%	38.6%
Delta Electronics	41	1.01	1.01	8.66	0.69	1.12	12.2%	34.2%
Ningbo Ginlong Technologies	35	1.02	1.03	8.24	0.74	1.14	20.0%	37.1%

Among the manufacturers that represented more than 1% of the Portfolio, SMA America had the lowest PI, performing on par with estimates. SolarEdge Technologies had the highest PI, performing 4.0% above estimates.

5.4 SHREC production analysis

5.4.1 SHREC minting process summary

As described in the SHREC Creation and Minting Process Standard Operating Procedure (the “SOP”) and email correspondence to changes in the procedure provided to DNV GL in June 2019, the Sponsor creates and mints SHRECs from qualified projects. [26]

A summary of the procedure is as follows:

- Obtain net production in kWh from the Locus monitoring data platform
- Adjust the production data with the CPR solar resource ratio
- Compare adjusted measured production to the energy estimate for each system.
- If the adjusted measured production exceeds 200% of the estimated production and is 500 kWh greater than the estimated production, the Customer assumes the value to be erroneous due to communication errors or back fed generation. Measured production is then limited to the 200% cap.
- 1 MWh equates 1 unit SHREC.

In order to understand future performance of the Portfolio in terms of the SHREC asset class, DNV GL has analyzed past performance of the Portfolio and converted the past performance of SHREC estimates using the processes described in the SOP. DNV GL understands that historically minted SHREC production is largely unavailable, as the Sponsor was granted permission in 2015 to mint SHRECs beginning with 2017.

5.4.2 Performance Index of estimated SHREC production

DNV GL has analyzed historical production and processes described in the Section 5.4.1 to develop a synthetic dataset of past SHREC performance. This is done due to the differences in comparisons between the metered production and SHREC forecast estimate, and the SHREC minting process. DNV GL has assumed that all MWh estimated convert to units of SHREC in the Sponsor’s SHREC estimate.

DNV GL has approached the analysis by considering the following:

- Utilize the cleaned dataset arrived after data quality management described in Section 5.2.1
- Adjusting the measured production on a monthly basis using the steps described in Section 5.4.1
- Reproduce Performance Indexes utilizing the method described in Section 5.2

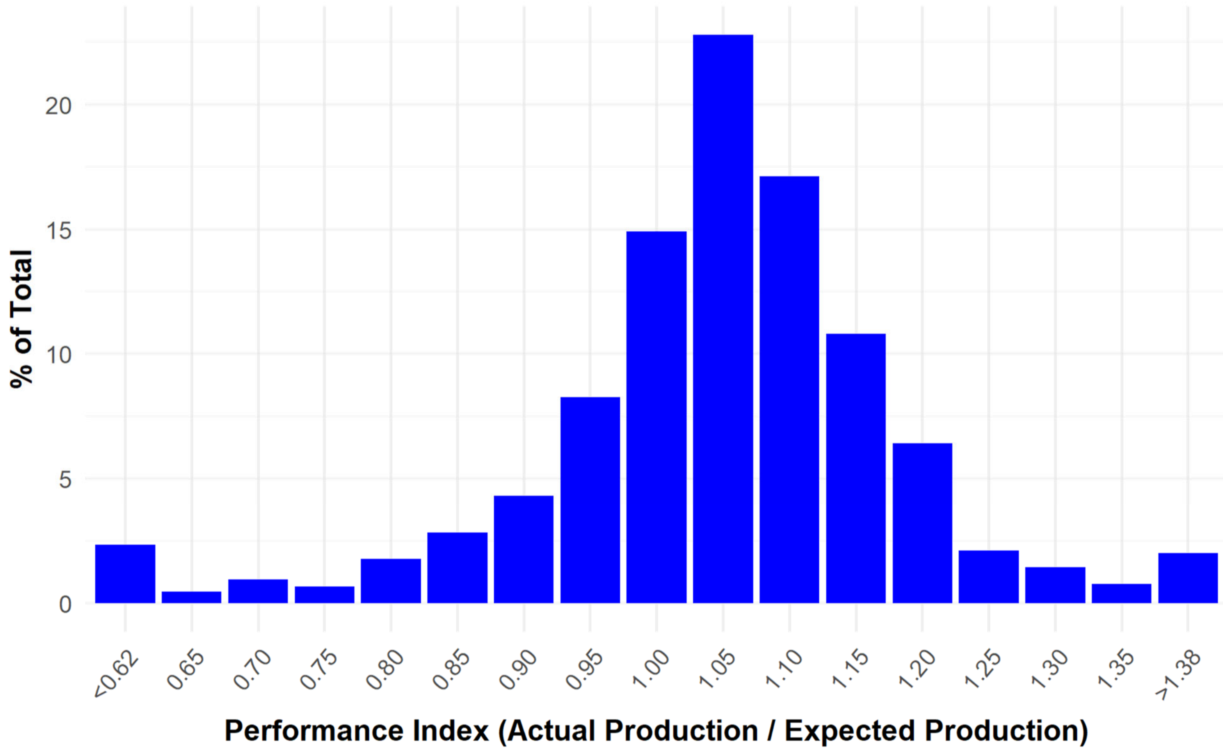


Figure 5-6 Performance Index distribution of the Portfolio

Table 5-8 Summary statistics of synthetic SHREC Production

Statistic	Summary
Count	2,553
Mean	1.043
Median	1.054
Standard deviation	15.6%
Minimum	0.007
Maximum	1.649
< 0.95	16.7%

DNV GL notes that the mean production is increased by 0.4% after comparing these results to those presented in Section 5.3.1. This is likely due to months with high production being capped at 200% of the adjusted estimated production rather than excluded from the analysis completely. Considering that exceedance of the threshold is a rare occurrence in the Portfolio, the small increase seems to align with expectations.

5.5 Forecast and uncertainty calculations

DNV GL has completed an uncertainty analysis specific to the Portfolio results presented above. This uncertainty analysis is utilized for Portfolio forecasting as presented in Section 5.5.4, below.

An ensemble of PV systems represents a lower uncertainty relative to the sum of individual systems—this is referred to as the "portfolio effect". DNV GL has estimated the uncertainty in its production forecast by the method described below.

5.5.1 Sources of uncertainty

The sources of uncertainty in the forecast of energy production can be categorized as two types: (1) those due to uncertainties in the historical data and analysis methodology; and (2) those due to the future variability of the solar resource and production loss factors. The portfolio effect arises due to the statistical independence of the contributing sources of uncertainty, which are described in the following subsections.

5.5.1.1 Historical uncertainty

- **Sample representation:**
  - **Production Index:** DNV GL's forecast is an adjustment to the Sponsor's forecast, which is assumed to follow the empirical distributions provided in Section 5.5.1. It is observed that regions with larger quantities of PV systems generally have lower production index uncertainty as defined by the law of large numbers.
  - **Limited Data:** For regions lacking a representative sample of production data, uncertainty has been increased.
  - **Technology:** For Portfolio systems whose specifications are as yet undefined, or whose technology (e.g., model type) is not analyzed in the available sample of production data, uncertainty has been assigned to account for any potential deviation in production.
- **Analysis process:**
  - **Sunniness:** The uncertainty associated with production data's period of record. This uncertainty is calculated by considering the region's inter-annual variability and reducing this value by the square root of the period of record of the production data. This uncertainty value represents the possible deviation in solar radiation and thus energy production, as compared to the long-term solar radiation of the region.
  - **Adjustment to long-term reference:** The uncertainty associated with an adjustment from the historical production data to a long-term solar radiation source. This adjustment process can determine and correct for above or below average solar radiation over the production data period of record.
  - **General:** The uncertainty associated with the general analysis process is taken into consideration. This accounts for factors such as the number of systems being forecasted versus the number of systems with production data in the portfolio, the consistency of the energy assessment forecasting methodology within the portfolio, and other portfolio-specific factors that may need to be accounted for. DNV GL notes that this portfolio has a typical level of general uncertainty.

- **Measurement/Data Reliability:** The accuracy of the production data, including the accuracy of the production metering hardware and validation results.

DNV GL's uncertainty expectation and methodology is set forth in the Table 5-9 below for each of the uncertainty factors. These values are blended to represent the Portfolio and consider the composition of the Portfolio and the Production Sample in terms of methodology used, the availability of production data, and the definition of system details.

Table 5-9 Uncertainty in the correction factor

Production Sample Representation	Analysis Process	Measurement and Data Reliability	Historical Uncertainty
2.0%	3.9	1.6	4.7%

5.5.1.2 Future variables

- **Interannual Variability (IAV):** In any given year, Portfolio production may be higher or lower as a result of variability in the incident solar radiation; and
- **Availability:** The variability of the future energy production due to availability.

Table 5-10 Future uncertainty

Inter-Annual Variability 1-Year	Inter-Annual Variability 15-Year	Availability	Future Uncertainty 1-Year	Future Uncertainty 15-Year
1.7%	0.4%	2.0%	2.6	2.0%

5.5.2 Portfolio mean and uncertainty

DNV GL presents correction factors for the Sponsor's Portfolio first-year energy estimates based on historical data and future uncertainty. Table 5-11 summarizes the estimated correction factors along with the corresponding uncertainty. DNV GL's annual forecast for future years for the Portfolio is provided below in Section 5.5.4.

Table 5-11 Correction factors for Year-1 and uncertainties

Correction Factor	Total Uncertainty 1-Year[1]	Total Uncertainty 15-Year[1]
1.033	5.4%	5.1%

Combining the model uncertainty (found using the principal values described in Section 5.5.1) with the solar resource and availability uncertainty for both the 1-year or 15-year future period cases yields overall Portfolio uncertainty of 5.4% and 5.1%, respectively.

5.5.3 Degradation

For an individual system utilizing standard crystalline modules, DNV GL utilizes an asymmetric degradation distribution with a mean of 0.81% and a P90 of 1.8% [27]. For an individual system utilizing SunPower E-series or X-series modules, DNV GL utilizes a normal degradation distribution with a mean of 0.25% and a standard deviation of 0.7%. For large portfolios of systems consisting of a variety of module models, some independent behavior with regards to degradation is expected. This independence reduces the overall Portfolio-level degradation uncertainty when compared to the individual system uncertainties.

To calculate the Portfolio-level degradation uncertainty, DNV GL performed a Monte Carlo simulation on the Portfolio systems. This simulation was run with the assumption that each module model behaves independently. DNV GL notes that other factors can create either correlation or independence in degradation; however, little data is available to inform how these factors behave. In each iteration of the simulation, the model sampled a degradation rate from the appropriate distribution for each module model, and the Portfolio-level degradation rate was then calculated by taking the energy estimate-weighted average of the degradation rates. The results of 5,000 simulations of the Portfolio are presented in Table 5-12.

Table 5-12 Portfolio degradation rates

Percentile	Degradation rate
P50	-0.68%
P75	-0.89%
P90	-1.10%
P95	-1.25%
P99	-1.53%

When calculating annual forecasts, DNV GL combines the degradation rates with the Year 1 model uncertainties and variabilities assuming an independent relationship. This results in a further reduction of the apparent degradation rate observed when a degraded forecast is compared with the Year 1 forecast for any of the downside scenarios.

5.5.4 Annual forecasts

Based on the observations above, DNV GL has developed an expectation of the annual production for the Portfolio at various probabilities of exceedance. The annual forecasts are the combination of the uncertainties reported in Section 5.5.2, the degradation uncertainty described in and Section 5.5.3, and reductions in availability during the years when inverters are expected to be replaced. Table 5-13 displays the downtime estimated due to inverter replacements by DNV GL.

Table 5-13 Estimated availability due to inverter replacements

Year	Availability due to inverter replacements
1	99.9%
2	99.9%
3	99.9%
4	99.9%
5	99.9%
6	99.9%
7	99.7%
8	99.4%
9	99.0%
10	98.4%
11	98.0%
12	98.6%
13	99.1%
14	99.5%
15	99.8%

The correction factor calculated in 5.5.2 represents the expected performance of the systems in the Portfolio on a going-forward basis and are therefore expressed as a percentage of the systems' current contractual estimates. Due to degradation, the contractual estimates are now lower than they were when the systems first began operating, making the correction factors higher than they would be if they were expressed as a percentage of the systems' first-year estimates. Because the Sponsor's financial model requires that the forecasts be expressed as a percentage of the Portfolio systems' first year energy estimates, it is necessary to calculate the extent to which the contractual energy estimates have been reduced by the contractual degradation rates for the system. DNV GL calculated the ratio of the Portfolio systems' estimates for the year of 30 April 2020 – 1 May 2021 to the total of the systems' first-year estimates to be 99.1%. This adjustment factor was applied to the annual forecasts in order to present the results as a percentage of the systems' first-year estimates.

The annual forecasts for various probabilities of exceedance for 1-year and 15-year periods are presented below in the tables below with Year 1 representing 30 April 2020 – 1 May 2021. These forecasts are expressed as a percentage of the Sponsor's contractual first year production estimate [28] and in production in MWh. DNV GL notes that the relative production forecasts shown will change if the final Portfolio composition differs materially from the Portfolio analyzed.

Table 5-14 Confidence limits for the Portfolio, 1-year period

Year	p(50)	p(75)	p(90)	p(95)	p(99)
1	102.3%	98.6%	95.2%	93.3%	89.5%
2	101.6%	97.9%	94.5%	92.5%	88.8%
3	100.9%	97.2%	93.8%	91.8%	88.0%
4	100.2%	96.4%	93.0%	91.0%	87.2%
5	99.5%	95.7%	92.3%	90.2%	86.3%
6	98.8%	94.9%	91.4%	89.3%	85.3%
7	97.9%	94.0%	90.4%	88.2%	84.2%
8	97.0%	93.0%	89.3%	87.1%	82.9%
9	95.8%	91.8%	88.1%	85.7%	81.4%
10	94.6%	90.5%	86.6%	84.3%	79.8%
11	93.6%	89.4%	85.4%	83.0%	78.4%
12	93.4%	89.1%	85.0%	82.5%	77.7%
13	93.2%	88.8%	84.5%	81.9%	76.9%
14	92.9%	88.3%	83.9%	81.1%	75.9%
15	92.5%	87.7%	83.2%	80.3%	74.9%

Table 5-15 Confidence limits for the Portfolio, production in MWh, 1-year period

Year	p(50)	p(75)	p(90)	p(95)	p(99)
1	40,937	39,292	37,811	36,925	35,262
2	40,659	39,012	37,528	36,640	34,974
3	40,382	38,727	37,236	36,342	34,664
4	40,103	38,438	36,933	36,029	34,333
5	39,823	38,142	36,620	35,701	33,980
6	39,530	37,831	36,286	35,350	33,597
7	39,191	37,471	35,901	34,945	33,156
8	38,809	37,066	35,469	34,491	32,662
9	38,358	36,593	34,966	33,966	32,095
10	37,852	36,063	34,407	33,382	31,468
11	37,447	35,627	33,935	32,881	30,913
12	37,391	35,520	33,771	32,676	30,633
13	37,319	35,394	33,586	32,447	30,325
14	37,189	35,210	33,342	32,159	29,956
15	37,024	34,990	33,060	31,832	29,547

Table 5-16 Confidence limits for the Portfolio, 15-year period

Year	p(50)	p(75)	p(90)	p(95)	p(99)
1	102.3%	98.8%	95.6%	93.7%	90.2%
2	101.6%	98.1%	94.9%	93.0%	89.4%
3	100.9%	97.3%	94.2%	92.2%	88.6%
4	100.2%	96.6%	93.4%	91.4%	87.8%
5	99.5%	95.9%	92.6%	90.6%	86.9%
6	98.8%	95.1%	91.7%	89.7%	85.9%
7	97.9%	94.2%	90.8%	88.7%	84.7%
8	97.0%	93.2%	89.7%	87.5%	83.5%
9	95.8%	92.0%	88.4%	86.1%	82.0%
10	94.6%	90.6%	86.9%	84.6%	80.4%
11	93.6%	89.5%	85.7%	83.4%	78.9%
12	93.4%	89.2%	85.3%	82.8%	78.2%
13	93.2%	88.9%	84.8%	82.2%	77.4%
14	92.9%	88.4%	84.2%	81.5%	76.4%
15	92.5%	87.9%	83.5%	80.6%	75.3%

Table 5-17 Confidence limits for the Portfolio, production in MWh, 15-year period

Year	p(50)	p(75)	p(90)	p(95)	p(99)
1	40,937	39,358	37,937	37,086	35,491
2	40,659	39,078	37,654	36,802	35,202
3	40,382	38,793	37,361	36,502	34,891
4	40,103	38,503	37,057	36,188	34,558
5	39,823	38,207	36,743	35,859	34,202
6	39,530	37,895	36,407	35,505	33,815
7	39,191	37,534	36,020	35,097	33,370
8	38,809	37,128	35,585	34,640	32,870
9	38,358	36,653	35,080	34,110	32,297
10	37,852	36,122	34,518	33,523	31,664
11	37,447	35,685	34,042	33,017	31,104
12	37,391	35,577	33,876	32,809	30,819
13	37,319	35,450	33,689	32,578	30,506
14	37,189	35,265	33,442	32,286	30,133
15	37,024	35,043	33,159	31,956	29,719

6. MAJOR AGREEMENT REVIEW

DNV GL has reviewed the Master Purchase Agreement (MPA) for SHRECs between CT Green Bank and Eversource Energy and UI. The MPA covers buying and selling SHRECs and is the sole offtake agreement. DNV GL also presents the solar incentive structure relevant to SHREC generation. Review of installer EPC agreements is not included; the CT Green Bank's procedures for qualifying installers are discussed in Section 2.

6.1 Master Purchase Agreement

6.1.1 Summary

SHREC sales to The Connecticut Light and Power Company (dba "Eversource Energy") and The United Illuminating Company ("UI") are provided for using a Master Purchase Agreement (MPA). DNV GL has reviewed the following executed agreements (collectively, "MPAs"), both dated 7 February 2017 with Eversource Energy [29] and UI [30].

The MPAs provide for the Sponsor to sell SHRECs at firm pricing ($50 per MWh for the first tranche, $49 per MWh for tranche two and $48 per MWh for tranche three) for 15 years. The Buyer, either Eversource Energy or UI, is obligated to purchase those SHRECs in a tranche associated with the energy generated by the projects assuming the pre-requisites have been met and continue to be met through the term. The main difference between the MPAs provided is the Buyer's Percentage Entitlement ("BPE"). Eversource Energy having a BPE of 80% and UI having a BPE of 20%. DNV GL has not identified other meaningful differences between the individual MPAs.

While the Buyer is obligated to purchase all SHRECs from a qualifying tranche, there is not a SHREC guaranty or other performance-based terms that require a minimum amount of electricity be produced from a tranche.

A summary of the primary findings and/or risks identified is provided in the following table.

Section	Primary Findings
6.1.1	**Parties and contract status:** Buyer of SHRECs: Eversource Energy (80%) UI (20%) Contract status: Executed 7 February 2017
6.1.2	**Term:** The tranche delivery term starts on 1 January of a tranche year and continues for 15 years. The Buyer's obligation to purchase tranche SHRECs will end no later than the earlier of when Sponsor achieves deployment of 305.4 MWdc of qualifying residential solar PV installations or 31 December 2022, meaning the final tranche start date would begin 1 January 2022.

Section	Primary Findings
6.1.3	**Sale of SHRECs:** The purchase price of each SHREC is $50.00 in the MPAs for Tranche 1, $49 for Tranche 2, and $48 for Tranche 3. The Sponsor establishes the price of each tranche in accordance with Connecticut General Statutes. An SHREC is equal to one megawatt hour (MWh) of electricity generated from a qualifying residential solar photovoltaic system. The Buyer is obligated to purchase all SHRECs generated by SHREC projects in a tranche. SHRECs are invoiced quarterly.
6.1.4	**Obligations of Sponsor**: The Sponsor is responsible for ensuring energy generation has begun prior to tranche delivery start date, providing the tranche purchase price and project details, ensuring the SHREC projects qualify as residential solar PV system, executed the tranche confirmation (Exhibit B), and completing delivery of SHRECs to Buyer.
6.1.5	**Obligations of Buyer:** The Buyer is responsible for ensuring it has received regulatory and corporate approval and has received tranche detail and executed the confirmation (Exhibit B).
6.1.6	**Energy generation and metering:** SHREC projects must be located behind a qualifying utility revenue meter and must have a separate meter dedicated to measurement of SHREC project's energy output. The meter shall be installed, operated, maintained, and testing to meet applicable requirements and standards of the utility and electric system operator.

6.1.2 Term and termination

The agreement term begins upon execution and, unless terminated earlier, continues for 15 years from the final tranche start date. The Buyer's obligation to purchase tranche SHRECs will end no later than the earlier of when Sponsor achieves deployment of 305.4 MWdc of qualifying residential solar PV installations or 31 December 2022, meaning the final tranche start date would begin no later than 1 January 2022.

The tranche delivery term starts on 1 January of a tranche year and continues for 15 years.

6.1.3 Sale of SHRECs

The purchase price of each SHREC is set by the Sponsor in accordance with the Connecticut General Statutes, currently not more than $50.00 (the price for each SHREC in Tranche 1), $49 (the price for each SHREC in Tranche 2), and $48 (the price for each SHREC in Tranche 3). An SHREC is equal to one megawatt hour (MWh) of electricity generated from a qualifying residential solar PV system. The Buyer is obligated to purchase all SHRECs generated by SHREC projects in a particular tranche, irrespective of any delays in REC deliveries, whether or not due to one or more force majeure events. Upon transfer and receipt, Buyer receives titles to all the SHRECs and Environmental Attributes.

Assuming all obligations are meet, SHRECs are bought and delivered within 90 days after tranche delivery term start date. For each contract year of the tranche term, SHRECs are delivered equal to the electricity produced by projects in the applicable tranche. Payment for any SHRECs are invoiced quarterly, with payment due by the last business day of the month following the month during which SHRECs were delivered.

6.1.4 General obligations

The Sponsor is responsible for providing notice to the Buyer certifying:

- Details of the tranche project's and their system size, tranche delivery term start date, and purchase price has been provided in Exhibit B and has been executed between both parties for each tranche.
- Energy generation has begun prior to tranche delivery start date
- The tranche purchase price
- The SHREC projects, as constructed, meet all of the requirements of a qualifying residential solar photovoltaic system pursuant to the Energy Act, which means the project:
  - Receives funding from the Connecticut Green Bank
  - Certified by the authority as a Class I renewable source (e.g. electricity generated from solar power)
  - Emits no pollutants,
  - Located on the customer-side of the review meter of a one-to-four family home,
  - Serves the distribution system of the electric distribution company
  - Capable of producing SHRECs
- Has satisfied all obligations in the MPAs to complete the delivery of the SHRECs to Buyer

6.1.5 Buyer's general obligations

The Buyer agrees to the following general obligations:

- Has received regulatory and corporate approvals
- Details of the tranche project's and their system size, tranche delivery term start date, and purchase price has been provided in Exhibit B and has been executed between both parties for each tranche.

6.1.6 Metering and interconnection

SHREC projects must be located behind a qualifying Connecticut electric system's revenue meter. The MPAs do not allow for a SHREC project to be interconnected to the utility electric system. The project must have a separate meter dedicated to measurement of the SHREC project's energy output. The meter shall be installed, operated, maintained, and tested to meet applicable requirements and standards of the utility and electric system operator.

6.1.7 Liability limits

In the MPAs reviewed by DNV GL, the Sponsor nor the Buyer is liable to the other party for any damages or otherwise.

6.2 Solar incentive structure

The following describes the current residential solar incentives as per the residential solar investment program website [31] which provides both current and historical incentive levels. As the program is structured as a declining incentive block structure, projects in Tranche 3 will have received various incentive levels:

- When purchasing a solar PV system for your home, the EPBB incentive is calculated at $0.426/watt up to 10 kW for utility consumption equaling the last 12 months of electricity usage and $0.328/watt from previous utility consumption for systems up to 20 kW. Systems that have a calculated design factor less than 75% receive a discounted incentive.
- For PV systems that are leased, the PBI is calculated at $0.03/kWh for system up to 20 kW. The PBI is paid quarterly over six years upon validation of system generation.

6.3 O&M Agreement

DNV GL understands that the Sponsor does not have direct responsibility for O&M costs for the Portfolio, as the Sponsor's role is as an asset program administrator. As such, DNV GL has not reviewed either O&M cost estimates or inverter replacement cost projections.

7. OPERATING SYSTEM REVIEW

7.1 Design audit review

DNV GL has completed electrical design reviews of a sample of 20 systems from the Portfolio for the purpose of confirming consistency with the Sponsor's agreed processes and identifying any specific issues or risks. The systems were independently selected by DNV GL to be representative of the Portfolio as a whole. The detailed findings from the review are presented in Appendix A and a summary of the audit systems is shown in Table 7-1.

Table 7-1 Design review system summary

System	Size [kW dc]	Installer	Drawing Rev Date
23359	7.42	Vivint Solar	12/15/2016
25902	12.8	Ross Solar Group	4/4/2017
26200	1.02	C-TecSolar	6/20/2017
28957	4.48	C-TecSolar	10/23/2017
29044	4.06	Vivint Solar	12/5/17
29047	8.64	Earthlight	2/27/2017
29426	13.02	Ross Solar Group	1/26/2018
29623	8.7	Posigen CT LLC	2/28/2017
29687	5.4	Tesla	11/8/2017
30047	13.4	Sunlight Solar Energy	12/14/2017
30543	6.38	Posigen CT LLC	6/6/2018
30631	4.225	Tesla	1/6/2018
31451	15.34	Trinity Solar	3/8/2018
32507	9.44	Trinity Solar	5/8/2018
32856	4.9	Sunpower	5/10/2018
33291	8.4	Sunrun	5/31/2018
34118	10.44	Sunpower	7/11/2018
36370	9.28	Sunrun	9/28/2018
36462	10.22	Sunlight Solar	10/2/2018
37248	5.52	Earthlight	11/5/2018

7.1.1 Electrical design

DNV GL reviewed the electrical design drawing package provided by the Sponsor via their BOX project folder for each sample system. The electrical design packages have varying degrees of consistency and completeness.

DNV GL notes the following observations:

- Fourteen of the systems did not indicate the racking system being utilized. DNV GL was unable to confirm which mounting structures are UL 2703 listed and assess racking specific grounding considerations for these systems. Racking details are typically included within the design, but DNV GL did note that the installation process includes inspection checklists that do indicate that the racking system is grounded.
- The self-inspection photos for seventeen of the systems did not provide adequate information for review of the warning label signs. DNV GL notes that for multiple projects low resolution photos were provided for review which showed warning signs have been applied to the systems - some photos were taken at close range and the warning label can be read easily, while some photos were taken at a distance and it is more difficult to read the text. DNV GL is unable to confirm the content of these warning signs, code compliance and if they are appropriate for their respective systems. The Sponsor has indicated that it will instruct installers to take clearer photos of labels and from a closer distance so that they can all be read in detail.
- One of the projects does not address technology selection nor design approaches that could provide Potential Induced Degradation (PID) mitigation which leaves the potential for performance degradation over time and possible warranty coverage issues (specific to module installation manual language compliance). This is a common omission within residential portfolios; however current design approaches are starting to include this focus within their design processes.
- One system utilized undersized OCPD for the inverter output circuit they are protecting. This is not necessarily a safety concern, but it could cause nuisance trips and is not code compliant.

Due to the omissions noted, the sampled system designs exhibit varying degrees of quality and do not necessarily reflect a unified design process. While the omissions noted should be rectified for future designs, critical issues were not found and therefore DNV GL considers that the projects meet standard electrical design quality compared with typical practices in the residential market. Plan sets provide the necessary details, conductors and OCPD are sized appropriately, and equipment is rated for its intended usage, except where noted. DNV GL does not expect that the PV systems in the Portfolio are at above-normal risk of electrical issues and the inspections checklists provide additional assurances.

The detailed findings from the electrical design review are presented in Appendix A.

7.1.2 Structural design

The Sponsor does not require installers to submit structural design drawings as part of project completion. As such, DNV GL was not able to select a sample of structural designs for audit. Site visit inspection results are summarized in Section 7.2 in lieu of a structural design audit sample review.

7.1.3 RSIP inspection report review

DNV GL reviewed self-inspection reports and third party-inspection reports, if available, provided by the Sponsor for each of the twenty systems in the design audit review sample shown in Table 7-1. Prior to receiving an incentive, passing inspection documentation is required to be submitted. Therefore, all systems reviewed were deemed to have passed by the Sponsor. DNV GL has reviewed the inspection reports for completeness and any inconsistencies in the reports. DNV GL notes the following observations:

- For 19 systems, the inspection forms were complete or missing items that were deemed to be low risk. The most prevalent low risk deficiency was failure to complete the performance data section and provide solar reporting device information. It's also noted that for two systems, passing checks were provided for backup generator and battery backup when photographs did not indicate that either were installed at the home, suggesting that all items were checked as passing without care and attention.
- For the remaining system, there were missing passing checks for supply interconnection. If proper bonding was not achieved and overcurrent protection is not in place this would pose a high risk to the home.

Notes on the findings are presented in Appendix A.**Site inspection review summary**

7.2.1 Site visit sample

Ten PV systems were inspected in February 2020. These systems are distributed across seven install contractors as shown in Table 7-2.

Table 7-2 2020 Site visit Sample summary

Install Partner	# of systems in Portfolio	% of systems in Portfolio	# of system inspected
Trinity Solar	2,047	43%	1
PosiGen	523	11%	3
Sunrun	348	7%	1
SunPower Capital	245	5%	1
Ross Solar	148	3%	1
Earthlight Technologies	155	3%	2
SolarCity	113	2%	1
Total	**3,579**	**74%**	**10**

7.2.2 Sampling considerations

DNV GL provided the audit sample systems as well as 15 additional systems to IBTS for site visit scheduling. These candidate systems for inspection were selected from the top 10 installers by installed capacity (MWac). Sites inspected were determined by scheduling logistics organized between IBTS and homeowners.

The age of the systems inspected was between 0-5 years. The inspected systems are presented below.

Table 7-3 2020 site visit sample by installer

System ID	Installer
RPV-29426	Ross Solar
RPV-34118	SunPower Capital
RPV-29687	SolarCity
RPV-28820	PosiGen
RPV-33566	PosiGen
RPV-32507	Trinity Solar
RPV-29047	Earthlight Technologies
RPV-37248	Earthlight Technologies
RPV-36370	Sunrun
RPV-29623	PosiGen

7.2.3 Inspection methodology

DNV GL employed IBTS as its sub-contractor for purposes of inspecting deployed CT Green Bank systems. Typically, IBTS inspectors are on site for approximately 1 hour. The inspection has five major sections, which include site and safety, point of interconnection, inverter, electrical, and mechanical. Twenty-one priority criteria have been identified, as presented in Appendix C.

Applicable questions per major category are determined based upon the specifics of the system being inspected. Overall, IBTS requires 70% of the total points available with no failed priority criteria to pass a system. IBTS grades each question on a pass / fail basis. Points are assigned as follows:

- Non-labeling criteria:
  - Pass = 5 points
  - Fail = 0 points
- Labeling criteria:
  - Pass = 1 point
  - Fail = 0 points

IBTS site visit reports are internally quality reviewed prior to delivery to DNV GL.

DNV GL has reviewed the IBTS summary reports as well as individual inspection reports and photo documentation per system. DNV GL's summary of the ten site visit results, with particular focus on structural and electrical issues, is presented in the following sub-section.

7.2.4 Site inspection findings

An initial summary of IBTS's findings is presented in Table 7-4, below.

Table 7-4 CT Green Bank site inspection finding summary – IBTS scoring

Case #	System ID	Installer name	IBTS Priority criteria missed	Overall score	Overall IBTS scoring
SQ-1-20-8933	RPV-37248	Earthlight Technologies	1	97.0%	FAIL
SQ-1-20-8947	RPV-32507	Trinity Solar	0	97.0%	PASS
SQ-1-20-8932	RPV-29047	Earthlight Technologies	0	98.0%	PASS
SQ-1-20-8943	RPV-34118	SunPower	1	96.0%	FAIL
SQ-1-20-8937	RPV-29426	Ross Solar Group	0	96.0%	PASS
SQ-1-20-8939	RPV-29687	Solarcity	1	94.0%	FAIL
SQ-1-20-8945	RPV-36370	Sunrun Install	0	94.0%	PASS
SQ-1-20-8934	RPV-29623	Posigen	0	96.0%	PASS
SQ-2-20-9271	RPV-28820	Posigen	0	89.5%	PASS
SQ-2-20-9270	RPV-33566	Posigen	1	93.12%	FAIL

DNV GL reviewed the IBTS results to identify which priority criteria where not satisfied and thus caused an automatic failure for the system with an otherwise high score.

Three of the ten systems were identified to have failed due to a structural priority criterion missed. For these systems, all failures were related to the inadequate installation of flashing. While IBTS considers this a priority criteria, DNV GL typically ranks these as low in the short term and medium risk in the long term, as they do not represent a risk of the system failing, and are easily identified visually and fixed. The Sponsor has indicated that it will add the following line on the inspection checklist to remind installers to confirm adequate flashing: "Any roof penetrations are properly flashed and sealed."

One failure was also reported for electrical issues. The issue was conductors in contact with the roof surface, which DNV GL ranks as a low risk in the short term but high risk in the long term. The loose conductor issue is related to installation quality.

7.2.5 Structural inspection findings

Table 7-5 summarizes the incidence rate for structural issues across the ten inspected CT Green Bank systems.

Table 7-5 Incidence of structural issues at CT Green Bank site visits

Issue	Fails	% of systems with an issue
Flashing and Additional Penetrations	3	30%
Roof Conditions	0	0%
Racking & Module Installation	0	0%
Mounting of Other Components	0	0%
PV Array Layout[4]	2	20%

Of the structural inspection categories, Flashing and Additional Penetrations and PV Array Layout have the highest issue prevalence, at 30% of systems inspected having one or more occurrence in these categories.

Major IBTS findings, per inspection category, include:

- **Flashing and Additional Penetrations** – This category typically includes flashing of racking attachment feet and penetrations for conduits. Flashing installation issues included not installing metal flashing far enough under the shingles to provided required overlap for two systems, and on another the inspector did not observe the flashing installed for the Zep mounting feet, as per the installation manual. Improper flashing of penetrations can result in roof leaks, which may result in increased O&M costs if repairs are required under warranty. The International Residential Code (IRC) Section R903 and R905.2.8 has requirements for flashing of roof penetrations. The Sponsor has indicated that it will add the following line on the inspection checklist to remind installers to confirm adequate flashing: "Any roof penetrations are properly flashed and sealed."
- **Roof Conditions** — Roof conditions overall were found to be in good condition at all sites, with no excessive wear noted and no residents reporting roof leaks. DNV GL notes that it does not appear that the inspectors entered the attic to inspect the roof framing or positive attachment of the racking system. No sites were indicated to require additional structural evaluation.
- **Racking & Module Installation** – Racking and module installation system issues were not noted to be observed at any of the ten sites.
- **PV Array Layout** –Two systems identified as having module layouts which did not have the minimum requirements for fire access as specified by the International Fire Code (IFC) 605.11.1 and IBC 1512.1. The Sponsor confirmed that these two projects were permitted before the latest IFC was adopted by Connecticut in October 2018.

7.2.6 Electrical inspection findings

Table 7-6 summarizes the incidence rate for electrical issues across the 10 inspected CT Green Bank systems.

[4] This is reflective of the IBTS report, please see the PV Array Layout discussion in Section 7.2.5.

Table 7-6 Incidence of electrical issues at IBTS site visits

Issue	Fails	% of systems with an issue
Conductors loose/low beneath array	1	10%
Undersized circuit breaker	2	20%
Inadequate labeling	10	100%

Of the electrical inspection categories, labeling is a commonly identified issue, with a 100% prevalence. Several NEC code violations were noted in these inspections. The Sponsor has indicated that it will instruct installers to take clearer photos of labels and from a closer distance so that they can all be read in detail. Wire management and labeling are already on the Green Bank inspection checklist but the Green Bank will increase correspondence with installers to reduce these occurrences.

Major IBTS findings, per inspection category, include:

- **Wiring and Wire Management** – One instance found where array circuit conductors were in contact with the roof surface or hanging loose, which over time due to roof abrasion could damage the PV wire and will lead to conductor failure. The criticality is low in the short-term but high for long-term reliability.

7.2.7 Discussion

DNV GL has assessed all the issues presented by the independent site inspection agency and has assigned a DNV GL criticality index (low, med, high) rather than relying on the "priority" designation provided by IBTS.

7.2.7.1 Structural

For the structural issues noted, most of the items observed do not represent a high criticality. The most prevalent issue found in the inspection reports relates to flashing, which represents a low criticality which may lead to long term roof damage if the flashing issues are not resolved and roof leaks develop, leading to increased O&M costs due to roof leak warranty claims. The Sponsor has indicated that it will add the following line on the inspection checklist to remind installers to confirm adequate flashing: "Any roof penetrations are properly flashed and sealed." The two systems where improper clearance for fire access was noted represent a high criticality in the case of a fire, as the clearances are intended to provide access paths for firefighting operations. Although the systems did not meet the setback requirements, DNV GL notes that for most residential systems there are typically alternative ventilation and access options, given that the PV system typically does not cover an entire roof in which it is installed, or adjacent roofs. Additionally, for residential fires local authorities may choose not to vertically ventilate and access the roof due to the risk, and local jurisdictions may choose to relax these setback requirements. The Sponsor confirmed that the IFC requirements for these clearances had not yet been adopted in Connecticut at the time of installation. Both systems had applied for permits before the fire code was adopted in October 2018.

7.2.7.2 Electrical

DNV GL notes that some of the issues identified are typical of other residential systems and common issues across most sites are inadequate wire management and improper labelling. Wire management over the entire array should be checked to ensure conductors are not contacting roof surfaces or hanging low. A review of NEC required labels during the design stage may help alleviate improper labeling, especially with the use of inverter integrated solar modules.

A complete list of the electrical issues and a detailed assessment/criticality assignment for each issue is included in Appendix D.

The high criticality designation has been assigned to the following electrical issues:

- Wire management with respect to long term reliability (system # SQ-1-20-8943, SQ-1-20-8945)

8. FINANCIAL MODEL TECHNICAL INPUT REVIEW

DNV GL has not received a project specific financial model for review. DNV GL's review of technical inputs relevant for revenue generation as well as O&M considerations and stress case considerations follows.

8.1 Revenue

8.1.1 Correction factors

As discussed in Section 5 and summarized in Section 5.4, using the synthetic SHREC production generated from the production data of the Portfolio, DNV GL has calculated a P50 value of 1.033 which is intended to be applied to the Sponsor's first-year energy estimates for the Portfolio. When adjusting the correction factor for age and inverter availability, the P50 Year 1 annual forecast, representing 30 April 2020 – 1 May 2021, is 1.023 and is intended to be applied to the Sponsor's first-year energy estimates for the Portfolio.

8.1.2 Degradation

Recommended Portfolio degradation rates are described in Section 5.5.3, and re-presented in Table 8-1 below.

Table 8-1 Portfolio degradation rates

Percentile	Degradation rate
P50	-0.68%
P75	-0.89%
P90	-1.10%
P95	-1.25%
P99	-1.53%

When calculating annual forecasts, DNV GL combines the degradation rates with the Year 1 model uncertainties and variabilities assuming an independent relationship. This results in a further reduction of the apparent degradation rate observed when a degraded forecast is compared with the Year 1 forecast for any of the downside scenarios.

8.1.3 Useful life

DNV GL expects well-designed, properly installed, and well-maintained PV systems to perform in line with expectations for 25–30 years. While DNV GL views system performance and maintenance requirements as increasingly uncertain beyond Year 30, as equipment replacement rates are expected to increase, DNV GL considers that well-funded and maintained systems could achieve an operational life beyond their designed service life and up to 35 years or longer. Given the broad equipment list and installer base, and given the varying care with which homeowners will keep the systems clean, the actual achieved lifetime for the PV systems is expected to vary within the Portfolio.

8.2 O&M

DNV GL understands that the Sponsor does not have direct responsibility for O&M costs for the Portfolio, as the Sponsor's role is as an asset program administrator. As such, DNV GL has not reviewed either projected Performance Guarantee payout liabilities or inverter replacement cost projections.

8.3 Stress cases

The stress cases outline below are intended to illustrate potential risks to the Portfolio. DNV GL considers lower-than-expected Project performance and limited or absent operational monitoring and PV system maintenance risks to Portfolio economics.

- **Production stress cases**

  DNV GL's correction factors for P75, P90, P95, and P99 production stress cases are presented in Section 5.5.4, above.

- **Installer bankruptcy / market exit**

  DNV GL has considered the case that an installer is no longer able to service its systems. This would have potential deleterious impacts on SHREC production.

  The Sponsor has taken steps to mitigate against this risk. As noted in Section 2.2, the Sponsor has contracted with Locus Energy, an AlsoEnergy Company, for Portfolio monitoring, and the Sponsor has contracted with SunSystem Technology as a third-party US residential O&M provider. DNV GL views this as an appropriate risk mitigation step.

  In addition, DNV GL further notes the emergence of market depth in the form of specialized firms able to step in as O&M service providers for residential portfolio. In alphabetical order, Energy Expert Services, IndaSpec, and Omnidian are three such firms.

DNV GL can evaluate other stress cases upon request.

9. REFERENCES

[1] Connecticut Green Bank, *5537 CGB-DNV GL Tranche 3 PSA_EXECUTED,* August 21, 2019.

[2] Connecticut Green Bank, "About Us - Making Green Energy Accessible | CT Green Bank," [Online]. Available: https://ctgreenbank.com/wp-content/uploads/2019/07/Comprehensive-Plan_FY-2020-and-Beyond_Final__071819.pdf. [Accessed February 2020].

[3] Conneticut Green Bank, *Tranche 3 Composition,* Tranche 3 Composition.xlsx, 20 September 2019.

[4] Connecticut Green Bank, "Request for Qualifications and Program Guidelines," Rocky Hill, CT, November 1, 2016.

[5] "Trinity Solar," [Online]. Available: https://www.trinity-solar.com/. [Accessed 08 August 2018].

[6] Vivint Solar, [Online]. Available: https://www.vivintsolar.com/why-vivint-solar. [Accessed 24 September 2018].

[7] Vivint Solar, "2019 Annual Report," 2020.

[8] [Online] https://www.posigen.com/about/ "PosiGen Website", retrieved on 12 November 2019.

[9] S. F. Price, "Re: Tranche 3 Rev C report," Received via e-mail on May 7, 2020.

[10] PosiGen, "Posigen Hires New Executive Vice President of Human Resources," 4 September 2019. [Online]. Available: https://www.posigen.com/posigen-hires-new-executive-vice-president-of-human-resources/. [Accessed 24 March 2020].

[11] Sunrun Inc., "2017 Annual Report," 2017. [Online]. Available: http://investors.sunrun.com/static-files/23cdb77a-6b06-47dc-bcbc-1115f69f8da2. [Accessed 08 August 2018].

[12] Sunrun Inc., "Sunrun Reports Fourth Quarter and Full Year 2019," 2019. [Online]. Available: https://investors.sunrun.com/news-events/press-releases/detail/195/sunrun-reports-fourth-quarter-and-full-year-2019-financial. [Accessed 27 February 2020].

[13] [Online] https://us.sunpower.com/company "SunPower Website", retrieved on 13 November 2019.

[14] SunPower Annual Report, dated 2018.

[15] [Email] S. Price from Selya.Price@ctgreenbank.com to D. Chatterjee Devduti.Chatterjee@dnvgl.com,, "re: Solarcity modules/installer information,," 14 November 2019.

[16] DNV GL, "PV Module Reliability Scorecard," [Online]. Available: https://www.dnvgl.com/energy/publications/index.html?kw=493. [Accessed 1 October 2018].

[17] Wood Mackenzie staff , "Wood Mackenzie US PV Leaderboard, Q2 2019," Wood Mackenzie, 2019.

[18] National Renewable Energy Laboratory, "Characterizing Shading Losses on Partially Shaded PV Systems," Albuquerque, NM, 2010.

[19] Clean Power Research, "SolarAnywhere PV Simulation Production Documentation v2.1," Last Updated 26 March 2018.

[20] "Dobos, A., "PVWatts Version 5 Manual", September 2014.".

[21] D. C. Jordan and S. R. Kurtz, "Photovoltaic Degradation Rates—an Analytical Review," *Progress in Photovoltaics: Research and Applications,* vol. 21, no. 1, pp. 12-29, 2013.

[22] "CPR follow-up on Fleetview reporting of inverters for 2 projects, email from Selya Price, Connecticut Green Bank, to Cory Cox, DNV GL, dated 3 April 2020.".

[23] Connecticut Green Bank, *Production Data Tape,* SHREC Tranch 3 Mon'ly Production_Non Filtered 12-19U.xlsx, 11 February 2020.

[24] Clean Power Research, *Solar Resource Ration Per Project ID_011420rfd_T3a.xlsx,* 11 February 2020.

[25] Patrick Keelin, CPR, *"What U.S. PV plant owners have seen in 2018/2019 is real: sunshine has been scarce",* 30 July 2019.

[26] Connecticut Green Bank, *SHREC creation and minting process SOP,* SHREC creation and minting process SOP (Rev 3.1.2018).xlsx, 01 March 2018.

[27] D. C. Jordan, S. R. Kurtz, K. VanSant and J. Newmiller, "Compendium of photovoltaic degradation rates: Photovoltaic degradation rates," *Progress in Photovoltaics: Research and Applications,* 2016.

[28] Connecticut Green Bank, "P50 P90 Per Project ID Update_Tranche 3 Sites_02072020.xlsx," 11 February 2020.

[29] "Master Purchase Agreement for the Purchase and Sale of Solar Home Renewable Energy Credits by and between the Connecticut Light and Power Company dba Eversource Energy and The Connecticut Green Bank," February 7, 2017.

[30] "Master Purchase Agreement for the Purchase and Sale of Solar Home Renewable Energy Credits by and between The United Illuminating Company and The Connecticut Green Bank," February 7, 2017.

[31] [Online]. Available: https://ctgreenbank.com/programs/homeowners/ . [Accessed April 2020].

APPENDIX A – ELECTRICAL DESIGN ISSUES LIST

Table A-1 Electrical Design Issues Summary

ID	Design Review Notes	Risks
RPV - 23359		
001	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
002	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 25902		
004	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
005	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 26200		
006	No issues noted	
RPV – 28957		
007	No issues noted	
RPV – 29044		
008	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
009	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC 690.
RPV – 29047		
010	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
011	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 29426		
012	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
013	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC 690.
RPV – 29623		
014	The solar OCPD at the main panel is undersized.	Regulatory, performance – OCPD should be sized to 125% of the inverter output current. Under sizing will cause nuisance trips leading to lost production.
015	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
016	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 29687		
017	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
018	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
019	There are no provisions to prevent PID and the dc system is ungrounded	Performance - Potential for significant performance degradation over time and potential module warranty coverage issues.
RPV – 30047		
020	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 30543		

ID	Design Review Notes	Risks
021	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
022	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 30631		
023	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
024	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
025	There are no provisions to prevent PID and the dc system is ungrounded	Performance - Potential for significant performance degradation over time and potential module warranty coverage issues.
RPV – 31451		
026	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 32507		
027	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 32856		
028	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
029	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 33291		
030	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
031	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 34118		
032	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
033	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
RPV – 36370		
034	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
035	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.
RPV – 36462		
036	No issues noted	
RPV – 37248		
037	Electrical design does not specify the PV Racking structure or it being UL listed.	Regulatory – all equipment is required to be listed as UL 2703 or to otherwise meet bonding requirements per NEC.
038	Warning signage was not provided for review.	Regulatory, safety – appropriate warning signage is required per NEC.

Table A-2 RSIP Inspection Report Summary

ID	Inspection Review Notes	Risks
RPV – 23359		
	Form missing complete performance data	Low risk
RPV – 25902		
	Form is complete	
RPV – 26200		
	Form should be marked as "n/a" for overcurrent protection and dc disconnect label due to use of microinverters. Missing passing criteria for inverter/interconnection. Green Bank inspector verified missing items as passing.	Low risk
RPV -28957		
	Form should be marked as "n/a" for overcurrent protection and dc disconnect label due to use of microinverters.	Low risk
RPV - 29044		
	Form is missing pass checks for supply side interconnection. Form is missing solar reporting device information.	High risk if proper bonding was not achieved and overcurrent protection is not in place.
RPV - 29047		
	Form is complete	
RPV - 29426		
	Form is complete	
RPV - 29623		
	Form missing performance data. Also note that "pass" checks were added for backup generator and battery backup, neither of which are shown in the photos, suggesting the installer simply checked all line items without reading them.	Low risk
RPV - 29687		
	Form missing complete performance data	Low risk
RPV - 30047		
	Form missing complete performance data, solar reporting device information.	Low risk
RPV - 30543		
	Form missing complete performance data. Also note that "pass" checks were added for backup generator and battery backup, neither of which are shown in the photos, suggesting the installer simply checked all line items without reading them.	Low risk
RPV - 30631		
	Form missing complete performance data	Low risk
RPV - 31451		

	Form is complete	
RPV - 32507		
	Form missing pass check for customer ability to access data	Low risk
RPV - 32856		
	Incorrect RPV system number listed	Low risk on incorrect RPV number since the homeowner name and address match contract
RPV - 33291		
	Form missing complete performance data, solar reporting device information.	Low risk
RPV - 34118		
	Form is complete	
RPV - 36370		
	Form missing complete performance data, solar reporting device information	Low risk
RPV - 36462		
	Form missing complete performance data, solar reporting device information	Low risk
RPV - 37248		
	Form is complete	

APPENDIX B – VALIDATION OF PRODUCTION ESTIMATES

DNV GL has attempted to replicate the Sponsor's energy forecasting process. System specifications and validation results are listed below.

Table B-1 SolarAnywhere Fleetview inputs for audits 1 to 5

Audit #	1	2	3	4	5
ID	RPV-28389	RPV-28957	RPV-29044	RPV-29047	RPV-29426
City	New Britain	Hamden	Meriden	Brookfield	Canton
State	CT	CT	CT	CT	CT
ZIP Code	06051	06517	06450	06804	06019
PTO Date	12/29/2017	3/20/2018	5/9/2018	2/2/2018	3/8/2018
PV Module Manufacturer	Jinko Solar	LG Electronics	Jinko Solar	SunPower	Silfab Solar
PV Module Model	JKM285M-60B	LG320N1C-G4	JKM290M-60B	SPR-X22-360-C-AC-240V	SLA-M 310W
Module Pmax (W)	285	320	290	360	310
DC Power (kWp)	2.85	4.48	4.06	8.64	13.02
Inverter Manufacturer	Solar Edge	Enphase	Solar Edge	SunPower	Solar Edge
Inverter Model	SE3800H-US	iQ6+	SE3800H-US	SPR-X22-360-C-AC-240V	SE10000A-US
No. of Inverters	1	14	1	24	1
Array 1 - DC Power (kWp)	2.85	4.48	2.61	4.68	6.82
Array 1 - Tilt (°)	39	32	23	26	30
Array 1 - Azimuth (°)	174	182	111	223	147
Array 1 - Average Shading Loss (%)	89%	94%	91%	94%	86%
Array 2 - DC Power (kWp)			1.275	3.96	2.17
Array 2 - Tilt (°)			23	16	30
Array 2 - Azimuth (°)			291	223	237
Array 2 - Average Shading Loss (%)			80%	93%	77%
Array 3 - DC Power (kWp)					2.17

Audit #	1	2	3	4	5
Array 3 - Tilt (°)					34
Array 3 - Azimuth (°)					147
Array 3 - Average Shading Loss (%)					94%
Array 4 - DC Power (kWp)					1.86
Array 4 - Tilt (°)					34
Array 4 - Azimuth (°)					237
Array 4 - Average Shading Loss (%)					84%

Table B-2 SolarAnywhere Fleetview inputs for audits 6 to 10

Audit #	6	7	8	9	10
ID	RPV-29623	RPV-29687	RPV-29825	RPV-30020	RPV-30047
City	Ansonia	Branford	Hamden	Ridgefield	Windham
State	CT	CT	CT	CT	CT
ZIP Code	06401	06405	06517	06877	06280
PTO Date	2/23/2018	4/10/2018	4/20/2018	4/23/2018	5/9/2018
PV Module Manufacturer	Silfab Solar	Hanwha	LG Electronics	Silfab Solar	LG Electronics
PV Module Model	SLA290M	Hanwha Q.Peak-G4.1/SC300	LG320N1K-A5	SLA310M	LG335N1C-A5
Module Pmax (W)	290	300	320	310	335
DC Power (kWp)	8.7	5.4	5.12	14.88	13.4
Inverter Manufacturer	Solar Edge	ABB	Enphase	Solar Edge	Solar Edge
Inverter Model	SE7600H-US	PVI-5000-OUTD-US (240V)	iQ6PLUS-72-2-US	SE7600H-US	SE6000H
No. of Inverters	1	1	16	2	2
Array 1 - DC Power (kWp)	8.7	5.4	5.12	14.88	9.045
Array 1 - Tilt (°)	20	13	28	40	40
Array 1 - Azimuth (°)	245	141	186	178	114
Array 1 - Average Shading Loss (%)	99%	76%	97%	79%	83%
Array 2 - DC Power (kWp)					4.355
Array 2 - Tilt (°)					40
Array 2 - Azimuth (°)					204
Array 2 - Average Shading Loss (%)					73%

Table B-3 SolarAnywhere Fleetview inputs for audits 11 to 15

Audit #	11	12	13	14	15
ID	RPV-30543	RPV-30631	RPV-31451	RPV-32507	RPV-32856
City	Bristol	Danbury	New Britain	Plainville	Windsor
State	CT	CT	CT	CT	CT
ZIP Code	06010	06811	06051	06062	06095
PTO Date	6/19/2018	5/23/2018	5/7/2018	9/20/2018	7/23/2018
PV Module Manufacturer	Silfab Solar	SolarCity	Hanwha	Hanwha	SunPower
PV Module Model	SLA290M	SC325	Hanwha 295 Q.PEAK-BLK G4.1 295	Hanwha 295 Q.PEAK-BLK G4.1 295	SPR-X21-350-BLK-D-AC
Module Pmax (W)	290	325	295	295	350
DC Power (kWp)	6.38	4.225	15.34	9.44	4.9
Inverter Manufacturer	Solar Edge	Delta	Solar Edge	Solar Edge	SunPower
Inverter Model	SE5000H-US	Solivia 5.2 TL	SE6000H	SE7600H	SPR-X21-350-BLK-D-AC
No. of Inverters	1	1	2	1	14
Array 1 - DC Power (kWp)	5.22	4.225	8.26	1.475	4.9
Array 1 - Tilt (°)	30	37	19	30	22
Array 1 - Azimuth (°)	166	190	82	86	178
Array 1 - Average Shading Loss (%)	73%	100%	83%	95%	86%
Array 2 - DC Power (kWp)	1.16		7.08	3.245	
Array 2 - Tilt (°)	15		18	30	
Array 2 - Azimuth (°)	346		262	176	
Array 2 - Average Shading Loss (%)	66%		72%	90%	
Array 3 - DC Power (kWp)				4.72	
Array 3 - Tilt (°)				23	
Array 3 - Azimuth (°)				176	
Array 3 - Average Shading Loss (%)				99%	

Table B-4 SolarAnywhere Fleetview inputs for audits 16 to 20

Audit #	16	17	18	19	20
ID	RPV-33291	RPV-34118	RPV-36370	RPV-36462	RPV-37248
City	Clinton	New Milford	Danbury	New Milford	South Windsor
State	CT	CT	CT	CT	CT
ZIP Code	06413	06776	06810	06776	06074
PTO Date	8/23/2018	9/26/2018	1/9/2019	12/17/2018	12/28/2018
PV Module Manufacturer	LG Electronics	SunPower	REC Solar	LG Electronics	SunPower
PV Module Model	LG350Q1C-A5	SPR-X22-360-D-AC	REC290TP2 BLK	LG365Q1C-A5	SPR-X21-345-D-AC
Module Pmax (W)	350	360	290	365	345
DC Power (kWp)	8.4	10.44	9.28	10.22	5.52
Inverter Manufacturer	Solar Edge	SunPower	Solar Edge	Enphase	SunPower
Inverter Model	SE7600H-USRGM	SPR-X22-360-D-AC	SE10000H-US	iQ7PLUS-72-2-US	SPR-X21-345-D-AC
No. of Inverters	1	29	1	28	16
Array 1 - DC Power (kWp)	1.4	10.44	5.51	2.92	5.52
Array 1 - Tilt (°)	18	23	24	34	24
Array 1 - Azimuth (°)	327	195	128	162	215
Array 1 - Average Shading Loss (%)	83%	77%	78%	70%	99%
Array 2 - DC Power (kWp)	7		3.77	7.3	
Array 2 - Tilt (°)	42		23	31	
Array 2 - Azimuth (°)	147		308	162	
Array 2 - Average Shading Loss (%)	63%		71%	59%	

Table B-5 SolarAnywhere Fleetview results for audits 1 to 5

Audit #	1	2	3	4	5
ID	RPV-28389	RPV-28957	RPV-29044	RPV-29047	RPV-29426
As-built expected first year production [kWh]	3,190	5,622	3,657	9,801	13,776
DNV GL Prediction from SolarAnywhere Fleetview [kWh/year]	3,190	5,622	3,657	9,828	13,761
Deviation [%]	0.00%	0.00%	0.00%	-0.27%	0.11%

Table B-6 SolarAnywhere Fleetview results for audits 6 to 10

Audit #	6	7	8	9	10
ID	RPV-29623	RPV-29687	RPV-29825	RPV-30020	RPV-30047
As-built expected first year production [kWh]	10,084	5,035	6,504	14,605	13,091
DNV GL Prediction from SolarAnywhere Fleetview [kWh/year]	10,084	5,035	6,504	14,605	13,084
Deviation [%]	0.00%	0.00%	0.00%	0.00%	0.05%

Table B-7 SolarAnywhere Fleetview results for audits 11 to 15

Audit #	11	12	13	14	15
ID	RPV-30543	RPV-30631	RPV-31451	RPV-32507	RPV-32856
As-built expected first year production [kWh]	5,759	5,517	14,600	11,224	5,323
DNV GL Prediction from SolarAnywhere Fleetview [kWh/year]	5,759	5,517	14,600	11,224	5,323
Deviation [%]	0.00%	0.00%	0.00%	0.00%	0.00%

Table B-8 SolarAnywhere Fleetview results for audits 16 to 20

Audit #	16	17	18	19	20
ID	RPV-33291	RPV-34118	RPV-36370	RPV-36462	RPV-37248
As-built expected first year production [kWh]	7,027	10,152	8,287	10,489	6,712
DNV GL Prediction from SolarAnywhere Fleetview [kWh/year]	7,027	10,153	8,287	10,490	6,712
Deviation [%]	0.00%	0.00%	0.00%	0.00%	0.00%

APPENDIX C – IBTS INSPECTION CRITERIA

- Site and Safety
  - System Powered On
  - Any Ground Faults
  - Tripped Breakers
- Point of Interconnection
  - Overcurrent Device Protecting Panelboard Busbar
  - Supply Side of Service Disconnecting
  - Breakers Listed for Back Feeding
- Inverter
  - Is Inverter Operating
- Electrical
  - Conductors on Rooftop Properly Sized
  - DC PV Source Circuits Run Inside Buildings
  - System Conductors Readily Accessible
  - Conductors Exposed
  - Are Conductors Loose Beneath Array
  - Are Conductors Touching Roof Surface
  - System Properly Grounded
  - Modules Electrically Grounded Accordance
  - Code Violations
- Structural and Mechanical
  - Is Equipment Mounted Securely
  - Are Boxes Securely Installed
  - Any Objects or Hardware in Contact
  - Any Sign of Damage
  - Are Footing Support Structure

APPENDIX D – IBTS INSPECTION COMMENTARY

Case #	System ID (RPV #)	Overall score	Priority Criteria Missed	Commentary	Electrical code violations	Criticality of Electrical issues noted (low, med, high)	Structural /building code violations	Criticality of Structural/Building code issues noted (low, med, high)
SQ-1-20-8933	RPV-37248	97.00%	1	6.9 Comment - PRIORITY CRITERIA Flashing for racking not installed far enough under the courses of shingles to provide critical overlap as identified in IRC. 7.3 Comment - NEC 690.31 DC conduit warning label applied to AC conduit. 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only.	NEC 690.31/17	NEC 690.31/17 have to do with PV system labels. Criticality is low as it is a documentation issue.	IBC R903, R905.2.8	IBC R903 and R905.2.8 have to do with roof flashing requirements; Inspection indicates flashing for racking not installed far enough under courses of shingles to provide overlap as identified in IRC. Criticality is low in the short term but medium for long term as roof damage may occur if roof leaks occur due to improper flashing.
SQ-1-20-8947	RPV-32507	97.00%	0	System is not installed with respect to IFC required clearances to allow adequate access. 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only. 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating the locations of the PV system disconnecting means when not located at the same location per NEC 690.56(B).	NEC 690.17/56	NEC 690.17/56 have to do with PV system labels. Criticality is low as it is a documentation issue.	IFC 605.11.1, IBC 1512.1	IFC 605.11.1, IBC 1512.1 provides requirements for clearances around solar array for fire access; based on site photos, array appears to extend to edges of roof, not providing minimum clearances for firefighting access; criticality is high in case of fire, and represents possible life safety risk in case of fire
SQ-1-20-8932	RPV-29047	98.00%	0	7.5 Comment - Missing label identifying AC disconnect as required per NEC 110.22(A) 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only. 7.9 Comment - Missing values for nominal AC voltage and AC output current per NEC 690.54. 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating the locations of the PV system disconnecting means when not located at the same location per NEC 690.56(B). 7.11 Comment - Missing label identifying system is equipped with rapid shutdown per NEC 690.56(C), 690.31(G)(4)	NEC 110.22(A) NEC 690.17/54/56/31	NEC 690.17/54/56/31 and NEC 110.22(A) have to do with PV system labels. Criticality is low as it is a documentation issue.	None	None
SQ-1-20-8943	RPV-34118	96.00%	1	5.16 Comment - PRIORITY CRITERIA One conductor is contacting abrasive roof surface. 7.3 Comment - NEC 690.31 DC conduit warning label applied to AC conduit. 7.5 Comment - Missing label identifying AC disconnect as required per NEC 110.22(A) 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only. 7.9 Comment - Missing values for nominal AC voltage and AC output current per NEC 690.54.	NEC 110.27(B) NEC 110.22(A) NEC 690.17/54	NEC 110.27(B) has to do with wire management issues and criticality is low in the short term but high for long term reliability NEC 690.17/54 and NEC 110.22(A) have to do with PV system labels. Criticality is low as it is a documentation issue.	None	None
SQ-1-20-8937	RPV-29426	96.00%	0	System is not installed with respect to IFC required clearances to allow adequate access. 6.10 Comment - Conduit into conditioned space not properly sealed per NEC 300.7. 7.2 Comment - Hand written label information is not durable or permanent as required per NEC 110.21(B). 7.4 Comment - Missing required label for ungrounded systems per NEC 690.35 "WARNING ELECTRIC SHOCK HAZARD.	NEC 300.7 NEC 110.21(B) NEC 690.35	NEC 300.7 has to do with sealing conduits routed in different temperature locations to prevent condensation. Criticality is moderate. NEC 690.35 and NEC 110.21(B) have to do with PV system labels. Criticality	IFC 605.11.1, IBC 1512.1	IFC 605.11.1, IBC 1512.1 provides requirements for clearances around solar array for fire access; based on site photos, array appears to extend to edges of roof, not providing minimum clearances for firefighting access; criticality is high in case of fire, and represents possible life safety risk in case of fire

				THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED".		is low as it is a documentation issue.		
SQ-1-20-8939	RPV-29687	94.00%	1	System is not installed with respect to IFC required clearances to allow adequate access. 6.9 Comment - PRIORITY CRITERIA Unable to verify flashing for Zepp solar mounts. All documentation on web shows mounts installed with flashing attached. 7.2 Comment - Hand written label information is not durable or permanent as required per NEC 110.21(B). 7.4 Comment - Missing required label for ungrounded systems per NEC 690.35 "WARNING ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED". 7.5 Comment - Missing label identifying DC disconnect. as required per NEC 690.13(B). 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only. 7.9 Comment - 690.54 label is present, but values are incorrect. Current value reads 23A, but it should read 20.83A.	NEC 110.21(B) NEC 690.36	NEC 690.35/13/17/54 and NEC 110.21(B) have to do with PV system labels. Criticality is low as it is a documentation issue.	IFC 605.11.1, IBC 1512.1 IBC R903, R905.2.8	IFC 605.11.1, IBC 1512.1 provides requirements for clearances around solar array for fire access; based on site photos, array appears to extend to edges of roof, not providing minimum clearances for firefighting access; criticality is high in case of fire, and represents possible life safety risk in case of fire; IBC R903 and R905.2.8 have to do with roof flashing requirements; Inspection indicates flashing for Zep Solar mounts is not able to be verified, whereas web shows mounts installed with flashing attached. Criticality is low in the short term but medium for long term as roof damage may occur if roof leaks occur due to improper flashing.
SQ-1-20-8945	RPV-36370	94.00%	0	5.9 Comment - Improper strain relief used where conductors transition into conduit. 5.15 Comment - Some loose and sagging array conductors are not properly supported beneath the array per NEC 110.27(B). 7.2 Comment - Hand written label information is not durable or permanent as required per NEC 110.21(B). 7.6 Comment - AC enclosure labeled incorrectly with NEC 690.17 label that applies to DC components only. 7.8 Comment - Ungrounded system inverter has labels for both ungrounded system and grounded system. Only the ungrounded label should be present (NEC 690.35(F)). 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating the locations of the PV system disconnecting means when not located at the same location per NEC 690.56(B). 7.11 Comment - Missing label identifying system is equipped with rapid shutdown per NEC 690.56(C), 690.31(G)(4)	NEC 300.16(B) NEC 110.27(B) NEC 110.21(B) NEC 690.17/35/56/31	NEC 300.16(B) has to do with strain relief and criticality is low in the short term but high for long term reliability. NEC 110.27(B) has to do with wire management issues and criticality is low in the short term but high for long term reliability NEC 690.17/35/56/31 and NEC 110.21(B) have to do with PV system labels. Criticality is low as it is a documentation issue.	None	None
SQ-1-20-8934	RPV-29623	96.00%	0	3.25 Comment - Inverter OCPD sized too small at 35A. Should be 40A. 7.4 Comment - Missing required label for ungrounded systems per NEC 690.35 "WARNING ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED". 7.6 Comment - Missing required NEC 690.17(E) label "WARNING ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION". 7.7 Comment - All values are absent at NEC 690.53 label. 7.9 Comment - Missing values for nominal AC voltage	NEC 240.6 NEC 690.35/17/53/54/56	NEC 240.6 has to do with OCPD sizing. Criticality is moderate as the undersized OCPD may cause nuisance trips. NEC 690.35/17/53/54/56 has to do with PV system labels. Criticality is low as it is a documentation issue.	None	None

				and AC output current per NEC 690.54. 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating the locations of the PV system disconnecting means when not located at the same location per NEC 690.56(B).				
SQ-2-20-9271	RPV-28820	89.50%	0	2.8 Comment - Inverter overcurrent protection device sized too small at 35A. 3.25 Comment - Inverter OCPD sized too small at 35A. Should be 40A. 5.26 Comment - Equipment grounding conductor on roof is not run with the circuit conductors within the same raceway per NEC 690.43(F). 5.31 Comment - ILSCO taps are not rated for use on cloth-wrapped wires. 6.6 Comment - EMT conduit not securely fastened and supported within 3 feet of the junction box per (NEC 358.30(A)). 7.4 Comment - Missing required label for ungrounded systems per NEC 690.35 "WARNING ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED". 7.9 Comment - 690.54 label is present but values are incorrect. Current value reads 27A, but it should read 31.67A. 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating	NEC 240.6 NEC 300.3(B) NEC 110.14 NEC 358.30(A) NEC 690.35/53/54/56	NEC 240.6 has to do with OCPD sizing. Criticality is moderate as the undersized OCPD may cause nuisance trips. NEC 300.3(B) has to do with conductor grouping. Criticality is moderate. NEC 110.14 has to do with terminations. Criticality is moderate. NEC 358.30 has to do with conduit supports. Criticality is low in the short term but high for long term reliability. NEC 690.35/54/56 has to do with PV system labels. Criticality is low as it is a documentation issue.	None	None
SQ-2-20-9270	RPV-33566	93.12%	1	6.1 Comment - Modules installed in an un-level, non-planar fashion. 6.9 Comment - PRIORITY CRITERIA Flashing for conduit supports not installed far enough under the courses of shingles to provide critical overlap as identified in IRC. 7.4 Comment - Missing required label for ungrounded systems per NEC 690.35 "WARNING ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED". 7.9 Comment - 690.54 label is present but values are incorrect. Current value reads 22A, but it should read 20.83A. 7.10 Comment - Missing required plaque or directory at the service disconnecting means indicating	NEC 690.35/53/54/56	NEC 690.35/54/56 has to do with PV system labels. Criticality is low as it is a documentation issue.	IBC R903, R905.2.8	IBC R903 and R905.2.8 have to do with roof flashing requirements; Inspection indicates flashing for racking not installed far enough under courses of shingles to provide overlap as identified in IRC. Criticality is low in the short term but medium for long term as roof damage may occur if roof leaks occur due to improper flashing.

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, we empower our customers' decisions and actions with trust and confidence. We continuously invest in research and collaborative innovation to provide customers and society with operational and technological foresight. Operating in more than 100 countries, our professionals are dedicated to helping customers make the world safer, smarter and greener.