From: Jeremy Price
Sent: Wednesday, September 13, 2023 11:54 AM
To: vankerkhoffmark@KaneCountyIL.gov
Cc: rford@kanecoboard.org; Berkhout, Keith <BerkhoutKeith@KaneCountyIL.gov>; Benjamin Jacobi <BJacobi@Polsinelli.com>
Subject: Petition 4615 - RPIL Solar 8 LLC Continuance Request

Good Morning Mark:

Based on a brief discussion with Keith, I am providing RPIL Solar 8 LLC's formal request here in writing to continue Petition 4615 to the scheduled 10/17 meeting. I have copied Chairman Ford here as well for awareness (thank you).

We are kindly requesting this continuance in order to conduct additional outreach to abutting landowners who had not initially respond to our project outreach mailer, but provided comment last night at the ZBA public hearing.

We appreciate the Development Committee's consideration of this request. Please advise if additional information is needed on our end.
Sincerely,

Jeremy Price
Project Developer

M: (978) 382 - 1751
jprice@renewprop.com

Renewable Properties, LLC
44 Montgomery Street, Suite 3150
San Francisco, CA 94104
www.renewprop.com

Technical Memorandum

To:	Mr. Ron Ford, Chairman & Kane County Development Committee Members
From:	Jeremy Price, Project Developer RPIL Solar 8, LLC
Subject:	Kane County September 12, 2023 Zoning Board of Appeals Hearing Follow-up
Date:	September 19, 2023

As a follow-up to the September 12, 2023, Zoning Board of Appeals (ZBA) Meeting for the Plato Road Solar Project ("Project"), RPIL Solar 8, LLC has compiled the following technical memorandum providing additional information and responses to raised comments and/or concerns for this Committee's consideration.

Project Landowners

Linda and Robert Matson are fifth (5th) generation Kane County residents, who have raised their three children through the Central School District 301 ("District"). Linda Matson was a third (3rd) grade teacher for five years within the District, and further support the District for another 10 years by helping educate those sick or otherwise homebound. Robert Matson is a landowner, retired U.S. military veteran, and served as an auxiliary policeman and fireman for nearly 10 years. Robert has been an active board member of the St. Charles Historical Society since 1963.

Project Outreach

As part of the Project's commitment to transparency and collaboration, in addition to following all state and locally required abutter notification procedures, the Project has on two separate occasions mailed written correspondence to abutters within 250' of the Project site prior to the ZBA hearing. These notification letters included our contact information and an invitation to further discuss any questions or concerns. Municipalities and/or other regulatory entities were contacted directly as part of these efforts. No calls or emails were returned from these mailers.

During the September 12, 2023 meeting, Gregory and Lynn Peloquin, a neighbor provided testimony. Immediately following the ZBA Public Hearing, the Project reached out (to his home and work phone) directly to discuss their comments. As of the submission of this letter, our message has not been returned.

During the ZBA public hearing, testimony was also provided by the District's Communication Director that the Project had not reached out to the District, as indicated during our presentation. The Central School District was a recipient of both mailers outlined above. Additionally, the Project had left direct messages for the District's Superintendent, Dr. Esther Mongan, and sent a follow-up email on August 1, 2023. As part of this outreach the Project also spoke with Principal Podgorski, and left a message with Dan Polowy of facility operations upon Principal Podgorski's guidance. Following the ZBA hearing, the Project followed up again with the District, and we have successfully scheduled a meeting for the week of September 25th, 2023.

Property Values

One of the main concerns identified during the hearing pertained to potential impacts to property values. As indicated during this meeting, Renewable Properties, LLC has contracted with CohnReznick ("CR"), a leading property Valuation Advisory Services firm based out of Chicago, Illinois. CR has conducted a literature review report, as well as a project-specific Property Value Impact Report within Illinois.

CR has conducted over 35 studies across 18 states analyzing both residential and agricultural properties, the findings of which indicate that solar facilities have not "caused consistent and measurable negative impacts on Property values". Furthermore, their findings have determined that solar farms have "not deterred the development of new single-family homes on adjacent land". Lastly, CR has conducted a series of interviews with more than 60 County and Township assessors where at least one solar project is located. These interviews have confirmed solar farms do not negatively impact property values. Assessors from LaSalle, Winnebago, Fayette, and Champaign County within Illinois were included in the mentioned interviews. The Project is willing and able to provide a copy of the literature review-based Property Value Impact Report as deemed useful.

Toxicity and Water Quality Issues

Please find the below excerpt attesting to the non-toxicity of solar panels from the attached Health and Safety Report included in **Exhibit A.**

"In 2019, an international team of experts conducted an International Energy Agency (IEA) - Photovoltaic Power Systems Program (PVPS) study to assess if there is a public health hazard caused by lead leaching from the broken silicon PV panels during the life of a utility scale solar facility. The study simulated worst-case scenarios, unlikely to be experienced by an actual solar facility, utilizing conservative assumptions to evaluate extreme scenarios. The study examined worst-case exposure routes of soil, air, and ground water for a typical 100 MWAC PV facility for crystalline modules. For example, the worst-case residential groundwater exposure assumed that all broken panels from the entire array were exposed to acid rain, for an entire year, and any chemicals released from every broken panel transported to the same groundwater well located just 25 feet away. Again, this is not a realistic scenario, but it was assumed in order to generate the most conservative potential outcome. The study found that under this very unlikely, worst-case, scenario, lead exposure via groundwater was four orders of magnitude (i.e. a factor of more than 10,000) less than the maximum levels defined by the EPA to have no adverse health effects, which is the same standard used for public drinking water in the U.S. This study demonstrates that there is no risk to public health from lead or cadmium leached from broken PV panels."

Additionally, most newly manufactured panels use a lead-free solder as part of the manufacturing process, further reducing the risk of impacts to the soil or groundwater. During regularly scheduled maintenance visits, panels are evaluated for damage and/or irregular wear. As necessary, panels are replaced where damage is discovered. The Project's expected panels have received their IEC 61215 accreditation which reviews the quality and safety of materials and under simulated stress conditions, evaluates potential for defects, failures, and panel leakage from moisture or weather conditions.

Given these results, it is unlikely that panels on the site in operating conditions would pose any threat to soil, stormwater, or groundwater, including downstream. Based on the expected erosion reductions through the meadow conversion and additional plantings, water quality leaving the Project limits would be improved over today's conditions. Accordingly, the Cardinal Creek Forest Preserve would not be harmed, but rather benefit from the Project's construction.

School District Solar Facility Proximity

Various school districts throughout Illinois have chosen to use solar energy to power their schools. No adverse effects have been documented, and the schools have benefited from the energy generated. Several local schools (e.g. Huntley Community School District 158 and Mooseheart) have installed ground-mounted systems on-site.

Access & Visibility

The Project was designed to abide by ordinance requirements for easements, as well as future right-of-way accommodation. Vegetative screening will be installed as necessary to mitigate views of the panels themselves. A mix of deciduous trees, shrubs, and other plantings will be used to ensure that screening is present year-round. The Project is willing to further coordinate with the abutting landowners on potential adjustments and/or modifications.

Stormwater

There were expressed concerns that stormwater leaving the property would impact downstream residents. The Project's existing conditions are agricultural land, subjected to compaction as a result of continuous farming. The proposed condition will be a meadow (native grasses and forbs) with little additional impervious area aside from the gravel access road, panel posts, and equipment pads. The proposed conditions will allow for a lower site outflow compared to existing conditions, as the proposed land type will allow for better stormwater infiltration. As detailed by the stormwater report included in the petition, the Project is expected to yield reductions in site runoff compared to the existing conditions during the modeled 2-year and 100-year storm events. These reduction calculations are 27% and 12.8% respectively. Please note that these estimates are conservative and do not account for the additional plantings to be installed by the project which will provide additional infiltration, bioremediation, and other benefits.

The existing on-site wetlands will be maintained and not impacted by the proposed development. Panels will not collect or impact stormwater drainage, and existing flow patterns will be maintained. The Project will comply with the proposed stipulations by the Kane County Water Resources Department; however,

will need further clarification on the proposed #7 stipulation to better understand the request, and determine the Project's ability to meet the requirement.

RENEWABLE PROPERTIES

Exhibit A

HEALTH AND SAFETY ASSESSMENT REPORT – TOXICITY –

[redacted]

Two 5.0 MW_{AC} Photovoltaic Facilities

[redacted]

ABSTRACT

This is an assessment of the potential health and safety impacts of two proposed 5.0 MW_{AC} solar photovoltaic facilities in [redacted]. The assessment evaluates potential toxicity impacts on public health and safety by considering the project design, equipment specifications, operations, and decommissioning. The conclusion of the assessment is that toxicity from the two projects will not create negative health and safety impacts.

Tommy Cleveland
Solar Health and Safety Expert

June 11, 2023

Health & Safety Assessment Report - Toxicity [redacted]

[redacted]

- **Project Company:** [redacted]
- **Developer**: Renewable Properties
- **Capacity**: up to 5.0 MW_{AC} (~7.0 MW_{DC})
- **Project Area Inside Fence**: ~36.8 Acres
- **Solar Panels**: bi-facial crystalline silicon, Astronergy 540 watt (or equivalent)
- **Structure**: single-axis trackers (north-south rows, slowly rotate E to W each day)
- **Inverters**: string inverter type, Sungrow SG125HV 125 watt each (or equivalent)
- **Batteries:** none
- **Point of Interconnection**: NYSEG medium voltage overhead distribution circuit at western edge of project
- **Interconnection Equipment**: Pole top equipment such as disconnect switch, recloser, and meter

[redacted]

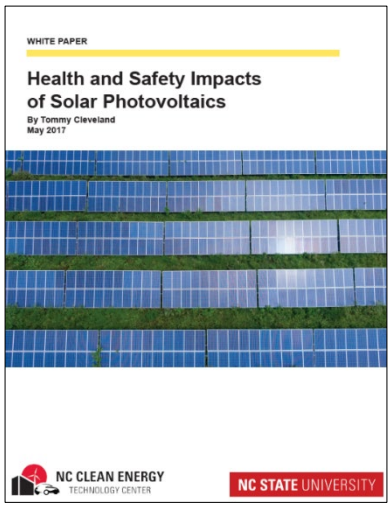
[redacted]

- **Project Company:** [redacted]
- **Developer**: Renewable Properties
- **Capacity**: up to 5.0 MW_{AC} (~7.0 MW_{DC})
- **Project Area Inside Fence**: ~24.6Acres
- **Solar Panels**: bi-facial crystalline silicon, Astronergy 540 watt (or equivalent)
- **Structure**: single-axis trackers (north-south rows, slowly rotate E to W each day)
- **Inverters**: string inverter type, Sungrow SG125HV 125 watt each (or equivalent)
- **Batteries:** none
- **Point of Interconnection**: NYSEG medium voltage overhead distribution circuit at western edge of project
- **Interconnection Equipment**: Pole top equipment such as disconnect switch, recloser, and meter

[redacted]

Report Author

The author of this report is **Tommy Cleveland,** an expert in solar energy and its community impacts, based in Raleigh, North Carolina. Mr. Cleveland graduated from North Carolina State University with undergraduate and master's degrees in mechanical engineering, where he focused on energy. His solar career started with his master's thesis, which led to working over 12 years at the North Carolina Clean Energy Technology Center at NC State University. While at the university, Tommy worked on nearly every aspect of solar energy; from teaching, to testing equipment, to research & development, to leading a statewide stakeholder group in the development of a template solar ordinance. During his time at NC State, North Carolina became the state to install more photovoltaic (PV) capacity than any state other than California, mostly in the form of 2-5 MW_{AC} utility-scale solar facilities covering around 40 acres each. Utility-scale solar was unfamiliar to the hundreds of communities around the state where the systems were proposed, and many of those communities had questions about the technology and its potential to harm public health or the environment in their community. Many of those questions found their way to Mr. Cleveland and he expanded his already broad knowledge of photovoltaics to research and find answers to the questions being asked. Over time he became an expert on the potential health and safety impacts of photovoltaics and was the lead author of the 2017 NC State white paper on the topic (pictured to the left). Since mid-2017 Mr. Cleveland has worked as a solar engineer at an energy engineering firm conducting interconnection commissioning of utility-scale solar and battery facilities for utilities in North and South Carolina. In this role Mr. Cleveland was the engineer responsible for (interconnection) commissioning over 60 PV sites and 4 battery sites. Mr. Cleveland has been licensed as a professional engineer in NC since 2007, and is also licensed in SC, VA, FL, and OH.



Introduction

Purpose:

This report assesses the potential toxicity impacts to health and safety of the proposed [redacted]"). It also seeks to educate readers on the health and safety impacts of photovoltaic systems using accurate scientific sources of information.

Overview of Potential Impacts:

The proposed solar photovoltaic (PV) systems are likely to remain in operation at least 35 years, and this report considers the potential impacts in [redacted] from the start of construction onward, including decommissioning of each project and restoration of the land. This assessment considers all aspects of the project but focuses on those unique to solar projects. PV facilities, like any electricity generating facility, including coal and natural gas, provide some potential for negative health and safety impacts. This assessment report focuses on public health and safety concern about potential toxicity of PV systems.

Utility-Scale PV Equipment, Construction, and Operations[1]

To understand the potential impacts of a utility-scale PV system it is helpful to understand the components of the facility, as well as how a facility is constructed and maintained. The components and practices in this overview are typical of the industry and representative of the proposed [redacted] The initial site work occurs first, but the order of the other construction steps is flexible and may occur concurrently.

Initial Site Work (construction entrance/driveway, sedimentation and erosion control installation, clearing and grubbing, potentially some light grading, perimeter fence, and internal roads)



Underground Work (trenching for wires from PV combiner boxes to inverters, inverter pad installation, medium voltage cables to interconnection equipment)



PV Panel Structure/Racking (driving of steel piles, installation of racking "tables", installation of PV panels)



[1] Photo sources: author, ncre-usa.com, NC DEQ, blueoakenergy.com, solarbuildermag.com, hbc-inc.com, solarprofessional.com, ccrenew.com, and landiscontracting.com

Electrical Work (connection of PV module wiring, combiner boxes, inverters, transformers, interconnection facilities)






Establishment of Ground Cover (required to close out sedimentation and erosion control permit)


Operations and Maintenance (24/7 monitoring, vegetation maintenance, preventative maintenance)



Toxicity Assessment

Toxicity is probably the most common health and safety concern about photovoltaic systems members of the public may have, although as detailed below, the systems do not pose a material toxicity risk to the public or the environment. This report examines all possible sources of toxicity, from site construction to decommissioning at the end of the project life. The potential sources of toxicity are organized into two categories: equipment and operations and maintenance (O&M).

Toxicity: Equipment

The main equipment at a solar facility is PV modules (a.k.a. solar panels or PV panels), metal structures for mounting the solar panels, and wiring to collect the electricity they produce. The other major components are inverters and transformers. Inverters are enclosed power electronic equipment that do not contain liquids and are treated like other electronic waste at the end of their life. Transformers contain non-toxic mineral oil or vegetable oil and are no different than the typical transformers outside of most residences, schools, and shopping centers. Solar panels have raised the most public concerns related to toxicity, so they are covered in depth below, and since transformers contain liquid they are also addressed below in detail. The other components in the facility include the steel racking, the conduits (PVC plastic and galvanized steel), and copper and aluminum wires. The conduit and wires are common construction materials. The racking for the PV panels is generally galvanized or raw steel posts with galvanized steel or aluminum cross members. None of these supporting materials (wire, conduit, and racking) create a toxicity concern. The galvanized coating on the steel is a zinc coating, and zinc non-hazardous. PVC plastic and galvanized steel conduits and all types of copper and aluminum wiring have been building staples for many decades. These materials have not caused a toxicity concern in buildings where people are close to this equipment day and night so there is no reason to think they have any risk of creating a toxicity concern when used at a utility scale solar facility.

Contents of PV Panels

Crystalline Silicon PV Panels

[redacted] will use crystalline silicon PV panels from a Bloomberg Tier 1 manufacturer[2]. The PV panels are the most expensive and most important component in a solar facility, so the project owner performs industry-standard due diligence to ensure that the panels selected and delivered to the project are properly manufactured, certified, and tested.

One way to learn the contents and hazards of some materials is a document created by the manufacturer called a Safety Data Sheet (SDS), known as a Material Safety Data Sheet (MSDS) prior to 2013, however SDSs are not available for PV modules because the requirement to supply a safety data sheet does not apply to PV panels. The Occupational Safety and Health Administration Hazard Communication Standard, 29 C.F.R. § 1910.1200, is the regulation that includes the SDS requirements, including what materials require an SDS and which materials are exempt from the SDS requirements.[3] Section 1910.1200(b)(1) summarizes the scope of this hazard communication standard as follows: "This section requires chemical manufacturers or importers to classify the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, safety data sheets, and information and training. In addition, this section requires distributors to transmit the required information to employers." Then Section 1910.1200(b)(2) summarizes the application of the requirement as "This section applies to any chemical which is known to be present in the workplace in such a manner that employees may be exposed under normal conditions of use or in a foreseeable emergency."

[2] The financial information firm Bloomberg has developed a tiering system for PV module makers based on bankability that is the standard the PV industry uses to differentiate between the hundreds of manufacturers of solar modules on the market. Tier 1 is the highest of three tiers, which are determined by banks' confidence in a manufacturer's PV panels as demonstrated by their willingness to supply project financing backed only by the assets of the project. The details are described by BloombergNEF in this document: PV Module Tier 1 List Methodology https://data.bloomberglp.com/bnef/sites/4/2012/12/bnef_2012-12-03_PVModuleTiering.pdf

[3] United States Department of Labor, Occupational Safety and Health Administration, 1910.1200 Hazard Communication; https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1200

The rest of the sub-sections in section 1920.1200(b) explicitly define specific applications and exemptions of the hazard communication standard. Section 1910.1200(b)(6)(v) exempts "Articles" from SDS requirements, where an article is defined as "a manufactured item other than a fluid or particle: (i) which is formed to a specific shape or design during manufacture; (ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use; and (iii) which under normal conditions of use does not release more than very small quantities, e.g., minute or trace amounts of a hazardous chemical (as determined under paragraph (d) of this section), and does not pose a physical hazard or health risk to employees." Thus, **PV modules are clearly exempt from SDS regulations** in the same way that roof shingles, frying pans, and cell phones are all exempt.

As explained above, **the law that requires SDS does not apply to consumer products that are not a fluid or a particle, instead consumer products, including PV modules, must meet federal consumer product safety requirements**, which are generally regulated by the US Consumer Product Safety Commission.[4]

In 2016 one of the leading PV module manufacturers, Hanwha Q Cells, elected to prepare a safety data sheet for their PV modules, which they did as a convenience for parties interested in the product safety and familiar with the SDS format. This SDS was last updated in 2018 and appears to be the only SDS prepared for a commercial PV module. The most recent version of this Hanwha SDS is provided for reference in Appendix A of this report. While this module is similar to the modules planned for these sites, the inclusion of this SDS is not an indication that either project is planning to use Honwha Q Cells modules. The Hanwha safety data sheet references the PV module installation and operation manual for more information about the hazards of their PV modules, which is the documentation where consumer product safety regulations require PV module manufacturers to provide warnings about potential hazards of installing and using the product. Copies of the operational manuals for the PV module proposed for these two projects are included as attachments.

The diagram below shows the components of a typical silicon PV panel, including a closeup of the solar cells and the electrical connections. Over 80% of the weight of a PV panel is the tempered glass cover (or, front and back heat-strengthened glass) and the structural aluminum frame, which work together to create a strong, durable panel that outlasts its 30-year performance warranty. The encapsulation films are clear plastic lamination layers that protect the cells and electrical contacts from moisture for the life of the panel. These layers also maintain the panel as a single unit in the event of breakage of the glass cover(s), similar to the film in auto windshields that keeps them from fragmenting if the windshield shatters.

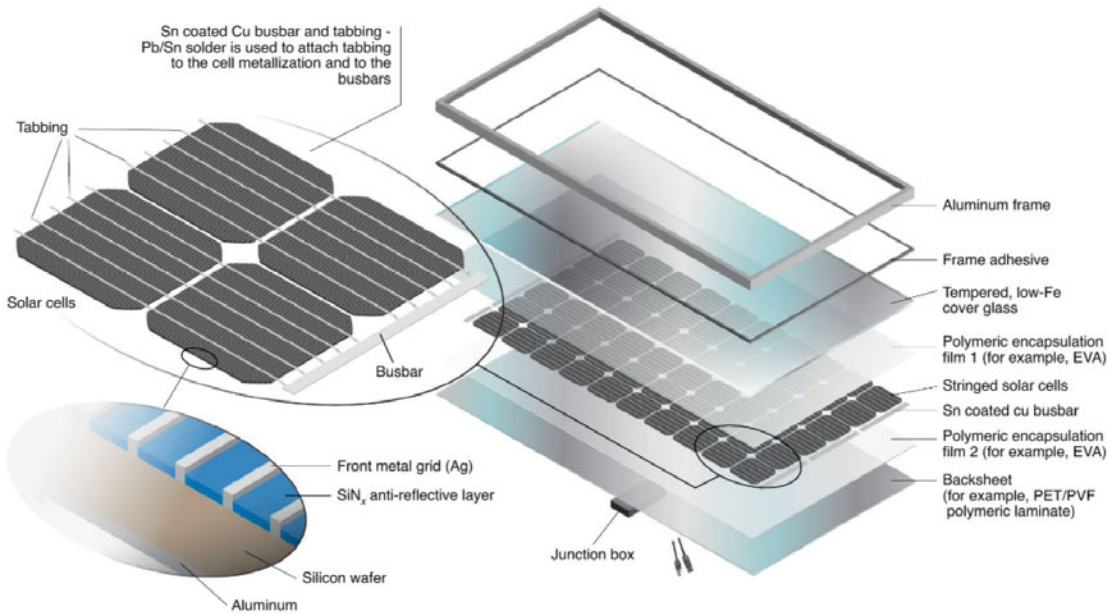


Figure 1. Contents of Framed Crystalline Silicon Panels (Source: NREL)

[4] US Consumer Product Safety Commission: https://www.cpsc.gov/Regulations-Laws--Standards

As can be seen in the above diagram, there are no liquids to leak from a broken panel. The plastic layers are inert. The silicon PV cells are nearly 100% silicon, which is harmless and is the second most common element in the Earth's crust. The only components of a PV panel that have any potential of toxic impact is the lead in the solder used to connect the solar cells together and to the busbars at the end of the panel, and the thin strips of silver that collect electricity from each cell.[5] The solder, which is 36% lead and 64% tin, is the same tin-lead solder standard in the electronic industry in products like microwave ovens, and televisions. The tiny amount of silver in a panel does not create a toxicity hazard, but it does add potential recycling value.

Even though there are only a few grams of lead in each panel, there are a large number of PV modules in a utility-scale project so it is reasonable to consider the total amount of lead in all the PV panels at a site. One way to take all the modules into account is to compare the lead in all the modules to the lead naturally occurring in the soils in New York.[6] Even when accounting for all of the lead solder in an entire facility, the amount of lead in the solder in the entire facility is less than the naturally occurring lead in just the top 2-3 inches of soil under the panels.[7]

Thin Film PV panels

The vast majority of utility-scale PV projects around the world and in the US use silicon-based PV modules, but this is not the only type of PV panel available or utility-scale PV. The leading alternative PV technology to silicon-based PV is cadmium telluride (CdTe), which sometimes referred to as thin film PV. While the [redacted] projects plan to use silicon PV modules, and thus not use any CdTe modules, this assessment report is still providing a basic introduction to CdTe modules because it is not uncommon for stakeholders to have confusion about the differences in the two technologies**.**

CdTe is referred to as thin film because the active layers are less than 1/10th the thickness of a human hair. The CdTe PV cells consist of an incredibly thin layer of cadmium telluride with an even thinner coating of cadmium sulfide (roughly 1/60th the thickness of the CdTe film). Above these active layers is a transparent conducting metal oxide, commonly tin oxide (SnO_2), and below the active layers is a layer of metal to conduct away the electricity. This thin stack is sandwiched between two sheets of heat-strengthened glass that provides electrical insulation and physical protection. Like silicon modules there is no liquid to leak. The only aspect of CdTe modules that raises toxicity concern is the cadmium in the cadmium telluride and cadmium sulfide. Cadmium is a toxic heavy metal, but when cadmium is chemically bonded to tellurium in the crystalline cadmium telluride compound, it has only 1/100th toxicity to humans of cadmium on its own (i.e. not bonded to another element in a compound, also known as free cadmium).[8] The compound cadmium telluride is very stable, so it does not easily break down into cadmium and tellurium. Cadmium telluride PV panels have been in use for decades, and their potential for creating a health hazard has been studied for at least as long. As shown in the sections below and the some of the reading resources linked at the end of this section, CdTe panels are extremely safe and do not pose any risk to public health and safety, including when installed in large numbers.

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[5] A detailed bill of materials for crystalline silicon PV modules is provided in Table 2 of the International Energy Agency (IEA) PVPS's report entitled: Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems, December 2020 https://iea-pvps.org/wp-content/uploads/2020/12/IEA-PVPS-LCI-report-2020.pdf

[6] Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L., 2013, Geochemical and Mineralogical Data for Soils of the Conterminous United States: U.S. Geological Survey Data Series 801, 19 p., http://pubs.usgs.gov/ds/801/

[7] PV: 12 g of lead (per panel) per 65 ft^2 (panel footprint of 21.5 ft^2 / ground coverage ratio of 0.33) = 0.185 g of lead/ft^2
Soil: 20 mg of lead per kg of soil * 45 kg of soil per ft^3 * 2.5 inches (0.208 ft) soil depth * 65 ft^2 = 12.17 g of lead / 65 ft^2 = 0.187 g of lead/ft^2

[8] C. Miller, I.M. Peters, and S. Zaveri, Thin Film CdTe Photovoltaics and the U.S. Energy Transition in 2020, https://qesst.org/resources/thin-film-pv-report-2020/, June 2020

Broken PV Panels

There is **zero risk of toxicity escaping from undamaged PV panels** because any solder lead or cadmium is sealed from air and water exposure by the industrial laminate described above. Individual panels damaged during the life of the solar facility are identified quickly through either remote monitoring of system performance or from visual inspections during maintenance by onsite staff.

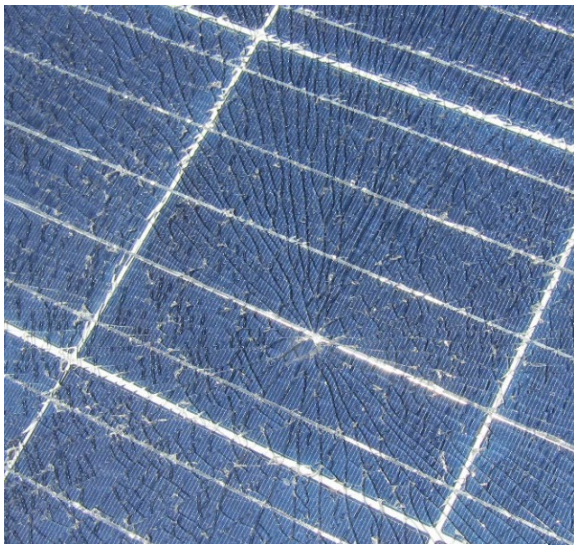

Figure 2. Close-up photo of impact point that broke the glass front of this PV panel

In 2019, an international team of experts conducted an International Energy Agency (IEA) - Photovoltaic Power Systems Programme (PVPS) study to assess if there is a public health hazard caused by lead leaching from the broken silicon PV panels during the life of a utility-scale solar facility. The study simulated worst-case scenarios, unlikely to be experienced by an actual solar facility, utilizing conservative assumptions to evaluate extreme scenarios.[9] The study examined worst-case exposure routes of soil, air, and ground water for a typical 100 MW_{AC} PV facility for crystalline modules. For example, the worst-case residential groundwater exposure assumed that all broken panels from the entire array were exposed to acid rain, *for an entire year,* and any chemicals released from every broken panel transported to the same groundwater well located just 25 feet away. Again, this is not a realistic scenario, but it was assumed in order to generate the most conservative potential outcome. The study found that under this very unlikely, worst-case, scenario, lead exposure via groundwater was four orders of magnitude (i.e. a factor of more than 10,000) less than the maximum levels defined by the EPA to have no adverse health effects, which is the same standard used for public drinking water in the U.S. **This study demonstrates that there is no risk to public health from lead or cadmium leached from broken PV panels.**

GenX and PFAS

Some solar opponents have raised questions about the possibility of per- and poly-fluoroalkyl substances ("PFAS") chemicals being emitted by solar panels. PFAS chemicals are a group of man-made chemicals informally known as "forever chemicals" due to their durability in the environment. These chemicals have been used in many industrial and consumer products for over 60 years, including food packaging materials, firefighting foam, waterproof clothing, and stain resistant carpet treatments.

As explained in a fact sheet from the University of Michigan entitled "Facts about solar panels: PFAS contamination", PV panels do not contain PFAS materials.[10] Neither the self-cleaning coating on top of the solar panel, the adhesives in the panel, nor the front or rear covers/substrates contain PFAS. The "backsheet", or traditional rear substrate of a silicon PV panel, is the thin opaque plastic layer on the rear of a single-glass PV panel that provides electrical insulation and physical protection for the rear of the PV cells. Polyvinyl fluoride (PVF) is the base material for the most common backsheet material (Tedlar), but several other materials have also been used as backsheets, some consisting of multiple layers. Depending on which definition of PFAS that is used, PVF may be classified as PFAS, however the most recent and applicable definition of what is and is not a

[9] P. Sinha, G. Heath, A. Wade, K. Komoto, 2019, Human health risk assessment methods for PV, Part 2: Breakage risks, International Energy Agency (IEA) PVPS Task 12, Report T12-15:2019. ISBN 978-3-906042-87-9, September 2019 https://iea-pvps.org/key-topics/iea-pvps-t12-15_human-health-risk-assessment-methods-for-pv-part-2/

[10] "Clean Energy in Michigan" Series, Number 12, Facts about solar panels: PFAS contamination, By Dr. Annick Anctil, https://graham.umich.edu/media/pubs/Facts-about-solar-panels--PFAS-contamination-47485.pdf

PFAS material was created by the Organization for Economic Co-operation and Development (OECD)[11] in 2021 and PVF does not meet this modern PFAS definition[12].

However, not all PV panels even have a backsheet, in fact, the trend in PV module design is to replace the backsheet with a thin sheet of glass so that the module has thinner front and rear sheets of glass instead of a thicker sheet of front glass and a thin plastic backsheet. Bi-facial modules like those planned for these Projects, require a clear glass covering on their back to allow light to reach the rear of the PV cells and therefore do not have a backsheet. Thus, the bi-facial modules at the Projects should not contain any PFAS, by any definition of PFAS.

PV Panel End-of-Life

PV panels last a very long time, but they do not last forever. Their output declines slightly each year, but panels rarely fail in less than 40 years. The expected economic life of utility-scale PV panels is 25-40 years, at which point they may be replaced by new panels, or the entire project may be decommissioned, returning the land back to how it was before the solar facility was installed. In both instances, the original PV panels are removed from the site. At a typical solar facility, there are three possible fates for solar panels at the end of their economic life at a project, described below. The facility owners are required to handle and dispose of the equipment and other facility components in conformance with federal, state, and local requirements.

- **Reuse**: It is most likely that when the PV panels at the [redacted] projects are decommissioned, they will still produce approximately 80% of their original output and have another decade of productive life, making them viable to be reused as solar panels on rooftops or ground-mounted applications.
- **Recycling**: Any panels that are not reused as working panels could be recycled. Currently in the US, it is possible to recycle the largest constituents of silicon PV panels using the existing glass and metal recycling infrastructure.

  The Solar Energy Industries Association (SEIA) started the SEIA National PV Recycling Program several years ago to accelerate PV recycling in the US. Currently the program aggregates the services offered by recycling vendors and PV manufacturers, making it easier for the industry to select a cost-effective and environmentally responsible end-of-life management solution. The program identifies Preferred Recycling Partners through an evaluation process. These partners are capable of recycling PV modules, inverters, and other related equipment today. The current SEIA PV Recycling Partners are listed on the program's website, and full access to the program and the Preferred Recycling Partners is available to SEIA members.

Figure 3. PV Panels Waiting to be Recycled (Source: LuxChemtech GmbH)

  Renewable Properties already has two recycling partners they do business with for their projects in New York [redacted]., and they plan to continue to partner with these vendors for the Two Rod and Stolle projects.

- **Disposal**: If panels cannot be reused or recycled, federal waste management laws (Resource Recovery and Conservation Act, RCRA) require that PV panels, like any other commercial/industrial waste, be disposed of properly, which is typically

[11] OECD is an intergovernmental organization with representatives of 38 industrialized countries. OCED developed the updated definition in response to an international call for "programmes and regulatory approaches to reduce emissions and the content of relevant perfluorinated chemicals of concern in products and to work toward global elimination, where appropriate and technically feasible." OECD Portal on Per and Poly Fluorinated Chemicals: www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/

[12] OECD (2021), Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, OECD Series on Risk Management, No. 61, OECD Publishing, Paris. www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/terminology-per-and-polyfluoroalkyl-substances.pdf

in a landfill. In order to determine the proper disposal method, RCRA requires that all commercial/industrial waste be identified as either hazardous or non-hazardous waste, which is generally determined using the Toxic Characteristic Leaching Procedure (TCLP) test developed by the U.S. EPA. This test seeks to simulate landfill conditions and check for leaching of 8 toxic metals and 32 organic compounds. Researchers at Arizona State University's Photovoltaic Reliability Laboratory have done the most robust investigation of methods for conducting accurate TCLP tests on PV panels, and their latest research found that all three of the crystalline silicon PV panels tested passed the TCLP test, **classifying them as non-hazardous waste.**[13] Based on this ASU research, a new ASTM standard on a *Standard Practice for Sampling of Solar Photovoltaic Modules for Toxicity Testing* was published in late 2022.

A worst-case scenario would be tons of PV panels being disposed of in a non-sanitary landfill, which is essentially a huge pile of garbage with little to no effort to minimize leaching from the waste that is illegal in many world regions, including in New York. A recent IEA-PVS research study on PV panels disposal risks used this worst-case situation to evaluate the potential for cancer and non-cancer hazards through comparison of predicted exposure-point concentrations in soil, air, groundwater, and surface water with risk-based screening levels created by the EPA and the World Health Organization (WHO).[14] One the report's authors, Gavin Heath with the US Department of Energy's National Renewable Energy Laboratory (NREL), summarized their findings about lead in silicon PV panels this way: "under the worst-case conditions, none of them exceeded health-screening thresholds, meaning they're not deemed to potentially have significant enough risk that you'd want to do a more detailed health risk assessment."[15] The worst-case scenario defined in the research has many conservative assumptions, and thus overestimates the risk of disposal in a *non-sanitary* landfill. It is important to stress that New York only allows solid waste disposal in sanitary landfills, which are engineered facilities with plastic liners, leachate collection systems, and covers, all of which dramatically reduce the potential for human exposure compared to non-sanitary landfills. This and other research show that when PV panels are disposed of in a landfill, they will not create any negative public health impact.

The [redacted] projects have each prepared a Decommissioning Plan consistent with [redacted] Dept. of Agriculture and Markets Guidelines, and will execute a Decommissioning Bond with the Town. This will ensure the Town has funds available and backed by a third-party surety provider to decommission and restore the site to its pre-project conditions.

Transformer Oil

While PV modules and inverters do not have any liquids that could leak into the environment, the inverter step-up (ISU) transformers located within the solar array do contain an oil. Several types of oil can be used in transformers to provide the needed electrical insulation and cooling, but the most common type of transformer oil is mineral oil, which has been used in transformers since transformers were first manufactured in the 1890s. Due to the large volume of oil contained in a transformer in a substation, they are installed with a secondary containment structure under them to contain any oil leaked or spilled. The transformers in a utility-scale PV array are approximately the same size as the transformers located throughout every community; behind schools, shopping centers, apartments, etc., and they typically do not provide secondary containment. However, ongoing monitoring of transformer

[13] Tamizhmani, G., et al. (2019). Assessing Variability in Toxicity Testing of PV Modules. In 2019 IEEE 46th Photovoltaic Specialists Conference (pp. 2475-2481). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/PVSC40753.2019.8980781 Publicly-accessible version: https://dev-pvreliability.ws.asu.edu/sites/default/files/93_assessing_variability_in_toxicity_testing_of_pv_modules.pdf

[14] P. Sinha, G. Heath, A. Wade, K. Komoto, Human health risk assessment methods for PV, Part 3: Module disposal risks, International Energy Agency (IEA) PVPS Task 12, Report T12-16:2020. ISBN 978-3-906042-96-1, May 2020

[15] Green Tech Media, Landfilling Old Solar Panels Likely Safe for Humans, New Research Suggests, April 2020, www.greentechmedia.com/articles/read/solar-panel-landfill-deemed-safe-as-recycling-options-grow

temperature and pressure, and regular preventative maintenance, is likely to find the rare leak when it is still small before it has a chance to leak much oil.

There was a time when most transformer oil was toxic. From 1929 to 1977 polychlorinated biphenyls (PCBs), a man-made alternative to mineral oil, was commonly used as transformer oil instead of mineral oil. However, the toxicity of PCBs was eventually understood, leading to PCBs being banned in the US in 1979. Today, transformers either use mineral oil or vegetable oil, both of which are free of PCBs. Mineral oil is non-toxic to humans, in fact "baby oil" that is commonly used to soothe babies' skin is a scented mineral oil. Although non-toxic to humans, mineral oil is an environmental contaminate and harmful to aquatic ecosystems, so any release to the environment should be avoided. The potential for negative environmental impact from spilled vegetable oil is much less than mineral oil because these oils are biodegradable, so the time they impact the environment is short-lived.

Federal regulations dating back to the Clean Water Act of 1973 require that facilities with significant quantities of oil prevent pollution of water.[16] The current EPA regulations require that facilities with over 1,320 gallons oil, and with the potential for spilled oil to impact surface water, develop and implement an oil spill prevention, control and countermeasure (SPCC) plan. While the risk of negative environmental impact from a transformer oil spill/leak cannot be eliminated entirely, these regulations along with standard industry practices result in a low probability for a substantial spill and a high probability for a quick clean-up response to minimize impact if a spill were to ever occur.

Toxicity: Operations & Maintenance

Unlike most other electricity generation facilities, photovoltaic systems do not produce any emissions. The only way they could produce emissions is in the case of a fire. The potential human health impacts from contact with smoke from burning PV panels was studied by the International Energy Agency (IEA) PVPS in their first report on human health risk assessment. In that study they did not study ground-mounted PV, presumably because of the extremely low risk of significant fire, but they did investigate the potential health impacts of lead in silicon modules dispersing in smoke from a fire in a building that is covered in PV modules. The study considered several worst-case scenarios for different size buildings and different environments and found no risk of harmful health impacts from the smoke from PV panels.[17]

The only other two aspects of operations and maintenance (O&M) that have raised concerns about toxicity are the fluids used to wash panels and herbicides used to maintain vegetation.

- **Panel Washing** – Across NY there is ample rain and snow to keep the panels clean. If the panels need to be washed, it would occur infrequently and typically with use of deionized water and cleaning brushes with no soaps, solvents or surfactants.
- [redacted]

[16] Environmental Protection Agency, webpage: Overview of the Spill Prevention, Control, and Countermeasure (SPCC) Regulation, www.epa.gov/oil-spills-prevention-and-preparedness-regulations/overview-spill-prevention-control-and

[17] P. Sinha, G. Heath, A. Wade, K. Komoto, 2018, Human Health Risk Assessment Methods for PV, Part 1: Fire risks, International Energy Agency (IEA) PVPS Task 12, Report T12-14:2018, https://iea-pvps.org/wp-content/uploads/2020/01/HHRA_Methods_for_PV_Part1_by_Task_12.pdf

Sources for Further Reading on Toxicity:

- QESST (Engineering Research Center at Arizona State University): Thin Film CdTe Photovoltaics and the U.S. Energy Transition in 2020, June 2020
- International Renewable Energy Agency (IRENA): End-of-life management: Solar Photovoltaic Panels, June 2016
- Electric Power Research Institute (EPRI): Solar PV Module End of Life: Options and Knowledge Gaps for Utility-Scale Plants, December 2018
- EPRI: Feasibility Study on Photovoltaic Module Recycling in the United States, April 2018
- EPRI: Solar Photovoltaics: End-of-Life Management Infographic, March 2021
- National Renewable Energy Laboratory (NREL): A Circular Economy for Solar Photovoltaic System Materials, April 2021
- Solar Energy Industries Association (SEIA): SEIA National PV Recycling Program, with factsheet, checklist, and peer-reviewed article, (accessed December 2021)
- North Carolina Department of Environmental Quality: Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment, January 2021

Conclusions

Based on my knowledge of science and engineering, personal experience with PV technology, review of academic research, and review of materials provided by the project developers about the proposed [redacted] solar PV facilities in the [redacted] my conclusion is that the development and operation of the [redacted] solar projects will not result in negative toxicity impacts to public health or safety. Even if the project were much larger, or if many similar sites were located together, there would not be a risk to public health or safety.

Appendix A: Product Safety Data Sheet for Hanwha Q Cells Solar PV Modules (5 pages)

PRODUCT SAFETY DATA SHEET

HANWHA Q CELLS SOLAR PV MODULES ARE ARTICLES AS DEFINED BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION HAZARD COMMUNICATION STANDARD (HCS), 29 C.F.R. § 1910.1200 AND ARE EXEMPT FROM THE LABELING AND SAFETY DATA SHEETS (SDS) REQUIREMENTS OF THE STANDARD.

Hanwha Q CELLS provides this product safety data sheet only for convenience of interested parties in the United States of America who are used to the format of safety data sheets in order to assess the product safety. This product safety data sheet does not replace any other documents provided by Hanwha Q CELLS such as Safety Information, Installation and Operation Manual, Packaging and Transport Information, Product Data Sheet as well as Warranty Terms of the respective product.

SECTION 1: IDENTIFICATION

Solar PV modules convert light into electricity. Light-sensitive cells are electrically interconnected in series and sealed between glass and plastic foils for this purpose. This product safety data sheet is applicable to the following solar PV modules of the Q CELLS brand made by Hanwha Q CELLS:

- Q.PLUS-G4.X, Q.PLUS BFR-G4.X, Q.PLUS L-G4.X, Q.PEAK-G4.X, Q.PEAK BLK-G4.X, Q.PEAK L-G4.X,
- Q.PLUS DUO-G5, Q.PLUS DUO BLK-G5, Q.PLUS DUO L-G5, Q.PLUS DUO-G5.X, Q.PLUS DUO BLK-G5.X, Q.PLUS DUO L-G5.X,
- Q.PEAK DUO-G5, Q.PEAK DUO BLK-G5, Q.PEAK DUO L-G5, Q.PEAK DUO-G5.X, Q.PEAK DUO BLK-G5.X, Q.PEAK DUO L-G5.X,
- Q.PEAK DUO-G6, Q.PEAK DUO BLK-G6, Q.PEAK DUO L-G6, Q.PEAK DUO-G6.X, Q.PEAK DUO BLK-G6.X, Q.PEAK DUO L-G6.X

Minor variations within the product families listed above can be identified by a versioning system which replaces character "X" with numerals of either "1", "2" or "3" to form G4.1, G4.2, G4.3, G5.1, G5.2, G5.3, G6.1, G6.2 and G6.3, respectively. All of these variants as well as the ones with additional suffix "/TAA" are covered by this product safety data sheet. This is also true for B-grade modules which have minor optical imperfections. Product names of these replace "Q." with "B.LINE". B-grade modules of Q.PEAK-G4.1 are named B.LINE PEAK-G4.1 for example.

Responsible Party as Importer:
Name: Hanwha Q CELLS America
Address: 300 Spectrum Center Drive, Suite 1250, Irvine, CA 92618
Phone: 1-949-748-5996

SECTION 2: IDENTIFICATION OF SAFETY RISKS (HAZARDS IDENTIFICATION)

Hanwha Q CELLS solar PV modules do not pose any risk of hazardous chemicals. Hazard symbols and precautionary hazard statements for hazardous chemicals are not applicable. No symptoms or effects – neither acute nor delayed – have to be expected when Hanwha Q CELLS solar PV modules are handled as stipulated in the Installation and Operation Manual. Hanwha Q CELLS provides a Safety Information sheet with all modules shipments. This document contains detailed risk statements and recommendations for installation and operation. Before installing the module, read the Installation and Operation Manual for Q CELLS modules carefully. You can obtain the complete Installation and Operation Manual from your retailer.

Attention: Only qualified and authorized specialists may install modules and put them into operation. Keep children and unauthorized persons away from the modules.

Risks:
- Risk of death from electrocution! Solar modules generate electricity and are energized as soon as they are exposed to light.
- In rare cases, solar PV modules – as any other electrical device – can cause fire due to worn electrical contacts which result in electrical arching.
- Solar PV modules can reach high temperatures which can cause skin burns.
- Sharp edges, corners and broken glass can cause injuries.
- Solar PV modules can cause Injuries due to their weight.
  - Falling solar PV modules can cause injuries.
  - Lifting solar PV modules can cause injuries.

For precautionary statements, please refer to the Installation and Operations Manual of the respective product.

MISUSE OR INCORRECT USE OF SOLAR MODULES VOIDS THE LIMITED WARRANTY AND MAY CREATE A SAFETY HAZARD AND RISK PROPERTY DAMAGE. THIS INCLUDES IMPROPER INSTALLATION OR CONFIGURATION, IMPROPER MAINTENANCE, UNINTENDED USE, AND UNAUTHORIZED MODIFICATION.

Q CELLS

PRODUCT SAFETY DATA SHEET

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Safety data sheets are only required for hazardous chemicals covered by the Hazard Communication Standard (HCS). Solar PV modules made by Hanwha Q CELLS are not covered by HCS. The following table provides an overview of materials solar PV modules by Hanwha Q CELLS are made of. The values given for the share of weight are targets and can vary for the products covered by this Product Safety Data Sheet.

COMPONENT	MATERIAL	TOTAL SHARE	REMARK
FRAME	Aluminum	8% – 16%	not hazardous
	Silicone	<2%	not hazardous, see section 8
LAMINATE	Glass	60% – 80%	not hazardous
	Plastics (EVA, PET, PE, PPE, PC)	8% – 16%	no hazards known
	Silicon	2% – 4%	not hazardous
	Metals (Aluminum, Copper, Tin)	1% – 3%	not hazardous
	Lead	<0,1%	hazardous
	Silver	<0,05%	not hazardous

SECTION 4: FIRST-AID MEASURES

In case of electrocution:

- Always protect yourself by taking all necessary safety precautions before rescuing persons injured.
- Attention: Stay away from sources of high voltage and leave the rescue to qualified personnel with appropriate personal protection equipment!
- Call emergency rescue services.
- Do not touch live parts. Qualified personnel should shut down the PV system as far as possible – e.g. disconnect the modules at the inverter before uncovering any live electrical parts. Be sure to observe the specified time intervals after switching off the inverter. Highvoltage components need time to discharge. Follow OSHA requirements for control of hazardous energy at 29 C.F.R. § 1910.147.
- In the event a person is electrocuted or affected by electrical energy of the solar PV module, CALL 911. Before attempting rescue, SHUTDOWN THE POWER SOURCE.
- Remove the victim from the power source using only insulated tools ONLY IF CONTACT WITH LIVE ELECTRICAL COMPONENTS CAN B PREVENTED.
- Carefully move the injured from the zone of danger.
- After moving to a safe location, check heartbeat, respiration and consciousness of the injured person.
- Apply appropriate life-saving measures (CPR) accordingly before taking care of minor injuries.
- Consult a medical professional even if there are no visible injuries.
    - Flush thermal skin burns caused by touching hot surfaces of solar PV modules with cool water. Consult a medical professional.
    - Injuries due to sharp edges, corners and broken glass need to be appropriately treated. Consult a medical professional.
    - Other types of injuries need to be treated appropriately as well. Consult a medical professional.

SECTION 5: FIRE-FIGHTING MEASURES

- Hanwha Q CELLS solar PV modules are fire rated as Class C according to IEC and UL 1703 as well as Type 1 according to UL 1703.
- Hanwha Q CELLS solar PV modules are extensively tested at the factory to ensure electrical safety of the product before shipment.
- In rare cases, solar PV modules – as any other electrical device – can cause fire due to worn electrical contacts which result in electrical arching.
- In case solar PV modules which are not part of an array are on fire, USE FIRE EXTINGUISHERS RATED FOR ELECTRICAL EQUIPMENT, Class C.
- IN CASE A SOLAR PV MODULE ARRAY IS PRESENT, ANY FIRE SHOULD ONLY BE FOUGHT BY PROFESSIONAL FIREFIGHTERS. FIREFIGHTERS NEED TO TAKE PRECAUTIONS FOR ELECTRICAL VOLTAGES UP TO 1,500 VOLTS (DC).
- Some components of the modules can burn. Potential combustion products include oxides of carbon, nitrogen and silicon.
- In case of prolonged fire, solar PV modules may lose their structural integrity.

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General recommendations from the below-mentioned reports:

- Fire service personnel should follow their normal tactics and strategies at structure fires involving solar power systems, but do so with awareness and understanding of exposure to energized electrical equipment. Emergency response personnel should operate normally, and approach this subject area with awareness, caution, and understanding to assure that conditions are maintained as safely as possible.
- Care must be exercised during all operations, both interior and exterior.
- Responding personnel must stay back from the roofline in the event modules or sections of an array may slide off the roof.
- Contacting a local professional PV installation company should be considered to mitigate potential hazards.
- Turning off an array is not as simple as opening a disconnect switch. As long as the array is illuminated, parts of the system will remain energized.
- When illuminated by artificial light sources such as fire department light trucks or an exposure fire, PV systems are capable of producing electrical power sufficient to cause inability to let go from electricity as a result of stimulation of muscle tissue, also known as lock-on hazard.
- Firefighting foam should not be relied upon to block light.
- The electric shock hazard due to application of water is dependent on voltage, water conductivity, distance and spray pattern.
- It is recommendable to fight fire with water instead of foam if a PV system is present. Salt water should not be used.
- Firefighter's gloves and boots afford limited protection against electrical shock provided the insulating surface is intact and dry. They should not be considered equivalent to electrical personal protection equipment.

Readers interested in more details may refer to the following reports:

- National Fire Protection Association, Fire Protection Research Foundation report "Fire Fighter Safety and Emergency Response for Solar Power Systems" issued May 2010, revised October 2013
- Important recommendations from a report called "Firefighter Safety and Photovoltaic Installations Research Project" issued by Underwriters Laboratories on November 29, 2011

SECTION 6: FIRE-FIGHTING MEASURES

This section is not applicable.

SECTION 7: HANDLING AND STORAGE

Before installing the module, read the Installation and Operation Manual for Q CELLS modules carefully. Noncompliance with the instructions may result in damage and physical injury or death. Only qualified and authorized specialists may install modules and put them into operation. You can obtain the complete installation manual from your retailer.

Details about transport and storage of palletized Hanwha Q CELLS solar PV modules can be found in the Packaging and Transport Information of the respective module type.

Storage, transport and unpacking:

- Store the module dry, well-ventilated and properly secured. The original packaging is not weatherproof.
- Always transport the module in its original packaging.
- Do not stack the modules. This prevents damage of the junction box.
- The module is made of glass. Take great care when unpacking, storing and transporting it.
- Do not subject the module glass to any mechanical stress (e.g. through torsion or deflection). Do not step on the module or place any objects onto the module.
- Protect both sides of the module against scratching and other damage.
- Carry the module by holding the edges with both hands, or use a glass suction lifter.
- Never lift or carry the module using the module junction box or wiring. Avoid pulling on the wiring at all costs.

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SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Before installing the module, read the Installation and Operation Manual carefully. Noncompliance with the instructions may result in damage and physical injury. Only qualified and authorized specialists may install modules and put them into operation. You can obtain the complete installation manual from your retailer.

- Please follow the valid national regulations and safety guidelines for the installation of electrical devices and systems.
- Please make sure to take all necessary safety precautions.
- Ensure that all personnel are aware of and adhere to accident-prevention and safety regulations.
- For handling of modules wear suitable protective gloves.
- Do not install damaged modules. Ensure that all electrical components are in a proper, dry, and safe condition.
- Do not modify the module (e.g. do not drill any additional holes). Never open the junction box.
- Ensure that modules and tools are not subject to moisture or rain at any time during installation. Only use dry, insulated tools for electrical work.
- Only connect cables with plugs. Ensure for a tight connection between the plugs. Plugs click together audibly.
- Cover the modules with an opaque material during installation. Cover the modules to be disconnected.

Silicones used in manufacturing release methanol during curing. Once cured, no additional methanol is released during use. Small amounts of these chemicals may be present in shipping cartons. Upon receipt, open container in a well ventilated location and allow to stand for 5 minutes before removing units from cartons. Exposures above recommended limits for methanol of 200 ppm eight-hour time-weighted-average (TWA) will not occur.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

- Physical state: solid
- Voltage: refer to data sheet (below 50 volts for a single module)

Attention: Voltage of single modules add up when modules are electrically connected in series. Hanwha Q CELLS solar PV modules are designed and certified for voltages up to 1,000 volts or even up to 1,500 volts. Connection of modules in series is only permitted up to the maximum system voltage as listed in the applicable data sheet.

- Weight: refer to data sheet
- Solubility in water: insoluble in water

SECTION 10: STABILITY AND REACTIVITY

Under normal operating conditions as specified in the Product Data Sheet, Hanwha Q CELLS solar PV modules are chemically stable.

- Hanwha Q CELLS solar PV modules are tested for salt spray and ammonia resistance according to IEC 61701 and IEC 62716, respectively.
- Hanwha Q CELLS solar PV modules support ambient operating temperatures from –40 °C to +85 °C (–40 °F to +185 °F).
- Do not install modules above 13.120 ft (4000 m) altitude above sea level.
- Some components of the modules can burn. Potential combustion products include oxides of carbon, nitrogen and silicon.
- Do not scratch off dirt. Use a soft cellulose cloth or sponge to carefully wipe off stubborn dirt. Do not use micro fleece wool or cotton cloths.
- Rinse dirt off with lukewarm water (dust, leaves, etc.)
- Use an alcohol based glass cleaner. Do not use abrasive detergents or tensides.
- Isopropyl alcohol (IPA) can be used selectively to remove stubborn dirt and stains within one hour after it appeared.
- Follow the safety guidelines provided by the IPA manufacturer.
- Do not let IPA run down between the module and the frame or into the module edges.

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SECTION 11: TOXICOLOGICAL INFORMATION

Small amounts of methanol may be present inside shipping cartons. Open cartons and allow to vent before removing units. No exposure to hazardous chemicals will occur when the units are in use.

SECTION 12: ECOLOGICAL INFORMATION

Hanwha Q CELLS solar PV modules are designed to withstand outdoor operating conditions for 25 years. Biodegradation is not expected due to high chemical stability of the components.

SECTION 13: DISPOSAL CONSIDERATIONS

Hanwha Q CELLS solar PV modules should be recycled rather than dumped in a landfill. Raw materials of the product can be recovered by recycling companies. Disposal must be in accordance with national and local laws and regulations for electric/electronic waste.

SECTION 14: TRANSPORT INFORMATION

Hanwha Q CELLS solar PV modules can be shipped via standardized container freight. Regulations for hazardous goods do not apply. For further details, please refer to the Packaging and Transport Information which can be provided as a separate document by Hanwha Q CELLS.

SECTION 15: REGULATORY INFORMATION

- Hanwha Q CELLS solar PV modules are tested according to international standards IEC 61215, IEC 61730 as well as US standards UL 1703.
- Please refer to the Installation and Operation Manual and Product Data Sheet of the respective Hanwha Q CELLS solar PV module.

SECTION 16: OTHER INFORMATION

- Date of initial creation of this product safety data sheet: July 1, 2016
- Date of last revision: August 14, 2018

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Q CELLS

VSUN
Innovative & Smart

VSUN Crystalline Silicon PV Module Products Installation Manual

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Table of Contents

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Crystalline Silicon PV Module Products Installation Manual

(Version: 2020.01)

1 General Information

This manual contains information regarding the installation and safe handling of the photovoltaic module (hereafter is referred to as “module”) which are produced by VIETNAM SUNERGY JOINT STOCK CPMPANY (hereinafter is referred to as “VSUN”).

Installers must read and understand the manual before installation. Any questions, please contact the sales or customer service personnel of VSUN for further explanations. The installer should conform to all safety precautions in the manual and local laws & regulations when installing module; before installing a solar photovoltaic system, installers should become familiar with the mechanical and electrical requirement for such a system. VSUN has the right to refuse to compensate for the product damage due to construction or design defects of the solar photovoltaic system.

Keep this manual in a safe place for future reference (care and maintenance) and in case of sale or disposal of the modules.

2 Disclaimer of Liability

Customers shall strictly abide by the requirements of this manual when installing the modules of VSUN. If the conditions or methods of the installation, handling, use and maintenance of the customer are beyond the range specified in this manual and cause damage, VSUN does not assume responsibility for any loss, damage or expense thus caused.

No responsibility is assumed by VSUN for any infringement of patent right or other rights of third parties, which may result from the customer’s use of the VSUN’s modules. No patent license or patent rights is granted to customer, express or implied, due to its use of VSUN’s modules.

The information in this manual is based on VSUN’s best knowledge and experience and is believed to be reliable; but such information including product specification (without limitations) and suggestions do not specifications, or product information without prior notice.

Notification is needed while the the modules are reinstalling.

3 Safety Precaution

3.1 General Safety

- When installing the modules, it should be abided by the relevant local laws and regulations. It is need to obtain the required certificates in advance when necessary, such as the building permit.
- Installing solar photovoltaic systems require specialized skills and knowledge. Installation should be performed only by qualified persons. Installers should assume the risk of all injuries that might occur during installation, such as electric shock.
- Photovoltaic modules are designed for outdoor use. Modules may be mounted on ground, rooftops, vehicles or boats. Proper design of support structures is the responsibility of the system designers or installers. Mounting holes or clamp range and numbers suggested in this manual shall be used.
- A single module may produce the direct current (hereafter is referred to as DC) voltage of above 30V in direct sunlight and it is extremely dangerous to contact it. Do not touch or lean on an operating module.
- Do not disconnect under load or apply paint or adhesive to module surface.
- Keep all electrical contacts clean and dry. Do not change the wiring of the bypass diodes. Do not disassemble the modules or remove any attached nameplates or components from the modules.
- Do not use mirrors or other magnifiers to artificially concentrate sunlight on the modules. Do not expose the backside of modules directly to sunlight for a long time.
- Modules should store in a dry and ventilated environment. In the storage and handling process, in case of inclement weather (rain, snow, wind, etc.), materials such as plastic film and waterproof cloth need to be covered on the packing boxes.
- During normal work, materials such as plastic film and waterproof cloth are forbidden to be covered on the glass surfaces of modules.
- Unpack the modules with packing box when they are moving on the ground. Unpacking directly when the modules are superposed is forbidden.

3.2 Handling Safety

- Keep children and unauthorized persons away from the modules while transporting and installing

them. Improper transportation and placing may lead to glass breakage or power loss of the modules, resulting in the loss of the use value of modules.

- Handle modules with care. Lift and put down modules gently. Do not drop modules or drop objects on the modules. Pay special attention not to collide, scratch or press the module backside when transporting and installing the modules. The double glass module should be handled more carefully. Non-slip gloves are required when handling and during installation.
- It is forbidden to pull the junction box or cables when carry or lift the modules. Carry a module by its edges with two or more persons. Increasing one or two persons lift up the middle of the panel is necessary for Non-frame module.
- Do not stack the modules for transportation. Do not set the modules down on any hard surface, which maybe cause the cells broken.
- To avoid module damage, do not place heavy objects or tools on the modules, and do not stand or step on the modules.
- Inappropriate transport and installation may damage the module. Control the vehicle speed when the road condition is relatively poor.

3.3 Installation Safety

- Abide by the safety regulations for all other components used in the system, including wiring and cables, connectors, solar charge controller, inverters, storage batteries, etc. Use suitable equipment, connectors, wiring and mounting system for a PV system. Use the same type modules and ensure color grade consistent as far as possible in one system.
- Do not install or handle the modules when they are wet or during strong wind.
- Modules are constructed with tempered glass, which shall be handled with care. Improper operations may cause the tempered glass breakage. If the front glass is broken or if the backsheet is burned-out, contact with any module surface or the aluminum frame can produce electrical shock, particularly when the module is wet. Broken or damaged modules must be disposed properly.
- The maximum system voltage is indicated in the nameplate. During the system installation, the maximum open circuit voltage in series cannot exceed the maximum system voltage.

- Completely cover the module with an opaque material during installation to keep electricity fro m being generated. Under high temperature and high humidity environment, the material compo nent of glass surface will not cause pollution, such as rubber glue splotch, oil, printing and dy eing, etc. Contact the glass surface with bare hand is prohibited.
- Do not place the glass surface or the backsheet surface of the modules down directly on the g round in the installation site (mud, sandy land, grassland, Gobi, etc.).
- Modules not used up should be stored and transported after packaging in accordance with the manufacturer's packaging.
- Do not wear metallic rings, watchbands, ear, nose, lip rings or other metallic devices while ins talling or troubleshooting photovoltaic systems. Use insulated tools that are approved for worki ng on electrical installations and always keep them dry.
- The triangle hole punched on the backside frame of the module is the drain hole which cannot be blocked.
- During modules interconnection, guarantee to fix the connecting cables to the mounting system, so as to restrict the swing amplitude of the slack part of the wire.
- Conform to the allowable minimum bending radius of the wire (Defination: Minimum bending radius is 12 times of the wire's external diameter). Concerning to the wire with junction box, the allowable minimum bending radius is 12 times of OD (diameter). About theother minumum bending radius, please seek help from professinal installer.
- Always protect the wire with conduit where animals or children can touch it.
- Please use the connector which is specially designed for photovoltaic system and assemble it w ith the tools recommended or specified by the manufacturer. In case that the connector applica ble to the solar photovoltaic system is required, please contact the local supplier.
- Make sure that the polarity is correct when connecting the module with inverter, storage batter y or combiner box to avoid the unrecoverable damage of bypass diodes in the modules due to incorrect polarity.

4 Product Identification

Each module has labels providing the following information:

- Nameplate：Describes the product type, rated power, rated current, rated voltage, open circuit voltage,

short circuit current, all are measured at STC; weight, dimension, maximum system voltage and the fuse rating are all shown on the nameplate.

- Barcode：Each module has a unique serial number. It contains the relevant production information of the module.

5 Electrical Property Parameters of Modules

- Under Standard Test Conditions (1000W/m², AM1.5 and 25ºC (77°F)) the electric characteristics, including Isc and Voc, the deviation between the measured value and nominal value is within ±3.5%.
- Under normal outdoor conditions, a module is likely to produce different current and voltage than the values measured under STC in the specification of VSUN module products. Therefore, when determining the parameters related to the power output of the module, for example, nominal voltage, conductor capacity, fuse capacity and controller capacity, etc., refer to the values of short-circuit current and open circuit voltage of the modules, and take 125% of those values during design and installation.
- The maximum nominal voltage for all module series is 1000V or 1500V according to IEC/UL standards. Please check it according to the nameplate.

6 Installation Instructions

6.1 Installation Environment

- In most applications, PV modules should be installed in a location where they will receive maximum sunlight throughout the year.
- The module shall be installed in the place where the sunshine is adequate. The module should not be shaded at any time during its operation. During installation, the module surface shall not be partly shaded by clothes, tools, packaging materials, etc.
- Install the module in well ventilated place and guarantee that adequate natural air heat dissipation channels are provided at the back and sides of the module to ensure that the heat generated during operation is radiated in time.
- Never place the module in locations where flammable gases may be easily generated or collected.
- VSUN suggests installing the module in dry areas where the climate is moderate. The modules shall not be allowed to be mounted in the site with excessive hail, snow, sand, smoke dust and so on.
- VSUN's modules have passed the certification of IEC 61701 with 5% NaCl. But corrosion probably

occurs in the contact place between modules and mounting brackets. Without the approval of VSUN, modules should not be installed in the site which is within 500m away from the sea.

- Modules connected in series should be at the same tilt and azimuth. Differing orientations or angles may cause a loss of power output due to differing amount of sunlight exposure for each module. Typically, the optimal tilt for a module is roughly the same as the installation location.
- When unpacking the modules should be installed as soon as possible and connected to the combiner box to avoid connection failure. Protecting covers are advised to be used if modules are installed in the site with heavy sand or salt mist.

6.2 Selection of Mounting Structure

- Always conform to the instruction manual and safety rules attached to the mounting system.
- The entire PV system consisting of modules must be able to withstand anticipated mechanical pressure which comes from local wind force, snow, etc.
- Drilling holes on the surface of module glass may void the warranty.
- Drilling additional mounting holes on module frames may void the warranty.
- The mounting system structure must be made of durable, corrosion-resistant and UV-resistant materials.
- Forces generated during thermal expansion and contraction of the mounting system structure shall not influence the performance and use of the module.
- The bearing surface of the mounting structure must be smooth without any twist or deformation, and the connected support frames shall be at the same height.

6.3 Three kinds of Mounting

(A) Roof Mounting

- It is necessary to provide a special support frame for the roof mounting. When installing a module on a roof or building, ensure that it is securely fastened and cannot fall or be damaged as a result of strong winds or heavy snows. During roof mounting, check the building codes being used to ensure that the building and its structure where the module is installed have adequate bearing capacity. The roof needs to be penetrated during module installation and fixing shall be sealed to avoid rainwater seepage.
- To be suitable for operation, reduce steam condensation and facilitate the ventilation & heat

dissipation of the module during tile installation, the module shall be parallel to the wall or roof surface of the building, and the clearance between module and surface of the wall or roof shall be at least 115mm to prevent wiring damage and to allow air circulation, ventilation and heat dissipation behind the module. During stacking type installation, the module shall be installed on the fire-resistant roof. The modules Fire Resistance Rated Class of the modules is Class C, and the modules are suitable for mounting on an above Class A roof. Do not install modules on a roof or building during strong winds.

(B) Pole Mounting

- When installing a module on a pole, choose a pole and module mounting structure that will withstand the anticipated wind power of the local area. The support rod must be constructed on a solid foundation.

(C) Ground Mounting

- Select the height of the mounting system to prevent the lowest edge of the module from being covered by snow for a long time in winter in areas that experience heavy snowfalls. The module shall be installed on the mounting system with appropriate height instead of being directly laid on the ground. In addition, assure the lowest portion of the module is placed high enough, so that it is not shaded by plants or trees, and the module is not damaged by sand and stone driven by wind, or the module surface is not shaded by the mud splashed by rain water.

FIG 1 Pole mounting

FIG 2 Ground mounting

- Notice: For the roof system installed in the area that ever experienced relatively heavy snowfall or snow cover, the customer shall reinforce the mounting system at the lower frame of the module, in order to prevent the lower frame from being pressed and damaged by the falling snow, and avoid the module damage due to melt snow freezing in daytime. VSUN suggests to selecting the support reinforcing mechanism shown in Figure 3.

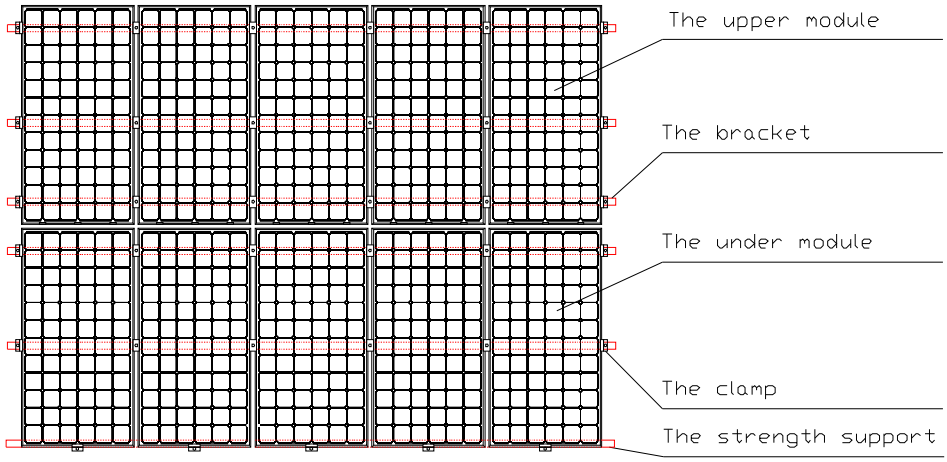


FIG 3 Schematic diagram of reinforcement mounting of module

6.4 Three Installation Methods

- Concerning to modules with frame (including double glass module). Modules can be installed on the frame using mounting holes or clamps. Modules must be installed according to the following examples. Not mounting the modules according to these instructions may void the warranty.
- The modules have been evaluated by IEC61215 standard for mechanical load design (testing load). According to the requirements of IEC61215, 1.5 times of safety parameter should be considered while calculating corresponding maximal design load.
- Normal load is suitable for the most condition of environment: the obverse side can sustain 5400Pa static load, the reverse side can sustain 2400 Pa static load.

  According to the requirements of IEC61215, in regard to dynamic load, like gust, 3 times of safety factor should be considered. That is to say, 800 Pa dynamic wind load in the condition of gust equles 2400 Pa static wind load (wind speed≤130km/h).
- The mounting system and other various goods & materials required (such as screw) shall be made of durable, corrosion-resistant and UV-resistant materials.

6.4.1 Screw fitting:

- Using corrosion-proof screws (M8) in the existing installing holes in the module frame. The range of torque is from 16-20N.M while tightening the screw.
- Do not attempt to drill holes in the glass surface or additional mounting.
- The frame of each module has 4 mounting holes used to secure. As showen in Figure 4, four

mounting holes are needed in normal. Regarding to large modules of type 72, eight mounting holes are needed or in the condition of sustaining higher load.

- The module frame must be attached to the mounting system using M8 stainless steel hardware together with spring washers and flat washers in four places symmetrical on the module, as shown in Figure 5.

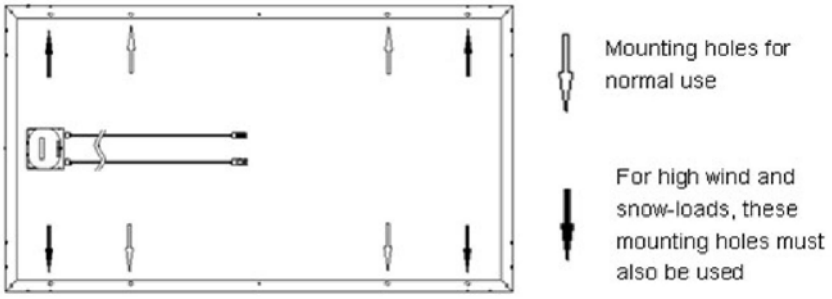


FIG 4 Mounting holes

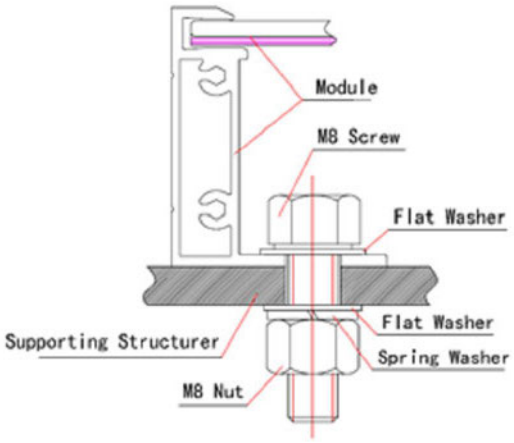


FIG 5 Screw fitting method

6.4.2 Clamp fitting (frame module):

- Using suitable module clamps on the side of the module frame to mount the modules, as shown in FIG 6. The thickness of the clamp should be no less than 3mm, the length should be no less than 40mm and the length of the overlap should be no less than 5mm.
- At least 4 clamps should be used in each module, and install 2 clamps on each side. For harsh environments, you can consider using 8 clamps to install (install 4 clamps on each side), which can withstand 5400Pa on the back side.
- Modules should be mounted by screw, flat washer and spring washer on mounting rack. The clamp shuold be mounted in a symmetric position respect to the center, as shown in FIG. 6. The torque should

be determined by the mechanical design standard of the screw. For instance, M8--16-20N.m.

- The clamp can not be attached with the front glass, and keep the shape of frame while mounting.
- Avoid shading effects creatived by clamps on the cells of modules' obverse side.
- If the customer has special clamping and installation schemes which are not included in this manual, please contact the local dealer for professional support.
- If heavy snowfall, relatively large snow load or large wind pressure exist in the module installation area, VSUN suggests the customer to ask help from professinal installer to improve the bearing capacity of the whole PV system.

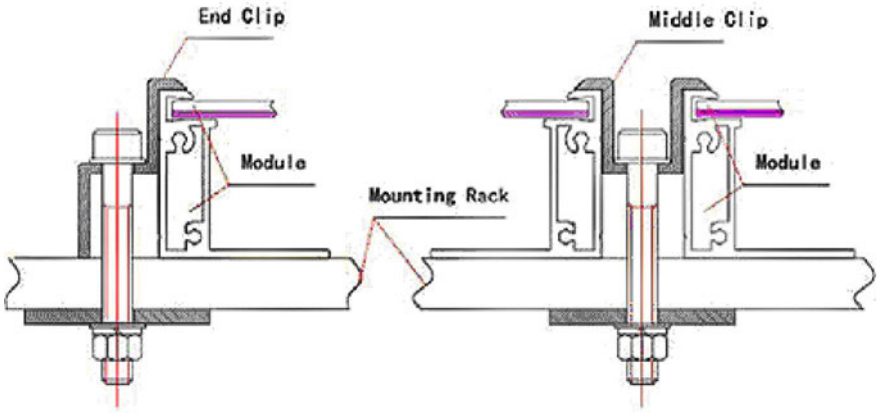
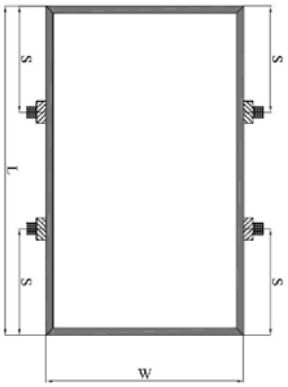
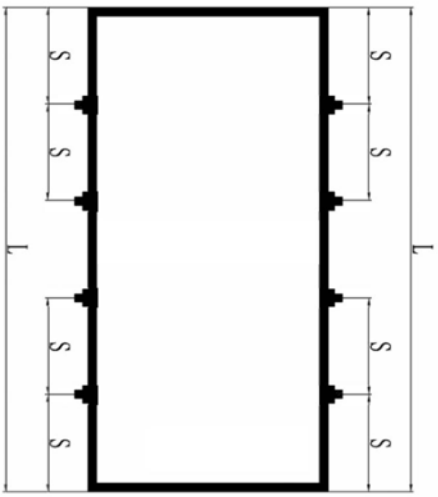


FIG 6 Clamping mounting method

Short Side	Long Side	
		
Back static load≤2000Pa、Front static load≤2000Pa： **0 ≤S≤ (W/4)**	Back static load≤2000Pa、Front static load≤2000Pa：**0 ≤S≤ (W/4)**	Front static load≤5400Pa、Back static load≤5400Pa：**(L/5-50) ≤S≤ (L/5+50)**
Back static load≤2400Pa、Front static	Front static	----

load≤2400Pa： **(W/20) ≤S≤ (W/5)**	load≤2400Pa、Back static load≤2400Pa：**(L/8) ≤S≤ (L/4)**	
----	Front static load≤5400Pa、Back static load≤2400Pa： **(L/4-50) ≤S≤ (L/4+50)**	----

6.4.3 NEXTracker Mounting System

- If VSUN modules will be mounted on NEXTracker system at 400mm short rail. The special mounting holes should be designed as FIG. 7.

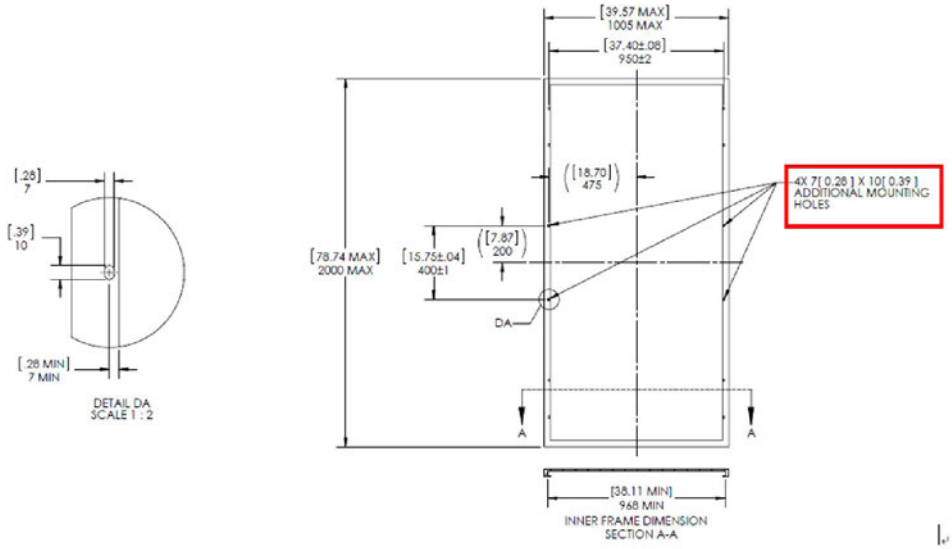


FIG 7. NEXTracker mounting holes at 400mm short rails

- The maximum pressure rating of front side and back side is 2400Pa for VSUN standard modules with 40mm height frame.
- Please confirm with NEXTracker supplier to obtain the detailed information of mounting system.

*** NOTES:**

VSUN's limited warranty will be void in cases where improper clamps or installation methods deviating from this manual are used. When installing inter-modules or end type clamps, take measures so as:

A. Not to bend the module frame.

B. The clips must only fix the modules by the contact with the frame. Do not allow contact between clip and glass.

C. Not to damage the surface of the frame.

D. When mounting, be sure that the module's drain holes are not blocked. For matters concerning installation not mentioned in this section, contact the local dealer for professional support.

7 Electrical Installation

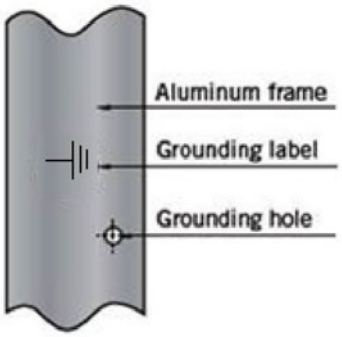
7.1 General With Regard to Electrical Installation

- Try to use the modules with the same configuration in the same photovoltaic system. If the modules are connected in series, the total voltage is the sum of voltages of all the modules, and the maximum number of the series modules (N)=Vmax (System)/[Voc(at STC)].
- If the system requires the installation of high current, several photovoltaic modules can be connected in parallel, and total current is the sum of current of all the modules. The maximum number of the parallel module strings (N)=Imax (fuse rating) / Isc.
- When connecting modules, make sure that the connectors of the same series module shall come from the same manufacturer or totally be compatible with each others, and the same requirements shall go to the connection terminals of module end and system end, for the connectors of the different manufacturers may not be compatible with each others, which easily leads to mismatch risk.
- The cross section area and connector capacity of the cable selected must satisfy the maximum short-circuit current of the system (It is recommended that the cross section area of the cable used for the single module is 4mm^2, and the rated current of the connector is not less than 30A. Please note that the upper temperature limit of the cable and connector is 85℃ and 105℃ respectively).
- When installing the module, place the end with the junction box up and try to avoid the rain.
- Do not carry out installation in rainy weather for humidity will void the insulation protection, thus causing safety accidents.

7.2 Grounding

- All module frames and mounting racks must be properly grounded. As shown in FIG 9-a. The grounding wire must be properly fastened to the module frame to assure good electrical contact. Use the recommended type, or an equivalent, connector for this wire.
- If the mount system is made of metal, the surface of the structure must be electroplated and have excellent conductivity.
- Proper grounding is achieved by connecting the module frame(s) and structural members contiguously using a suitable grounding conductor.

- The grounding conductor must then make a connection to earth using a suitable earth ground electrode. Recommend to use the ground wire accessories (lugs) connected to ground Cable. Welding ground cable to the jack of lugs, and then with the M4 screws inserted into the wiring nose ring and t the grounding hole of the module frame, fastening with nuts. Star spring washers should be used to prevent the screws from loosening and lead to poor grounding (as shown in FIG8).
- The module frame to EARTH resistance must be less than 4 ohm.
- VSUN recommends to install modules at the temperature from -40℃ to 50℃, and the relative humidity should be less than 85RH%. Besides, the ultimate temperature of working is from -40℃ to 85℃. If the modules are used in high-temperature and high-humidity environment, VSUN requires the customer to ground the negative end of the inverter (as shown in FIG9). Offset Box or PID Box can also be used instead to apply a positive voltage to the module arrays at night to avoid PID.



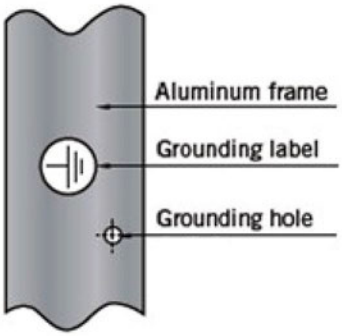


FIG 8-a Grounding hole

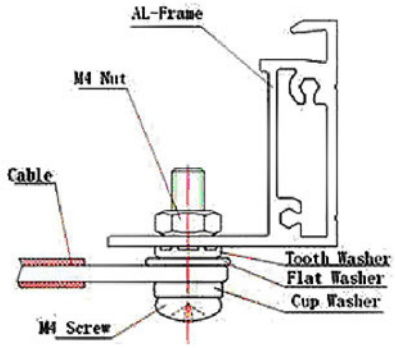
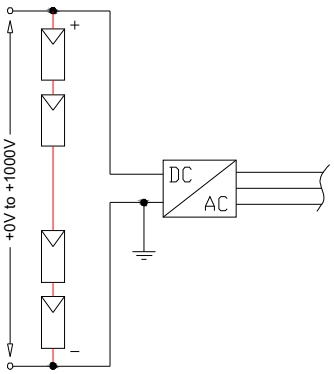


FIG 8-b Grounding method



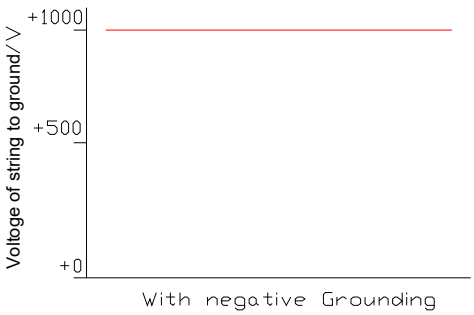


FIG 9 Schematic diagram for grounding potential of the inverter

8 Maintenance and Care

- Clean the glass surface on a regular basis. Avoid the hotspot risk caused by ornithocopros, leaves and

dead insects covering the glass surface.

- In general, use water and a soft sponge or cloth for cleaning. A mild, non-abrasive cleaning agent can be used to remove stubborn dirt.
- Avoid pressing part of the module hard during cleaning, such as washing modules by water torch. The strength on the module is less than 690kPa, because pressing hard may cause glass deformation, cell damage and service life reduction. Remove the snow covered on the module in time to avoid the module damage caused by long-term accumulation of snow cover and freezing of melted snow. Remove plants and sundries surrounding the modules in time to stop them from shading modules and influencing the property.
- Examine the PV module(s) for signs of deterioration. Check all wiring for possible rodent damage, weathering and that all connections are tight and corrosion free. Check electrical leakage to ground. Check fixing screws and mounting brackets, adjust and tighten as necessary.
- Never clean the electrical connectors including cable, junction box and connector with the cleaning agents that contain organic matters such as alkane.
- If any problem arises, have it investigated by a competent specialist.

* If the maintenance measures are not included in this manual, please contact the local dealer for professional support.

9 PV recycling

Do not dispose the PV module as unsorted municipal waste in accordance with WEEE Directive (Waste from Electrical and Electronic Equipment Directive), EN50419and all the other applicable laws.

-END