Fire Safe Solar White Paper

International Association for Cold Storage Construction

By HD Boesch

For the International Association for Cold Storage Construction

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Background

Is solar safe? Misunderstanding, lack of information amongst first responders, media, and the public have called the safety of solar into question.

In late 2013, a subcommittee of the IACSC-IARW Construction/Codes Committee was formed to investigate the issue and develop resources to help members better understand best practices in installing and maintaining a fire-safe solar photovoltaic (PV) system.

The subcommittee consisted of:

HD Boesch, Mangan Renewables

Curt Edmisten, MTC Logistics

Jason Fisher, HelioSage, LLC

John McIntosh, HelioPower, Inc.

Tom Millhoff, HelioPower, Inc.

Patrick Sahradnik, Hall's Warehouse Corp.

Bill Shevlin, Platinum Roofing, Inc.

The goal of the subcommittee was to assemble resources to help members have educated conversations about solar PV system safety with their vendors and local first responders. In their work, the subcommittee focused on:

1. Disconnecting means on roof
2. Proper organization of layout on roof
3. Awareness amongst first responders/What to communicate with first responders
4. Assessing safety of current PV system

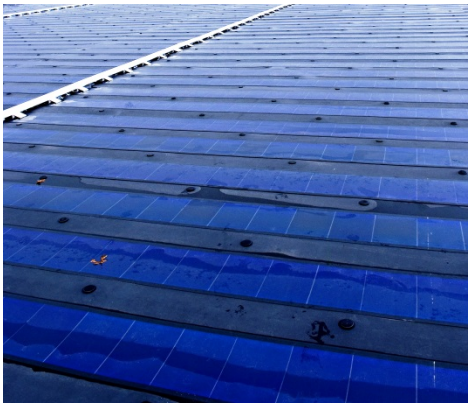
HD Boesch of Mangan Renewables authored this white paper to analyze the potential hazards and discuss means and measures to make any building powered by solar fire safe. The white paper was reviewed by members of the subcommittee as well as the IACSC-IARW Construction/Codes Committee.

The paper is followed by a “Checklist for Fire Safe Solar for Roof-top Solar Arrays” to help operators and contractors achieve proper roof layout. Rather than presenting standards, this white paper should serve as a tool to guide operators towards the “right” questions and “right” resources.

The paper was published in April 2014. Please consult with your contractor or solar specialists for the most current information about best practices in solar installations.

For additional information, contact IACSC at email@iacsc.org or +1 703 373 4300.

Introduction



A Solar Photovoltaic System is an installed aggregate of solar arrays generating power for a given application. These systems have become a potential energy solution for temperature-controlled facilities.

Solar is safe; if designed and installed to known best practices. Commercial and industrial buildings worldwide powered by solar electric systems operating with no fire hazards are impressive proof. Fires can happen, though, independent of solar. Thus, solar PV systems have to be designed and installed in ways to enable fire fighters extinguishing the fire without any hazardous risks.

Potential Hazards

A hazardous situation occurs when the metal of an energized wire comes into contact with other metal (‘ground fault’), which can cause a fire, burns, grave bodily injury and even deaths. Ground faults in solar electric systems can be avoided in all normal operating modes and additionally, if a ground fault does occur, they are detected by electric protection devices within the solar electric system, which would then shut down the system. This article focuses on potentially hazardous human interaction with the solar system in particular in emergency situations like a building fire.

Solar electric systems can cause electrical hazards during firefighting when not designed with power shut-off means installed at critical points of the system. To identify hazards the electrical potential of different parts of solar electric systems will be discussed.

Solar panels (A) generate electrical potential during the day, even on cloudy days. In operational mode electric current is flowing from the panels thru the combiners (B) thru the inverter (C) thru the switchgear (D) to electric appliances in the building. When the solar system is not working, for example when the inverter is switched off, all wires from the panels to the inverter are still energized and any contact will cause an electric shock.

Wires (1) between panels (A) and combiners (B) can be easily identified on the roof. They are small diameter similar to wires in residential households. They typically carry currents of 4 A to 7 A at 300 to 400 V DC. Any contact should be avoided.

Wires (2) between combiners (B) and inverters (C) on the roof and from the roof to the inverter can be easily identified, because they are 1/8” in diameter and larger. They typically carry currents of 100 A to 400 A at 300 to 400 V DC. This level of current is life threatening. Any contact has to be entirely avoided as long as the wires are energized.

Wires (3) between inverter (C) and switchgear (D) typically carry 300 A to 1600 A at 480 V AC. They are also life threatening while energized and any contact should be entirely avoided.

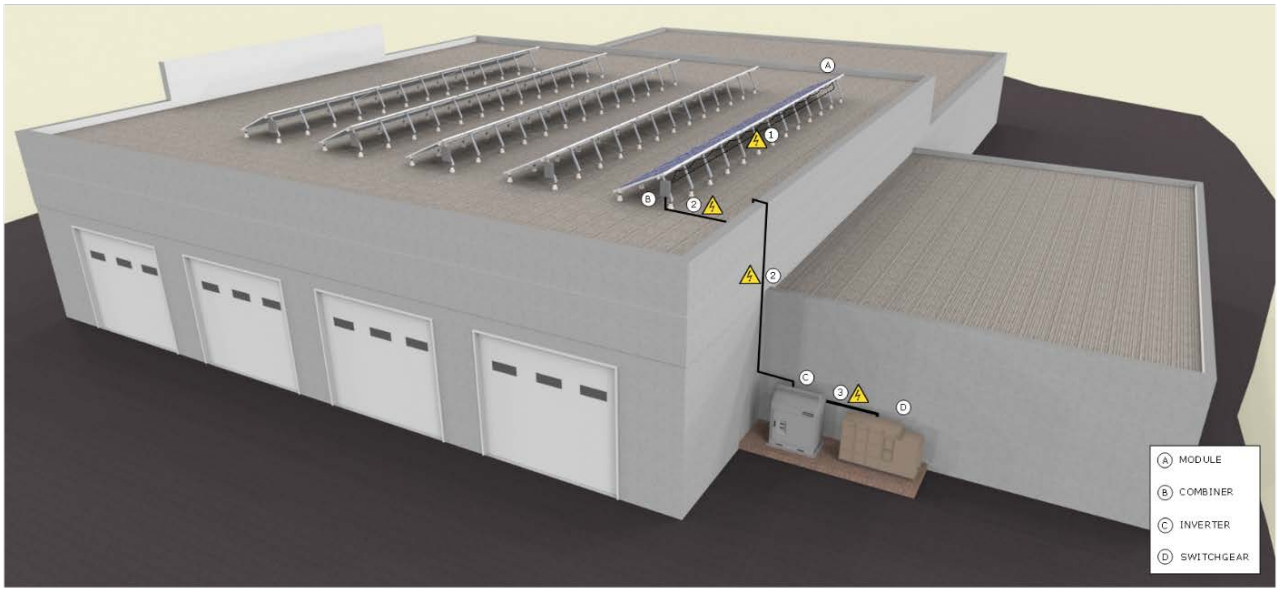


Figure 1. This diagram identifies the electrical potential of different parts of solar electric systems.

Safety Measurements

Inverter to Switchgear

Since the early days of solar electric systems switches have been installed close to the inverter or to the switchgear, wherever the fire department wanted to have them located, readily accessible during any emergency. This switch typically is called the 'Solar System Disconnect'. In case of an emergency such as fire, the main electric switch and the solar system disconnect shall be switched off to de-energize any wire from the inverter (C) to the switchgear (D) as well as the building's electric wires.

When the disconnect is switched off, operating this switch will typically shut down the inverter or at least will disconnect a portion of the solar array from the inverter. However, it may not de-energize the conductors. If the utility service has been disconnected from the building, it is likely that any wires from the inverter (C) to the switchgear (D) will be de-energized since these are energized from the utility.

However, all wires from the roof to the inverter still are energized, as described above, causing life threating hazards when cutting into them. Unless otherwise known, firefighters should consider all conductors and conduits from the solar array to the inverter as energized, even if there are switches in the system.

Note: When using decentralized string inverters a Main AC Solar Disconnect has to disconnect all inverters from the switchgear.

Combiner to Inverter

The wires from the combiners to the inverter are often in areas on the roof or the walls that are a hazard to firefighters when energized. Thus, it is mandatory to be able to shutoff these wires in case of emergency, whereby “mandatory” doesn’t mean mandated by Code, but by ‘Best Practices’.

It is strongly recommended that the solar PV system meets the “rapid shutdown” requirement as described in article 690.12, NEC 2014.

Available ‘best practice’ solutions are contactors in the combiners that can be switched off from a central emergency switch installed at a readily accessible location specified by the fire department. This central switch will de-energize all wires from the combiners to the inverter, eliminating a potentially hazardous situation whenever fire fighters have to cut into the otherwise high current carrying wires from the combiner to the inverter.

Note: When using decentralized string inverters, these inverters will be installed instead of combiners, providing the same level of safety, because they will switch off when the main AC solar disconnect is switched off.

Panel to Combiner

There are products available that can isolate or switch-off the wires at the solar panel level, thus, de-energizing all DC wires of the entire solar PV system. The different technologies that are available are panel-level switches, panel-level performance optimizers with safety switch, panel-level inverters, and AC modules (solar panels with integrated inverters). Some say that a panel-level switch-off feature is the safest solution.

It is strongly recommended to check if the product of choice is compliant with the “rapid shutdown” requirement as described in article 690.12, NEC 2014.

Panel

When the panel is switched off, that is electrically isolated from all other panels, the electric energy inside of a panel even when energized is s. Typically, a single PV panel (module), which is not connected to any other panel is under 80V DC.

Note: this white paper specifically addressed electrical danger. For any structure, there are additional mechanical dangers that should be taken into account.

Fire Pathways

Fire pathways are an additional and essential safety measure. The California Fire Guidelines, now adopted in several states, and largely incorporated into the 2012 International Fire Code, require that a solar system on a large roof is distributed in sub-arrays with fire pathways in between so that every part of the roof can be quickly and easily accessed. Also, additional pathways to smoke vents have to be free of solar panels and other obstacles. These guidelines should be followed even if the local code doesn’t require them.

New Solar Electric Systems

Every new solar electric system should incorporate provisions to allow firefighters to quickly and easily shut down all conductors that leave the immediate area of the solar panel array (NEC 2014). This shutdown may occur using manual switches or automatic devices. Even if the local building department does not require such provisions, we recommend that PV system designers incorporate means for rapid system shut down and discuss the proposed solutions with their local fire department

New solar electric system should have either combiner-level switch off, decentralized string inverters, or panel-level switches. Combiners or decentralized inverters should be installed within or very close to the solar array area.

Local fire departments may be satisfied with a central switch for combiners or decentralized inverters to ensure that all large wires on the roof and from the roof to the inverter are de-energized in case of emergency, while sufficient pathways give them the quick access to any place on the roof they need to go to.

It is essential to discuss the solar electric system and its operation during emergencies with the fire department prior to finalizing the design in order to integrate all safety measures they need. Operators and installers should consider hosting a training to show firefighters how to work on a roof with solar panels in case of emergency.

Retrofitting Solar Electric Systems

Existing solar electric systems that don't have combiners with contactors should be retrofitted. This would typically be a small investment to ensure solar system safety. If the existing solar array layout does not have fire pathways according to the guidelines, opening pathways should be considered. While this may reduce the system size by eliminating some panels on the roof, it is a small investment compared to a possible hazardous situation.

New products, such as panel-level switches, may not have been available when the system was installed and may provide a simple and effective way to disconnect some or all of the system DC conductors during an emergency. Owners of existing systems should consult a company experienced in designing and installing PV systems to discuss the best option for their rooftop system.

Conclusion

Solar electric system can be made safe for fire fighters to extinguish fires.

Checklist for Fire Safe Solar for Roof-top Solar Arrays

Please read the full white paper before using the checklist.

☑	#	Recommendation	Note
	1.	Maximum solar sub-arrays on the roof: 150’ x 150’	Minimum requirement
	2.	Fire pathways between solar sub-arrays: 8’ wide	Recommended
	3.	Fire pathways: 4’ wide AND 4’ x 8’ “venting cutouts” every 20’ OR bordering in existing skylights/smoke vents and ventilation hatches	Minimum requirement
	4.	Fire pathways to smoke vents and ventilation hatches: 4’ wide	Minimum requirement
	5.	Fire pathways around perimeter: 6’ wide	
	6.	Combiner boxes on roof with contactors that can be switched off from a centrally located emergency switch or decentralized inverters	Recommended
	7.	Solar panel level switch off (integrated in panel or installed at panel level)	Should be considered (makes #6 obsolete)
	8.	All connections between conduits are firm	Minimum requirement
	9.	Expansion kits are installed between conduit sections for long conduits (consult responsible engineer for the installation or any other engineer with solar design experience)	Minimum requirement
	10.	Cable tray used instead of single conductor bundles with wire ties	Recommended
	11.	Annual maintenance including but not limited to checking of all electrical and mechanical connections	Minimum requirement
	12.	Combiner boxes with arc fault detection or decentralized inverters with arc fault protection	Recommended for retrofit, required for new installations (NEC 2011)
	13.	Meeting with fire department, if fire department wasn’t involved and informed by installer	Minimum requirement
	14.	Placards and instructions for fire department at centrally located place (location defined by fire department)	Minimum requirement
	15.	Inspection and report by experienced engineering or installation company to check for all fire risks	Recommended, replaces #1-14

Note: “Minimum Requirement” is the recommended “best practice minimum requirement” for a fire safe solar, not necessarily required by local code.

Additional Resources

"Grounding PV Modules: Addendum Report on Corrosion Testing." Solar America Board for Codes and Standards. N.p., n.d. Web. 21 Mar. 2014. <http://www.solarabcs.org/index.html>.

"Photovoltaics." Cal Fire - Office of the State Fire Marshal. State of California , n.d. Web. 21 Mar. 2014. <http://osfm.fire.ca.gov/training/photovoltaics.php>.

"SEIA." Fire Safety & Solar. Solar Energy Industries Association, n.d. Web. 21 Mar. 2014. <http://www.seia.org/policy/health-safety/fire-safety-solar>.

"Solar and Fire Safety - Go Solar California." Solar and Fire Safety - Go Solar California. State of California, California Energy Commission & California Public Utilities Commission, n.d. Web. 21 Mar. 2014. <http://www.gosolarcalifornia.ca.gov/solar_basics/fire_safety.php>.

"We Are California Solar." Home. California Solar Energy Industries Association, n.d. Web. 21 Mar. 2014. <http://www.calseia.org/home>.