INSTALLATION, FIRE, PROPERTY DAMAGE, ENVIRONMENTAL DAMAGE AND OTHER LIABILITY RISKS ASSOCIATED WITH SOLAR PANEL SYSTEMS

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Green Job Hazards: Solar Energy

Solar is a growing sector for green energy and green jobs. Various worker health and safety hazards exist in the manufacture, installation, and maintenance of solar energy. Employers working in the solar energy business need to protect their workers from workplace hazards and workers need to understand how to protect themselves from hazards.

Two commercially viable solar energy sectors are solar electric and solar thermal or solar water heating.

Solar Electric

Solar energy can be converted into electricity using photovoltaics (PV), or concentrating solar power (CSP). PV systems are the most common and use semi-conductors and sunlight to make electricity. The more solar modules a PV system or array has, the more electricity will be generated. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride, and copper indium selenide/sulfide.

Solar Thermal or Solar Water Heaters

Types of solar water heating systems include direct and indirect (Glycol) systems and are chosen largely by climate; freezing temperatures can damage some types.

Workers in the solar energy industry are potentially exposed to a variety of serious hazards, such as arc flashes (which include arc flash burn and blast hazards), electric shock, falls, and thermal burn hazards that can cause injury and death. Solar energy employers (connecting to grid) are covered by the *Electric power generation, transmission, and distribution* standards and therefore may be required to implement the safe work practices and worker training requirements of OSHA's Electric Power Generation, Transmission and Distribution Standard, 29 CFR 1910.269. While solar energy is a growing industry, the hazards are not unique and OSHA has many standards that cover them. This page provides information about some hazards that workers in the solar industry may face.

Falls

Lockout/Tagout

Crane and Hoist Safety

Electrical

Heat/Cold Stress

Personal Protective Equipment

Fatalities/Incidents

There have been fatalities and incidents in the solar energy industry.

Resources

Solar Construction Safety (a report by the Oregon Solar Energy Industries Association)

Solar installations are increasing exponentially due to increasing energy prices and decreasing solar panel hardware and installation prices, which are decreased further by government subsidies. Furthermore, the power generated by a solar installation can be sold back to the electrical grid. If you fall into any of the following groups, however, a solar installation may pose additional risks that you will need to address:

- Building owner
- Homeowner or condominium owner association
- Apartment building owner or resident
- Solar array seller (wholesaler, lessor or retailer)
- Solar system installer
- Fire department
- Electrician
- Roofer
- Maintenance staff
- Others who require access to the roof

Photovoltaic solar panels rarely cause house fires directly, but the potential hazards they pose in the event of a house fire can be mitigated with proper installation and preparation.

This article pertains to photovoltaic (PV) solar installations, which turn sunlight into electricity in a PV cell. It does not address thermal solar installations, which heat a fluid in pipes or tubes (e.g., solar hot water heaters). While there are potential dangers associated with both types of systems, the PV systems are giving rise to greater confusion and concern among owners, fire departments and others who come in contact with them.

Solar installations may have implications for your property, general liability and workers' compensation insurance. If you are a seller, installer, maintenance firm or lessor, there are potential implications for your products liability and completed operations insurance.

Property - Solar panels can be damaged by fire, hail, wind, snow and ice loading, water and poor roof drainage. The cost to replace these systems may be significant. One estimate is in excess of $25,000 for a 2,500 square foot home where the homeowner does the repairs (based on a $25,000, 10.2 kW tied-grid system from a major retailer as of November 7, 2014).

An emerging problem that may increase the fire hazard associated with these systems is the reluctance of firefighters to attack fires at homes or business with solar panels on the roof. One recent case in Delanco, NJ in which a fire department with-drew was newsworthy due to the size of the fire and the building's solar array. A 268,000 square foot warehouse contained 35 million pounds of meat and had PV solar panels that completely covered the roof. Due to the size of the solar panel array, the fire department could not effectively attack the fire because they could not open up the roof to ventilate the structure while posing the threat of electrocution. They needed 24-hours to control the blaze and nine days to extinguish it completely.

While it's unknown what the loss would have been had there been no panels on the roof, numerous fire officials have stated that the only reason they could not get on the roof, or otherwise approach the fire, was the panels. The fire resulted in a total loss to the building (which has since been demolished) and its contents. There also was possible environmental damage and neighboring hostile fire losses. While this one incident cannot predict future fire department responses, it is worth noting due to the rapid growth of solar installations.

New Jersey state legislators responded to the above fire incident by passing a law requiring building owners to disclose to fire officials if such a system is in place. One- and two-family residences are exempt under the law.

In the past decade, firefighters had begun to encounter rooftop solar panels, but didn't know much about how to handle them when the home or building was on fire, Willette said. So after receiving an increasing number of requests from firefighters for information on how to best protect themselves, the NFPA's Fire Protection Research Foundation got funding from the U.S. Department of Homeland Security to undertake such a research project. Their report [PDF], issued in 2010, outlined not just the risks, but best practices for emergency response.

One year later, safety-testing group Underwriters Laboratories followed up with extensive lab research at their Northbrook, Ill. campus. The organization tested a range of materials on solar PV emergency fire response and issued a comprehensive report [PDF] released in 2011.

Risks and solutions identified by NFPA and UL were:

• **Electrical shock:** Firefighters coming into contact with solar panels run a risk as the system is generating electricity from exposure from sunshine, streetlights or the lights used during nighttime emergency response vehicles. In sunlight, panels can generate anywhere from between 60 to 120 V of electricity, according to Matt Paiss, a fire engineer with the San Jose, Calif. Fire Department. That number is of course a lot lower during the nighttime, but the solar dangers for firefighters are very real around the clock.

"There's a potentially lethal situation for firefighters, where anywhere from 40 milliamps (mA) to 240 mA of DC electric current can lock up the muscles and you can't let go," says Ken Boyce, UL's manager and principal engineer for product safety. The current could be strong enough where the firefighter could jump back and fall off the roof, fall into a solar panel, or be strong enough past 240 mA to cause ventricular fibrillation and cause death. At 70 mA, electrical burns causing cell necrosis could come into play, according to UL. Even the amount of light generated from fighting a nighttime fire adjacent to a building with rooftop PV could generate electricity in the solar panels, Boyce added.

Fire-induced damage to the arrays can also create new circuit paths as well, the UL report found, that can flow along the system's frame and racks, as well as through a building's metal roofs, flashings and gutters.

Sometimes the firefighters don't know a structure has rooftop PV panels beforehand—and even if the inverter can be located and switched off, the panels cannot be turned off, meaning that in most cases, electricity will still be generated.

Based on the complexity of this problem, Willette said that the NFPA is currently looking into how it can revise its electrical code to reflect requirements for improved labeling for first responders. But these changes would be limited in impact, as they'd only apply to new systems installed in the future.

Firefighters also cover panels as a way to stop the generation of electricity in residential systems. "But if you're talking about a commercial building or solar farm with tens, hundreds and possibly thousands of panels, reducing the electrical generation is impossible," Willette said.

UL found that covering a PV panel with heavy, opaque and densely woven fabric can bring down the amount of electricity close to zero. In fact, any tarp where light can be seen coming through should not be used, the report advised. But care should be taken to not place wet tarps in contact with energized equipment as the tarps can then conduct electricity.

"It's also incumbent upon firefighters to wear robust leather gloves," Boyce said. UL's study found that this material was effective in protecting the first responders from current, but only when dry.

• **Density of rooftop panels can be a hindrance:** As a common tactic among firefighters to contain incidents is by opening a hole in the roof for ventilation, Willette said, the density of solar panels can make it impossible for firefighters to create that hole.

And if the firefighter is opening up the hole from below and doesn't know that solar panels are installed on the roof, that creates another shock hazard, he added.

"It's definitely enough electricity in the larger arrays or commercial systems to possibly cause cardiac arrest," Willette said.

Solutions: As a result, the NFPA's safety and national electrical codes have required that a minimum amount of clearance be present. In California, regulations require a three feet perimeter around the array for firefighter access.

can also release harmful chemicals when exposed to fire as well, he said.

Solutions: The only solution we discovered in the course of reporting this story is to install fewer solar panels — which isn't really a solution.

• **Lack of communication/notification from home and building owners:** Clear communication—whether through signage at the front of the building or diagrams showing where the system can be shut off—would help fire crews determine their emergency response plan as swiftly as possible.

Solutions: New Jersey's law, signed in January by Gov. Chris Christie, requires buildings to post an emblem at their front entrance to notify firefighters.

Firefighters, in Part, Respond with Trainings

And as a result, some fire departments in the U.S. are taking action to train their personnel before it's too late.

As soon as firefighters arrive on scene, they are advised to make the determination between solar thermal panels and solar photovoltaics as each presents a different hazard (thermal panels pose the risk of scalding from hot fluid while PV panels carry the risk of electric shock).

During roof operations, firefighters will need to consider the additional weight of the PV array on a roof structure that may be weakened by the fire. Care should be taken throughout fireground operations never to cut or damage any conduit or any electrical equipment, and they should be treated as energized at all times. One tactic for minimizing or eliminating the electrical output from a solar module is to cover it with a 100 percent light-blocking material such as certain types of tarpaulin.

"We recognize that we need to do a better job as an industry educating first responders, especially firefighters, about solar panels," Solar Energy Industries Association spokesperson Ken Johnson told The Atlantic Cities blog shortly after the New Jersey warehouse fire.

"We are working very closely with firefighters across the United States on the developments of codes and standards," Johnson explained to Reuters in September. "After every incident, we learn from it and improve."

It's not clear just what progress has been made since then, as Johnson did not respond to SolarEnergy.net after repeated requests for an update.

Yet new products that seek to fill the fire risk gaps are emerging. A new solar panel sensor and fuse developed in Germany at the request of the Munich fire department (after the first responders had to let a building covered with rooftop PV burn to the ground) could be just what firefighters need. Perched between two solar panels, the TOPInno company product senses when the temperature reaches a certain threshold. At that point, the fuse will break, TOPInno General Manager Raymond Huwaë told Triple Pundit.

"The moment the fuses are broken due to the heat, the voltage will go down to below 120V, which is the legal requirement to be able to use water to extinguish the flames," he said.

The sensors/fuse product can also be turned off manually as well.

Boyce says though he sees momentum within the solar industry to address the fire risk issue, it's currently in a transition period so that products being released in the marketplace will be in compliance with new regulations.

One bright spot is in California, where CalSEIA has been working with the state fire marshal on an interim solution to the UL 1703 fire code that regulates how a rooftop PV system impacts the fire classification rating of the roofing material below it. CalSEIA has also held a webinar on this topic for the solar industry to understand the code's meaning, and how it can come into compliance, according to Executive Director Bernadette Del Chiaro.

"We just recently issued our first certification [under the UL 1703 fire code]," Boyce said, "so that's exciting news for the code community. They're excited to see this implemented with CalSEIA and others, and help them roll it out in the future."


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build solar panels with hail impact resistance. The market is changing quickly, however, and most moderate to high-quality panels are now being built to achieve improving hail impact resistance standards. Inexpensive or older solar panels, however, may not have been built to those standards, since they are not yet required in most juris-dictions. It is important to verify that panels are labeled for hail resistance in accordance with a recognized standard, such as UL 1703 (Underwriters Laboratories), IEC 61215, or FM 4476 or FM 4478 (Factory Mutual). Without adequate hail resistance, it is highly likely that your panels will be significantly damaged in a hail storm.

Wind uplift is another hazard associated with PV solar installations. Moderate to high-quality panels will have been tested against wind uplift, but their susceptibility to damage is also dependent upon the quality of the roof's construction.

PV modules can be manufactured to earthquake standards, such as FM *Approval Standard 4478,* but poorly mounted PV systems can compromise a building's response to an earthquake, which can lead to greater damages than would have occurred without the presence of the PV system.

General Liability – A PV solar installation is most hazardous to those who encounter it in an emergency scenario or are not aware of its potential dangers. At the roof level, where the solar panels are installed, there is an ever-present danger of electrical shock from the stored electrical energy in the panels (see the graphic below). As sun-light decreases, so does the electrical energy but powerful spot lights such as those used by contractors and fire fighters can generate electricity. It is critical, therefore, that emergency responders, security guards, maintenance personnel (particularly electricians) and others who access the roof under-stand the potential hazards. It is important to note that, like any other electrical system, a properly installed and well–maintained solar panel system is not inherently dangerous but when damaged or tampered with, it's like a powerful battery and can cause severe electrical injury or electrocution.

Workers' Compensation – The potential hazards stated above may obviously cause injury to the employees associated with the activities stated. As such, the hazards should also be considered in a context of WC. First responders, electricians, maintenance employees, and others whose duties put them in direct contact with a solar installation may be at risk from the hazards associated with the system, particularly if it has been damaged or compromised.

There are other solar installation hazards that can increase your exposure to loss from a property, general liability, and workers' compensation perspective. These hazards include traditional fire exposures; additional building collapse exposures and roof leaks resulting from the system installation. All of these hazards can be mitigated by a well-designed, properly installed and well–maintained system.

Fire Concerns with Roof-Mounted Solar Panels

As companies look to reduce their dependence on fossil fuels, many are turning toward rooftop photovoltaic (PV) power systems, or solar panels, as a source of renewable, clean energy. However, this technology comes with specific risks. One of the many dangers to solar panels is how the panel and its mounting system impact the combustibility of the overall roof system. Some solar panels, for example, include a backing of highly combustible plastic.

In laboratory-based fire tests of roof assemblies,[1, 2] the maximum allowable fire spread is between approximately 20 and 40 ft^2 (1.9 and 3.7 m^2), depending on whether an A, B or C rating is desired. In actual roof fires with roof-mounted solar panels, fire damage has involved areas of between 1,000 and 183,000 ft^2 (93 and 17,000 m^2). In the most extreme case the fire spread to the inside and destroyed the entire building (see Fig. 1).

Fig. 1. PV roof fire at a refrigerated warehouse in NJ in 2013 (photo courtesy of Vince Lattanzio, NBC Philadelphia)

While the results of a lab test and an actual fire are not always identical, such a wide disparity is reason for concern. Lab tests conducted by at the FM Global Research Campus in West Glocester, RI, USA, confirm these concerns. For such testing, an ASTM E108 test apparatus was utilized, placing PV panels over a commonly used, Class A-rated roof assembly (when the roof alone was tested), starting near the flame-exposed end. This roof assembly failed the test (see Fig. 2). While only one failure mode is required by the test standard, in this test all three of the following failure modes occurred: Fire spread laterally to both edges of the sample, material continued to burn after falling to the floor, and fire spread across the 13 ft (4 m) length of the assembly within 90 seconds.

Why did this happen? Regardless of the materials used in the construction of a PV panel, its mere presence changes the dynamics of a fire involving a roof assembly. Research tests done at Underwriters Laboratories[3, 4, 5, 6,7,8, 9, 10, 11] demonstrate that even a cement panel simulating the presence of a PV panel will increase fire spread across a common roof assembly.

There are three key considerations that affect fire spread along a roof where a roof-mounted PV array is installed:

In a typical roof fire, the flame is primarily vertical, or perhaps somewhat slanted due to wind. Once such flames spread under a PV panel, the flame is redirected much closer to the roof surface and nearly parallel to it. This increases the incident heat flux on the roof surface, often above its critical heat flux.

While the exterior fire classification of a roof is an effective way to rate the exterior fire performance of roof assemblies, even a Class A assembly will offer some fuel contribution to a roof PV fire, with most standing seam metal roof systems being the exception.

While the top surface of a rigid PV panel is usually made of tempered glass, the bottom of the panel may contain combustibles (used to protect the PV circuitry) in the form of polyester-based encapsulants and back sheets (see Fig. 3). If this ignites and the heat re-radiates, fire spread is likely to continue back and forth beneath the roof assembly and the PV back sheet.

PV rooftop fires have been caused by electrical arcs that occurs near the combiner box, where numerous wires from PV panels are connected. This is a location where there is considerable voltage, before the current is converted from DC to AC at the inverter, and where the roof assembly could ignite and result in fire spread under the PV panels.

Fortunately, there have been some improvements made by manufacturers during the past few years with regard to the electrical components that can reduce the potential for ignition. Some PV panels have micro-inverters on each PV panel, which convert voltage from DC to AC. This can be expensive, but it reduces the probability of ignition.

Manual firefighting efforts also can be hampered by the electrical risk associated with PV arrays. While minimum 4 ft (1.2 m) wide aisle spaces between panels at a maximum of 150 ft (46 m) apart have been recommended[12], this does not alleviate all the risk. Disconnecting electrical power from the PV array is complicated, and arrays continue to generate electricity, sometimes even at night. The PV array and the roof assembly should be designed so their construction limits potential fire spread and the entire burden for fire protection is not placed on manual firefighting efforts.

There are several design choices that can limit fire spread if ignition occurs:

Use a complete system (PV panels, securement, and roof assembly) that has been tested to simulate actual field conditions. FM Approval is available,[13] which includes testing for fire exposure as well as wind and hail.

If the existing roof has aged, it is recommended that a new roof be installed before installing a PV system. Choose roof assemblies that limit potential fuel contribution in the event of an exterior fire. Appropriate options include metal roof systems, as well as noncombustible materials (such as gypsum cover boards, mineral wool or expanded glass roof insulation) installed directly below single-ply or multi-ply roof covers. In some cases, coatings may need to be applied to the top of the roof cover.

melt at low softening temperatures and can flow when burning (such as expanded or extruded polystyrene insulation or multi-ply roof covers) may require protection such as a gypsum cover board installed over the insulation or a coating over the roof cover.

To prevent an exterior fire from entering the building, protect building expansion joints by securing mineral wool or other fire-resistant compressible insulation between wood nailers, covered by steel flashing.

Evaluate the potential for fuel contribution from the underside of the PV panel. The underside of the panel may have a glass backing, aluminum or fluoro-polymer-based back-sheet as an alternative to a polyester-based back-sheet.

Most importantly, it is best to use a PV panel that has passed a fire test with the proposed roof assembly.

For additional information, see FM Global Property Loss Prevention Data Sheet 1-15, Roof Mounted Solar Photovoltaic Panels.

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15.30 Scope

Photovoltaic panels, commonly known as solar panels, are an alternative electrical generation system which converts solar energy to electricity. These systems are known as photovoltaic systems, or simply PV. This system consists of photovoltaic solar panels and other electrical components used to capture solar energy and convert it to electrical power. Many systems are roof mounted, and present hazards to firefighting operations. Strings of photovoltaic modules are wired together to form an array, which can produce up to 600 volts commonly in a residential system. Photovoltaic modules are commonly mounted above existing roof surfaces. These modules and arrays can be powered by sunlight and by artificial light that could be produced from street lights and fire department scene lighting. These modules/arrays are then wired to an inverter that is used to convert the power generated by the PV modules from direct current to alternating current.

15.301 Guideline

Operating at incidents that involved PV systems may require adjustments to standard firefighting tactics to mitigate the situation in the safest and most effective manner.

The primary hazard to firefighters working around a PV system is an electrical shock. It is important that a thorough scene size-up is complete that identifies the presence of a PV system. After detecting the presence of a PV system it shall be important to note of the system itself is involved in the fire and if it is able to be de-energized. A risk-benefit analysis should be conducted. Incidents involving a PV system are unique in that components may remain energized within the structure or on the roof even after all utility supplied power has been de-energized.

It is important to note, that when controlling utilities, controlling the power at the electrical box and also at the inverter only controls the flow of electric from that point forward. All wiring leading from the PV modules and arrays to the inverter will still be energized if the module is receiving sufficient light to produce power. A qualified PV technician or electrician should be called to the incident to de-energize any system that has been compromised or creates a hazard.


ON
OFF

loss. The IC should also consider the presence of sunlight and artificial lighting. The IC should also consider the additional of the weight added to the roof by the PV system, especially in light weight truss or wooden I-beam construction could result in collapse if the fire has sufficiently degraded the roof's structural components.

Utility companies should be notified in the event of a working fire to control the utilities, but the utility company may not be able to control electric generated from a PV module and/or array. A contractor specializing in PV may be needed to control the PV system.

When personnel are performing roof operations and overhaul in a structure that has a PV system extreme care should be taken.

At fires that involved the PV module or an array, water streams can be directed onto the PV module or array as long as the hose stream originates at least 25 feet away from the module and/or array and is applied with a fog pattern set at 30 degrees or greater. Straight streams and foam will not be used as both are conductors and increase the risk to firefighters.

If roof operations are employed, roof crews should determine if the PV system components themselves are on fire, or are the PV components being impinged upon by fire. When working around a PV system that is on fire, firefighters should use respiratory protection. Roof objectives should be accomplished quickly and firefighters should then exit the roof, limiting their exposure to the PV system. Any vertical ventilation required will not be conducted in areas where PV modules or arrays are present. At no time shall personnel walk on a PV module.

PV system conduit containing energized conductors on the roof deck and in attic spaces poses a serious shock hazard to firefighters performing ventilation and overhaul. These PV systems may also be located in any portion inside the building and present a shock hazard. If PV system conduit is identified it should be communicated, including the location of the PV system conduit, with the Incident Commander and all personnel operating at the fire ground.

It is important to remember that the PV modules and arrays will still produce electricity to the inverter during the daylight hours and at night when artificial light is absorbed by the module. Traditional “Hot Sticks” are not recommended for use to detect the presence of electricity in PV systems.

Transferring the scene post incident, the Incident Commander should ensure that the property is safe. If hazards exist, they should be appropriately marked or barricaded.