| PHOENIX REGIONAL<br>STANDARD OPERATING PROCEDURES | |
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| Policy Name:<br>**PHOTOVOLTAIC INSTALLATIONS** | Policy Number:<br>**M.P. 205.20B** |
| This policy is for internal use only and does not expand an employee's legal duty or civil liability in any way. This policy should not be construed as creating a duty to act or a higher duty of care, with respect to third party civil claims against employees or the Phoenix Fire Department (PFD). Remedies for violations of this policy, if proven, are limited to administrative disciplinary action against PFD employees. | |
| Related Policies: 205.20, 205.20A, 202.19, 202.19A | |
| Other Reference: | |
| Date Implemented: 04/2023-R | Review Date: 04/2028 |

## PURPOSE

This procedure will establish a standard approach and response to Photovoltaic (PV) installations.

## POLICY

It is the policy of the Central Arizona Life Safety System Response Council to respond to reports of emergencies in facilities that have PV systems. Our objective is to provide for life safety and reduce property damage when and where it's safe to do so. It is important to note that because of the significant hazard they present, PV installations will change the way we operate in facilities that have them. Firefighters must recognize the existence of the PV installations early in an incident and know the associated hazards.

## PHOTOVOLTAIC SAFETY AWARENESS

PV systems are electrical generators. Photovoltaic arrays generate electricity by converting light energy into electrical energy. These systems are always generating electricity within the modules when they are exposed to light. Grid-tied systems can have electricity back feeding into the invertor until the disconnects are operated.

Photovoltaic Systems are found in residential, commercial and utility installations. All these systems represent a potential electrical shock hazard. Monsoon storms, hail, exposure to fire, or vandalism can create damage to the system which may cause electrical faults. These electrical faults may create a hazardous condition that can override the designed safety systems. Firefighters should use extreme caution when approaching PV systems and the structures they are found on.

## DANGERS OF PHOTOVOLTAIC SYSTEMS

PV systems create Direct Current (DC) that must be converted to Alternating Current (AC) for use in the electrical grid; this is done through an inverter. Depending on the type of PV installation and the occupancy, the expected voltages produced are as follows:

- Residential: Up to 600 Volts DC
- Commercial: Up to 1000 Volts DC
- Utility Installations: Up to 1500 Volts DC
    - Utility substations or power generating stations should not be entered and water streams should not be applied.

Note: Once converted through an inverter 1500 volts of DC current becomes 35,000 volts of AC current.

Emergencies involving PV installations and associated equipment contain hazards unique to electrical systems. This includes an electrocution hazard, toxic products of combustion, and thermal burns from electrical arcing. PV installations may consist of the PV cell, multiple cells mounted into a module, multiple modules mounted into an array, invertors, disconnects and electrical conduit. Some installations may have a Battery Energy Storage System (BESS).

The presence of a Photovoltaic array represents an increased dead-load on the roof structure. The impacts of this load shall be considered during operations.

### Emergency Procedures for Residential BESS systems.

When a PV system is identified it is critical to evaluate the system to determine if there is a BESS as part of the installation. Once identified the following steps shall be taken:

- Notify Command, the assignment shall be upgraded to a 3-1 Hazardous Materials Response, isolate the area.
- It is critical to operate electrical disconnects if it is safe to do so. This will isolate the battery system.
    - After operation of the electrical disconnects it is important to recognize that the batteries will still pose an electrical hazard due to the stranded energy that they contain.
- Crews will wear full PPE with SCBA Face Piece in place
- A charged hose line will be in place (1 ¾" or larger shall be used).
- Isolate the area surrounding the residential BESS a minimum of 40 feet. Hazardous Materials crews will set a hot zone.
- Avoid parking apparatus directly in front of the house
- Evaluate if the Battery Pack has been impacted by the initial fire or other event

- Contact vendor-specific technical support for assistance including battery management system (BMS) data.
- Consider an extended monitoring / cooling period of 12 hours in which the battery is monitored for signs of thermal runaway. This is a passive cooling period without water being applied.
    - Direct application of water is ineffective for cooling a battery to prevent a thermal runaway reaction. The construction of the battery pack prevents water from reaching the involved cells.
    - Temperature readings should be taken as early as possible and repeated at regular intervals (10 minutes) to identify trends. Is the battery getting hotter or beginning to cool?
- Water spray is the preferred agent for response to lithium-ion battery fires (Lithium-ion is not water reactive).
- Protect exposures through defensive firefighting.
- The Responsible Party must arrange for proper disposal and cleanup. The disposal company must be licensed/permitted to transport and dispose of damaged lithium-ion batteries.
- Contact the RP. They will be informed that they must contact the manufacturer for technical support.
- Command Officers shall make attempts to notify the building owner or occupant that there is a risk associated of a secondary event including fire as a result of continued power generation from the PV panels.
- Command or their designee may make notification over the radio that this notification has been made.

Hazardous compounds are used in the manufacturing process to make the cells. If panels are involved in fire, PPE including SCBA shall be worn. Exposure reduction through on scene decontamination shall be utilized.

Disconnects must be utilized to isolate the PV system from the electrical grid and BESS if present. It is important to note that some components of the system may continue to hold energy, this concept is called stranded energy and can represent a potential source of injury. PV panels or modules can be covered with opaque tarps to stop the generation of electricity if safe to do so.

Building integrated PV roofing tiles or shingles are unique in that they serve as the finished roof and generate electrical energy. This type of roof system not only has the electrical hazard associated with it, but they are extremely slippery and represent a fall hazard. Roof operations shall not be conducted on a building integrated PV tile or shingle roof.

When addressing concealed spaces including the attic, consider that electrical wires coming from the PV panels may be energized. It's possible for the aluminum frames of panels and the metal

components of mounting racks to become charged if the system has sustained physical damage. Avoid contact with these components.

## EMERGENCY RESPONSE PROCEDURES

Firefighters should identify the presence of PV installations early in the incident. Indicators that a PV installation is present are as follows:

- Visible array of PV panels
- Conduit coming from roof
- Invertors mounted on a wall or the ground next to building electrical panel
- Signage found around the electrical system

The presence of a PV installation shall be **announced on the tactical radio channel and acknowledged by Command**. It is critical that everyone on the fireground is aware of the presence of a PV installation. For example, interior companies must be aware of the potential for live electrical power to be still active in the attic and roof operations may not be possible depending on the layout of the PV array.

When a PV installation is present in a residential or commercial application, and when safe to do so, all disconnects should be operated to electrically isolate the system. In order to fully secure utilities to the structure firefighters should address the following:

- De-energize power coming into the building from utility company.
- De-energize electrical circuits leading from the PV system.
- Operate the rapid shut down switch to isolate the DC power for the PV system and confine the power to the array.
    - Older systems may not have this "rapid shut down switch" function and de-energizing procedures above will leave the circuit from the array to the disconnect fully energized.
- Evaluate the structure for the presence of a BESS and operate the disconnect if possible.

If a Responsible Party (RP) is available attempt to obtain information about the system and inquire if the PV installation includes a BESS. Direct the RP to contact their installer to respond to assess and mitigate hazards associated with the system.

## FIRE IN THE PV ARRAY (RESIDENTIAL AND COMMERCIAL)

If the PV array is involved in fire, it's possible to use water to extinguish the fire after the electrical disconnects have been operated. A fog pattern delivered at a minimum of a 10-degree pattern from a minimum distance of 20 feet away will provide for the safe application of water on a PV array. This tactic may only be employed on PV installations up to 1000 volts. Most residential and commercial PV systems generate less than 1000 volts. This tactic may not be employed on high voltage utility PV installations.

As the PV Panel burns the material can liquify and can follow the path of least resistance. This may extend the fire non-typically and cause extension below the panels and in the structure. Overhaul efforts must address this risk.

PV installations are becoming common in parking lots for electrical generation and to provide covered parking. It's critical in the event of a car fire in one of these systems to operate the electrical disconnects that feed the system. These systems are an example of where the decision to apply water to the panels may need to be made. It is mandatory to operate the disconnects prior to the application of water. These installations represent a unique hazard as the modules are overhead.

**PHOTOVOLTAIC GENERATING STATIONS (UTILITY SUBSTATIONS)**

In large utility substation events, we will not engage in any activities related to fire suppression inside the facility. We will simply isolate the area. All fire department personnel will remain outside the fence line and protect exposures as needed. Careful coordination with the proper utility company representatives is required before any action may be considered