Scarborough Fire Department
Scarborough, Maine

Standard Operating Guidelines

Book:	**Emergency Operations**
Chapter:	**Electrical Emergencies**
Subject:	**3500 - Responding to Photovoltaic System Incidents**
Revision Date:	**05/1/2018**
Approved by:	*B. Michael Thurlow*

PURPOSE

To establish a safe and effective method of firefighting in Photovoltaic (PV) equipped structures. Dispatch/Code Enforcement should create an inventory of properties featuring PV systems in Town based on information gathered from fire inspections and electrical permits.

POLICY

The following procedures should be used when arriving at a working incident in a structure with a PV system present. These procedures present an approach which will be applicable in the majority of situations, but they do not replace good judgment and experience in dealing with any particular incident.

SCOPE

The primary danger to firefighters working around a PV system is electrical shock. The Incident Commander must be immediately notified when evidence of a PV system is found at a working incident. Systems may operate at 600 volts on residences and up to 1,000 volts on commercial structures under bright light conditions. The inability to completely power-down photovoltaic panels and associated circuitry makes an incident in a structure powered by solar energy a hazard during the daytime and creates a potential concern at nighttime when artificial lighting is used.

DEFINITIONS

Inverter: Electrical component that converts DC current to AC current for use within the structure or to be sent back to the grid.
Lock-on: The body's inability to let go from electricity. If the muscles or nerves affected by the current include those that control breathing, cessation of breathing can result as long as the current flows – possibly until death by asphyxia.
Lockout/tag out (LOTO): Specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy. Reference SFD SOP# 3610.
PV Array: Assembly of mechanically integrated and electrically interconnected photovoltaic modules, photovoltaic panels or photovoltaic sub-arrays and its support structure.
PV Cell: Most elementary photovoltaic device. (**Solar Cell**).

PV Module: A complete, environmentally protected unit consisting of solar cells, optics, and other components designed to generate DC power when exposed to sunlight.
PV Panel: A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.
PV System: Assembly of components that produce and supply electricity by the conversion of solar energy.

PREREQUISITES

A. In residential and commercial applications, the PV system's integration is achieved through either a back-feed circuit breaker at the main panel, a bus tap, or at the switchgear serving a commercial building. In any case, the electricity generated from the PV system is "back- fed" into the building's electrical system.
B. The DC power generated by an array is carried back to an inverter via conductors in conduit or cable tray to the main panel. Inverters convert the direct current (DC) to alternating current (AC).
C. Depending on the type of system and when it was installed, securing the utilities may not reduce the shock hazard of an array. **Always assume the system is still energized**.
D. If there is a PV system involved, rule out the presence of a battery back-up system which will keep circuits in the building energized.
E. Scene lighting and exposure fires may provide a sufficient amount of illumination to solar modules to generate a "lock-on" hazard.
F. Damage to modules from the incident or tools may result in electrical and fire hazards. These hazards may occur in parts of the system other than at the point of damage.
G. Structural firefighting PPE must be worn, however they provide little protection against electric shock.
H. Fires under the array but above the roof may breach roofing materials and decking, aiding in fire growth.

PROCEDURE

A. On arrival:
    1. Size-up
    2. Identify and validate hazards
    3. Identify the existence of a PV power system and notify the IC.
    4. Locate rooftop panels, beware of energy and additional roof weight hazards.
    5. Always consider PV systems and their components as electrically energized.
    6. Locate the main electrical panel and open (shut off) the main breaker and any other disconnects present. Try not to open (shut off) all branch circuit breakers for investigation preservation.
    7. Use LOTO (Lock out/Tag out) system.
    8. Identify battery banks, usually located in garages or basements as they may be the cause of smoke or fire.
    9. Do not break the PV panels or cut wiring coming from them, they are electrically hot.
B. If you encounter a structure fire, implement structural firefighting techniques stressing all fireground personnel must stay clear of the electrical hazard. Serious injury can occur during daylight.

C. When engaging in firefighting tactics on structures that may have energized PV systems, the issue of whether or not to apply water or dry chemical extinguishers is an important tactical decision. Straight streams or foam should not be used.
D. If a PV array becomes engulfed in fire and water is used, the array should be attacked similarly to any piece of electrically energized equipment. Shut down the power and apply water to the array with the nozzle set to a 20-30 degree fog pattern. Firefighters should be at least 5 feet away from the energized source.
E. Rooftop firefighting operational hazards:
    a) Metal roofs may become energized.
    b) Tripping or slipping may occur on a rooftop in dark or smoky conditions.
    c) During roof operations fire fighters will need to consider the additional weight of the PV array on a roof structure that may be weakened by the fire.
    d) A rooftop solar array may prevent direct access to the section of roof providing the optimum point of ventilation.
    e) Under no circumstances should solar panels be damaged or compromised to perform vertical ventilation.
    f) Using any ladder near electrical equipment such as solar panels could create a conductive path to the firefighter.
    g) Panels have the potential to slide off roofs.
    h) PV conduits may run in attic spaces. The National Electrical Code® requires solar PV conduit/wiring systems to be installed more than 10 inches from the roof deck or sheathing unless they are directly under the array. However, firefighters should still proceed cautiously when operating saws for ventilation operations.
    i) Firefighters should consider using positive pressure ventilation (PPV) in dwellings equipped with solar panels.
F. Batteries generally burn with difficulty, although plastic battery casings provide a limited contribution to the combustion process.
G. Batteries that do burn or are damaged in a fire generate fumes and gases that may be flammable and or toxic. Lithium-ion batteries should be extinguished with large amounts of water in order to cool the reaction.
H. Spilled electrolyte from lead acid batteries can react with other metals and produce toxic fumes and flammable or explosive gases. Dry chemical, CO2, and foam are the preferred methods for extinguishing a fire involving these type of batteries. Water is normally not the extinguishing agent of choice.
I. Salvage and Overhaul:
    a) A fire event may compromise the PV conduit and wire system resulting in arcing, and may lead to a possible rekindle the next morning at sun up. Make sure to check the scene in the daylight after the event to ensure that no rekindle takes place.
    b) Once you isolate the system, removal of the PV modules should only be done by qualified personnel with electrical PPE.
    c) Energized system components located inside the building may create an electric shock hazard for interior overhaul crews. PV system conduit and wiring can be located in any portion of the building, including equipment rooms, closets, garages and attic spaces.
    d) The system should not be reenergized until a qualified solar provider/electrical contractor can satisfactorily recommission the system.

RESPONSIBILITIES

It is the responsibility of all Fire Department personnel in the Town of Scarborough to adhere to this policy.

REFERENCES

A. CAL FIRE–Office of the State Fire Marshal Fire Ops for PV systems
B. The Fire Protection Research Foundation
C. San Francisco F. D. Solar Photovoltaic (PV) System Safety and Fire Ground Procedures
D. Bill Brooks, Brooks Engineering, Solar ABC's Solar PV safety
E. Robert Backstrom Research Engineer, Fire Hazard Group, Corporate Research
F. David A. Dini, P.E. Research Engineer, Electrical Hazard Group, Corporate Research
G. Underwriters Laboratories Inc. Firefighter Safety and Photovoltaic Installations Research Project