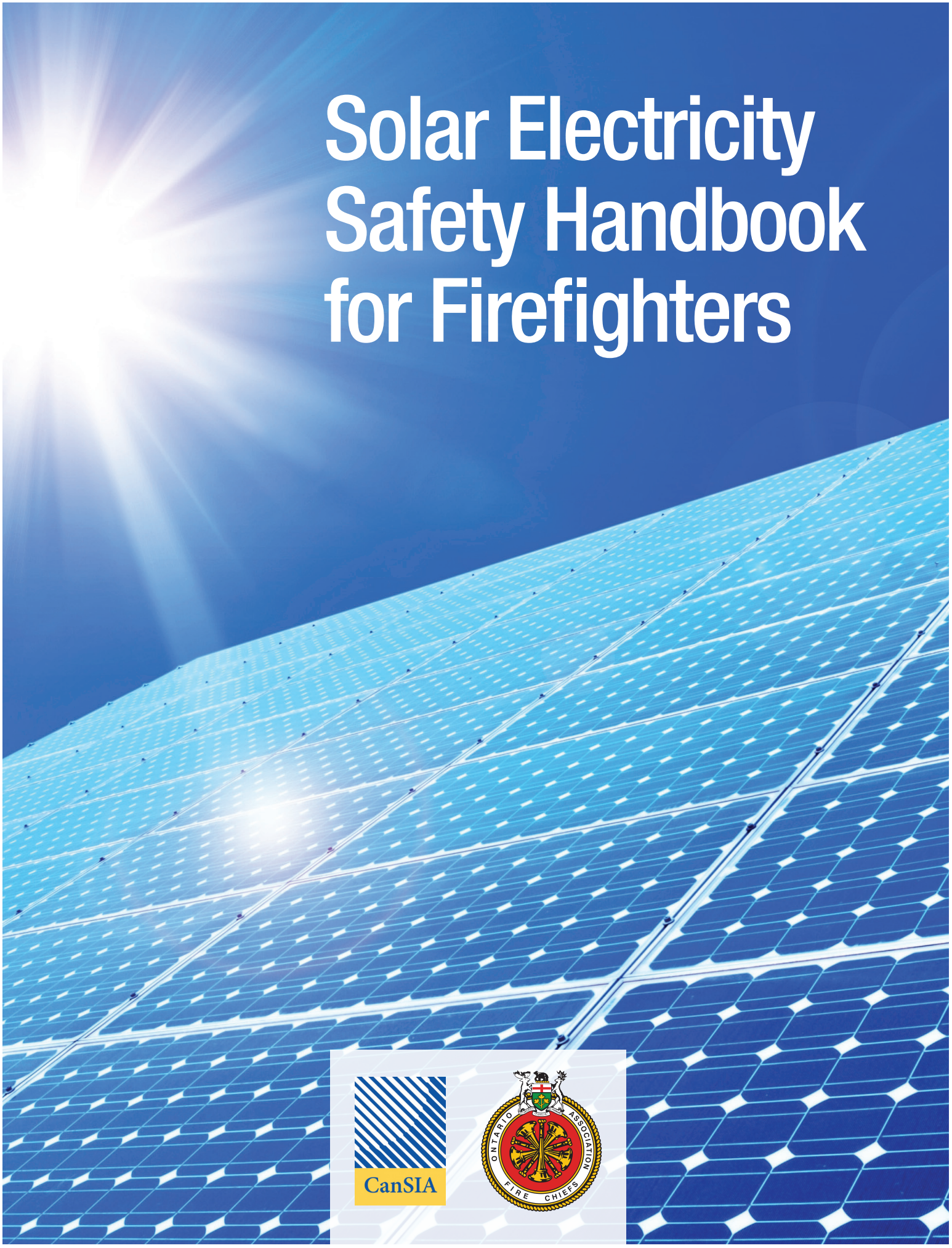
Solar Electricity Safety Handbook for Firefighters



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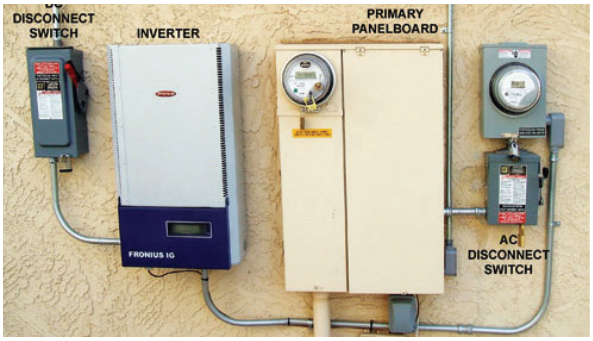
DISCONNECT SWITCH
INVERTER
PRIMARY PANELBOARD
AC DISCONNECT SWITCH
FRONIUS IG

Solar Electricity Safety Handbook for Firefighters

This handbook was prepared by the Ontario Association of Fire Chiefs (OAFC) and the Canadian Solar Industries Association (CanSIA). We gratefully acknowledge the following individuals who contributed information and reviewed content:

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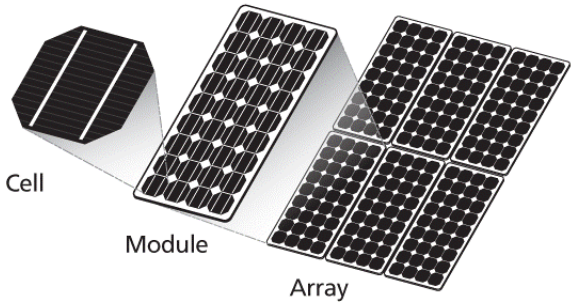
Definitions



Solar Photovoltaic (PV) Systems
The components and subsystems that in combination convert solar energy into electrical energy suitable for connection to conventional loads.

Grid-Tied PV System
A solar photovoltaic system that operates in parallel with, and that may deliver power to the utility grid.

Off Grid System
A solar photovoltaic system that operates independent of a utility grid.

PV Module
A manufactured and complete environmentally protected assembly of interconnected solar cells, mechanically fastened together and prewired to form a self-contained unit.

PV String
An electrical circuit created by one or more series connected PV Modules.

PV String Combiner
A piece of equipment that combines two or more PV Strings in parallel.

PV Inverter
Converts the direct current (DC) output of the PV Modules into alternating current (AC)

Utility-Interactive PV Inverter
An inverter intended for use in parallel with an electric utility, the output is fully synchronized with the utility power.

Off Grid PV Inverter
PV inverter intended for use independent of the electric utility grid.

Distributed Generation (DG)
The name used by utilities and the Electrical Safety Authority (ESA) to identify renewable energy or other generators connected to the utility grid. This includes solar PV systems. Warning signs and labels identifying solar PV system and associated equipment will reference DG in most cases.

Backfeed
A electrical generator feeding power back to the electrical system, often. This can be hazardous when the system is thought to be de-energized.

Photovoltaic (PV) Array
A collection of PV modules located together.

References

Ontario Fire Service Section 21 Advisory Guidance Note 6-34 Solar Photovoltaic (PV) Systems
www.oafc.on.ca/section-21-manual

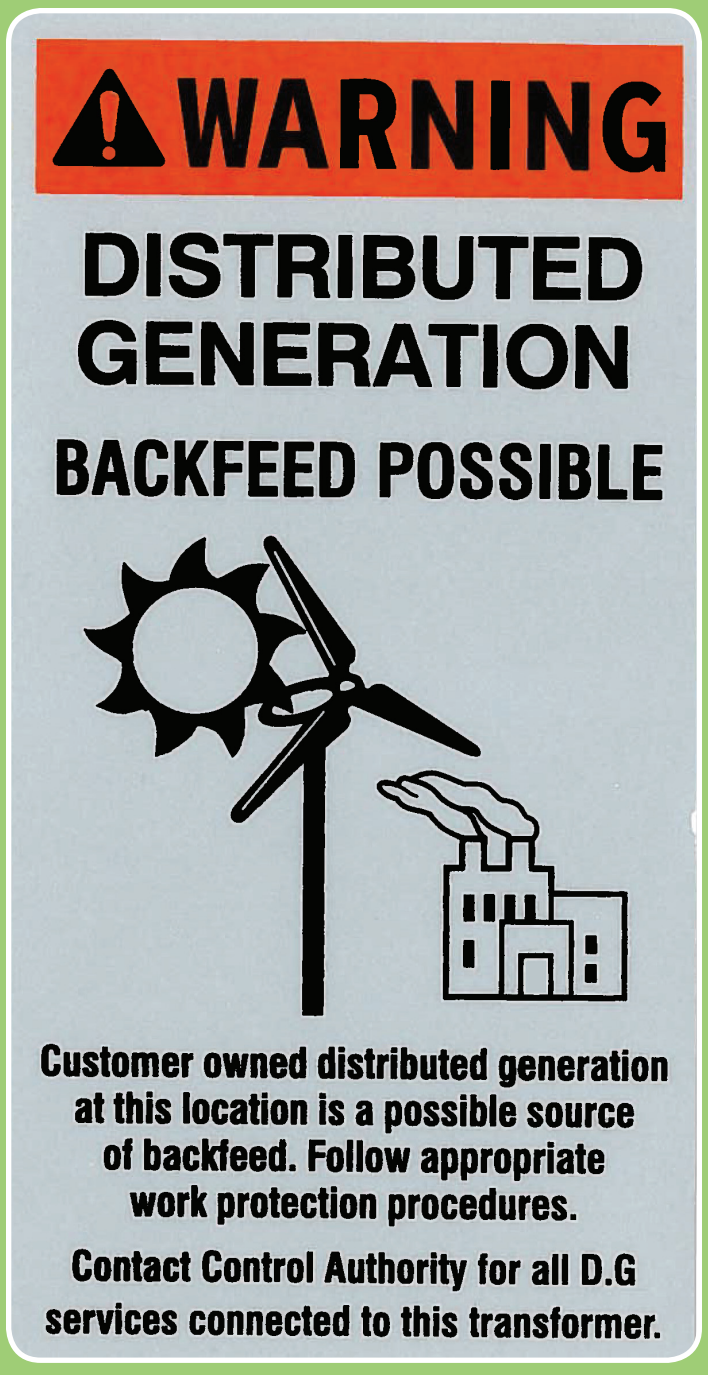
Introduction

This manual has been designed and developed jointly by firefighters, solar and insurance professionals to educate and protect first responders who may attend an emergency situation where solar energy installations are present.

Solar cells were originally introduced in the late 1800's, however didn't gain much traction in Canada until 2009 with the introduction of Ontario's Feed in Tariff (FIT) program. This program provides financial incentives to installation of Solar PV throughout the province. To date, there are over 45,000 solar installations found across the province that have been connected to the electricity grid on homes, schools, commercial and industrial units and in fields. Although there have only been a handful of emergency events, understanding electricity generation identification, potential hazards and important safety considerations is paramount to ensuring the health and safety of first responders.

Additional information on Ontario's Feed in Tariff (FIT) program can be found here:

http://fit.powerauthority.on.ca/



What are Solar (PV) Modules (Panels)

Flat roof with ballasted or attached installation

Typical retrofit. Note: No clearances along edges

Stand alone system

Modules that are integrated into shingles

What is a Photovoltaic (Solar) Module?

A packaged, connected assembly of photovoltaic cells (think of solar garden light = one cell). Rated by its direct current (DC) output, (typically between 100-300 watts) and weighs approximately 2-7 lbs per square foot (1-3Kg per 30cm^2).

Electricity Terms

Voltage = Pressure

Current (Amperage) = Flow Rate

Power (Watts) = Voltage X Current

How do they work?

Photons (fundamental particles of light) in sunlight hit solar panels. If they are not in the right range (frequency), they are either reflected or dissipated as heat. Those in the right range are absorbed further into the panel and start a chain reaction with electrons (negative charge). These electrons start moving and create what we know as electricity.

What are Solar Thermal Collectors?

SOLAR THERMAL COLLECTORS SHOULD NOT BE CONFUSED WITH PV PANELS AS THEY PRESENT DIFFERENT HAZARDS.

Solar thermal collectors are characterized by tubing for circulating heat transfer fluid.

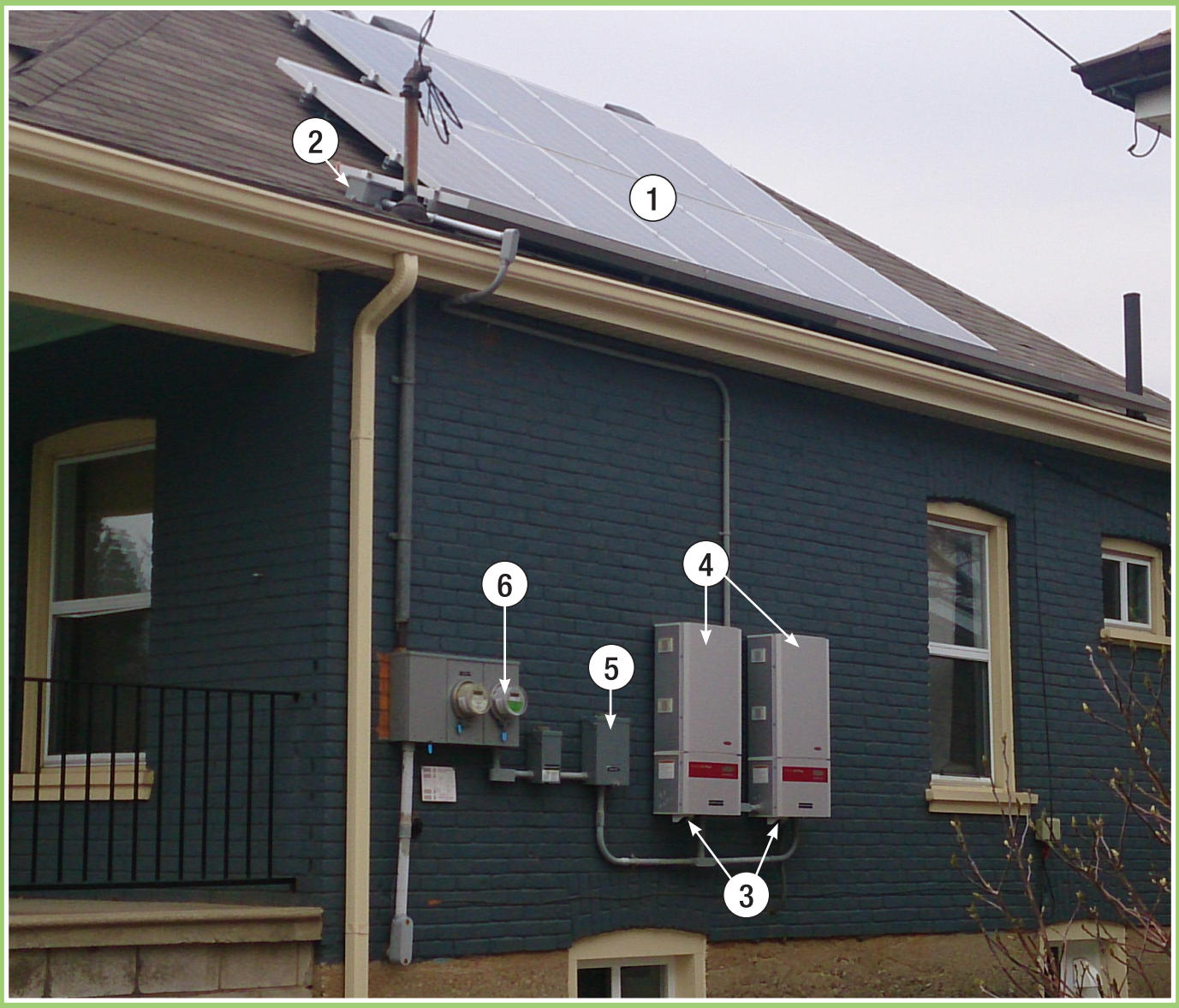
Sunlight heats the circulating fluid.

THERE IS NO ELECTRICITY GENERATED THROUGH THIS PROCESS.

Solar thermal collectors do contribute added load to the roof.

SOLAR THERMAL SYSTEMS GENERATE VERY HOT FLUIDS. DAMAGE TO A SOLAR THERMAL SYSTEM MAY EXPOSE PERSONNEL TO A RISK OF SCALDING BURNS.

The Photovoltaic System



1. Solar Modules
2. Combiner Box
3. DC Disconnect
4. Inverter
5. AC Disconnect
6. Generation Meter

What are PV Strings and Combiners?

Photovoltaic panels are usually assembled in a “string” which means that multiple panels are joined together in series to increase the system voltage. Each string can generate a maximum output of up to 1000v DC. These strings are connected in parallel in combiners (junction boxes) to increase the system current and are usually located near the solar modules. In small systems, the combiners allow all the wires to come together and only one main set to continue down to the inverter. In larger systems, there can be recombiners and multiple wire sets down to the inverter. Combiners and re-combiners can have fuses, breakers or switches.

What is an AC Disconnect?

The alternating current (AC) disconnect is a switch that is used to shut off power from the building to the inverter.

The AC disconnect switch may contain breakers or fuses.

It is similar to the DC disconnect switch, even with the AC disconnect shut off, the solar panels, wires and cables with the conduit may be energized.
Operation of the AC disconnect will not de-energize the DC components. Panels and cables will still be energized.

EVEN WHEN THE AC DISCONNECT IS IN THE "OFF" POSITION, ALL SOLAR PANELS AND CONDUIT MAY BE ENERGIZED. OPERATE THE AC DISCONNECT BEFORE OPERATING THE DC DISCONNECT.

METALLIC CONDUITS MAY BECOME LIVE IF CABLES AND/OR CONDUIT DAMAGE HAS OCCURED.

What is a DC Disconnect?

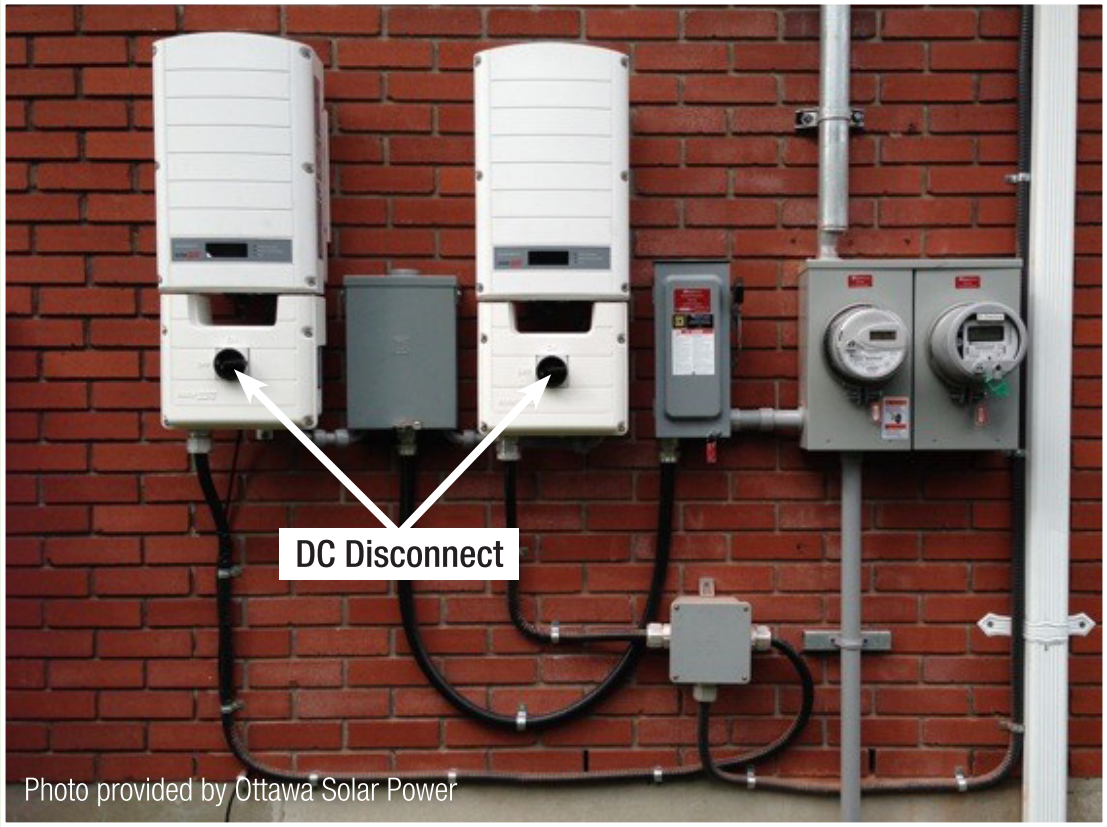


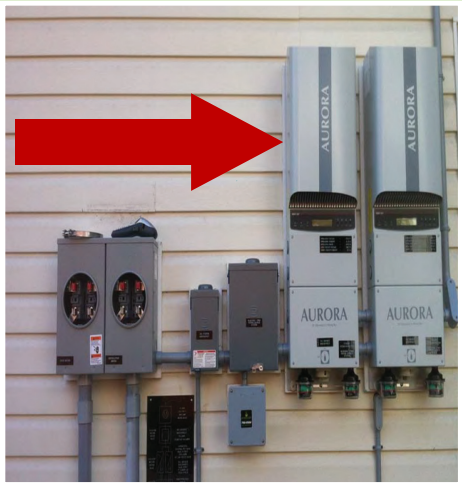
Photo provided by Ottawa Solar Power

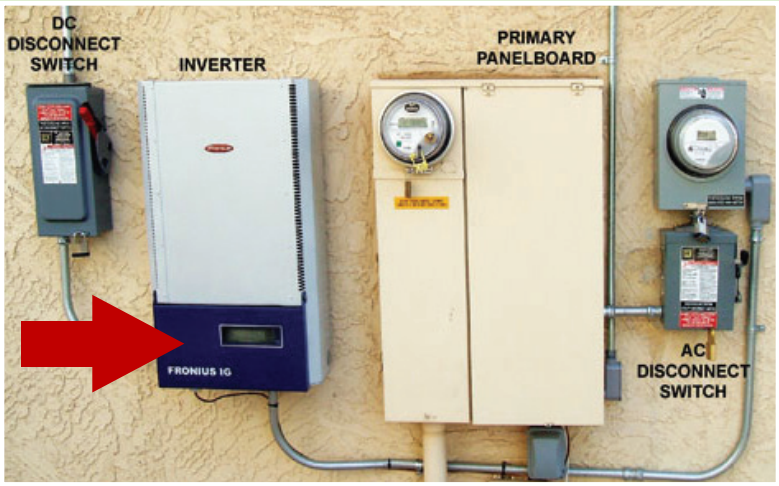
The primary function of the direct current (DC) disconnect switch is to shut down power from the solar panels to the inverter. The DC disconnect switch is usually located near the inverter but can also be attached directly on the inverter itself.

EVEN WHEN THE DC DISCONNECT IS IN THE "OFF" POSITION, ALL SOLAR PANELS AND CONDUIT LEADING INTO THE DC DISCONNECT WILL BE ENERGIZED.

OPERATE THE AC DISCONNECT BEFORE OPERATING THE DC DISCONNECT

What is an Inverter





The inverter is a device that is used to convert the direct current (DC) being generated by the solar panels into alternating current (AC).

In FIT and microFIT systems, the inverter must “see” power from the utility. It will not convert DC to AC without utility power.

Inverters can be found in various types and sizes such as central inverters, series string inverters and micro inverters.

THE INVERTER MAY BE LOCATED INSIDE THE BUILDING!

Various types of Inverters

Backfeed Hazards

The primary function of battery banks is to store power that is to be used in the building. Multiple battery banks can be found in closets, basements, crawl spaces, sheds and in other unsuspected or unmarked locations. Battery banks are present and located in systems that are NOT tied back into the grid. Battery backup systems are not permitted for directly connected facilities. Battery backup systems are permitted for systems connected in parallel but cannot, under any circumstances, be connected between the renewable generating facility and the generation meter.

BACKFEED GENERATION IS POSSIBLE FOR THESE INSTALLATIONS.

FIREFIGHTERS AND FIRST RESPONDERS MUST BE AWARE OF THE DANGERS AND HAZARDS ASSOCIATED WITH BATTERY BANKS.

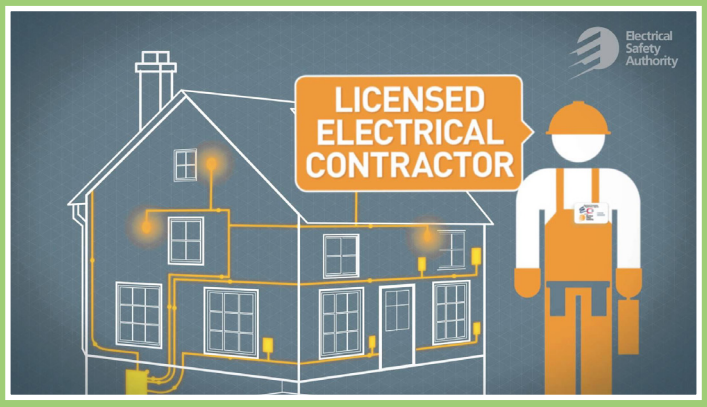
Installation of PV Systems

The majority of photovoltaic systems are installed by qualified professionals, using certified components.

ONE OF THE BIGGEST CONCERNS ARE "DO IT YOURSELF" INSTALLERS THAT PUT TOGETHER THEIR OWN SYSTEMS WITH HOME BUILT COMPONENTS, NO UNDERSTANDING OF ELECTRIC SAFETY REQUIREMENTS AND NO INSPECTION.

Who inspects PV Systems?

The Electrical Safety Authority (ESA) must inspect every solar photovoltaic installation in Ontario that they are aware of. All electrical work must conform to standards outlined in the Ontario Electrical Safety Code. The ESA inspector may not go on the roof to inspect. Not all muncipalities require a building code inspection.



HAZARDS

THERE IS ALWAYS AN ELECTRICAL SHOCK HAZARD

- PV systems may energize metal structures or ground water when flooding occurs.
- Added weight (dead load) when installed on roofs.
- Potential uplift in extreme winds.
- Can mask potential collapse due to racking system holding areas of roof decking.
- Cables and panels can pose trip hazards.
- Smoke from burning panels may release extremely toxic fumes when involved in fire.
- If contact is made with direct current (DC) there is little or no ability to let go because of the constant flow.
- Battery storage areas can generate corrosive and explosive gasses when exposed to fire.
- Don’t cover panels with tarps, salvage covers or foam.
- Backfeed generation is possible for these installations

SOLAR PANELS CANNOT BE SHUT OFF!

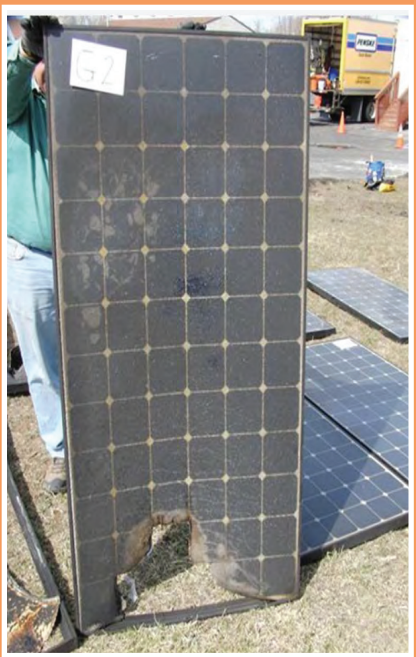
Hazards – Electric Shock Potential

A SINGLE SOLAR PANEL PRODUCES ENOUGH ELECTRICITY TO KILL YOU.

Electrical Shock from Firefighters Tools

Damage to panels from tools may result in both electrical and fire hazards. The hazard may occur at the point of damage or at other locations depending on the electrical path. Metal roofs and buildings present unique challenges in that the surface is conductive unlike other types such as shingle, ballasted or single ply.

Damaged Solar PV Panels



DAMAGED EQUIPMENT/SOLAR MODULES CAN BE LIVE!

Fire Hazard - Arc Fault

A fault in the wiring may cause an arc whenever the solar panel is exposed to light. DC arc is more dangerous than AC.

Always Treat as Live Because...

LIGHTING FROM FIRE APPARATUS OR STREET...
can produce dangerous electrical levels from solar panels. **TREAT AS LIVE!**

LIGHT FROM FIRE...
can also produce dangerous levels of electricity.

THE MOON...
in certain conditions, especially with cold temperatures, the light from the moon can also produce dangerous levels of electricity.

THE MORE INTENSE OR DIRECT THE LIGHT, THE GREATER THE HAZARD.

Personal Protective Equipment – PPE

Full Bunker gear must be worn when dealing with a photovoltaic emergency (coat, pants, boots, helmet, balaclava and gloves). Bunker gear is not designed or intended to provide protection from electrical current.

SCBA must be worn due to the fact that all fires are toxic.

Gloves and Boots, Electrical Insulation

Boots are only tested when they are new and dry. Dirt, water and damage (normal wear & tear) can reduce or negate the ability to provide electrical insulation.

Gloves are not tested for electrical insulation.

Rescue Considerations

Potential electrocution incident. How do we approach an injured person on, near or under an array that could be live?.....

DON'T TOUCH ANYTHING METAL THAT MAY BE IN CONTACT WITH THE SOLAR SYSTEM

NO CONTACT WITH RACKING, METAL ROOF, OR METAL FRAMES OF THE SOLAR PANEL

CONTACT UTILITY OR CONTRACTOR, WAIT FOR ISOLATION

Tactical Considerations

- [ ] The first step is identifying the type of solar PV system in use.
- [ ] A 360 degree survey of the scene is key to the decision making process for the Incident Commander.
- [ ] Call the local utility company to disconnect the electrical service.
- [ ] If the roof is not involved and there is no flame impingement on the solar panels, consider treating the incident as a room and contents fire until the fire has extended into the roof. Watch for wires or conduits.
- [ ] Ventilation is to be directed by the Incident Commander, who may consider the opposite side of the roof, horizontal or positive pressure ventilation.
- [ ] Look at the meter entrance to the building – may have a distributed generation (DG) meter.
- [ ] Shut off switches on all disconnects found.

INVERTERS MAY NOT BE VISIBLE!

UL experiments found that with a 10 degree fog pattern, the nozzle could be as close as 5 feet (1.5 meters) on systems energized up to 1000 volts DC.

All systems are required to have a permanent label on the disconnect.

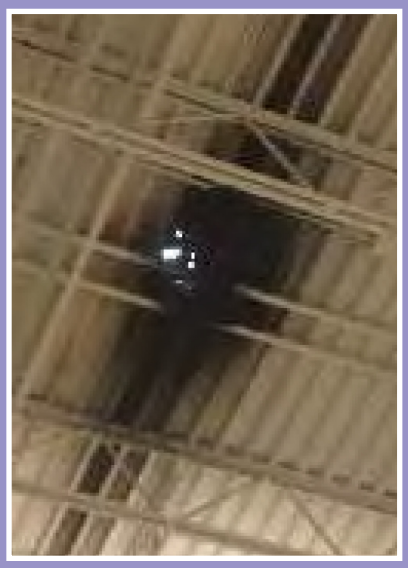
During night time, operations must be reviewed by the Incident Commander prior to sunrise to re-assess tactics - or when light conditions change such as less cloud, more scene lights.

During overhaul be aware that wiring may not be visible.

Fire departments should have a list of local installers to call for isolation of system in emergencies.

WHENEVER LIGHT IS PRESENT, TREAT ALL PANELS AND WIRING AS LIVE

Example of Solar PV Fire Damage

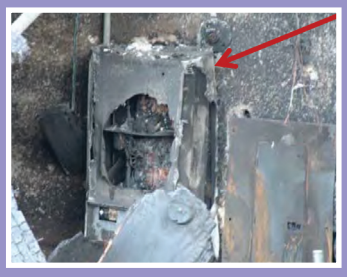


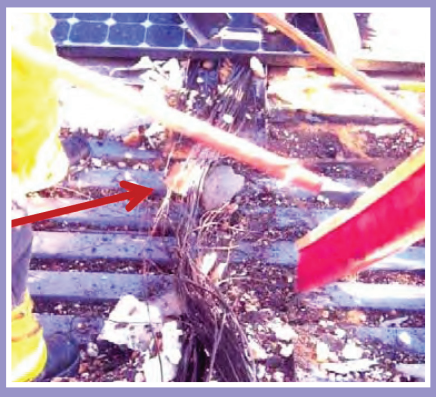
HOT ENOUGH TO BURN THROUGH THE STEEL ROOF DECK

Post Fire Hazard

Photovoltaic systems on a burning building may not be the cause of the fire but may be damaged as a result.

During clean up damaged wires may still be arcing.





FIREFIGHTERS SHOULD TREAT ALL WIRES AS LETHAL SHOCK HAZARDS

Notes

This handbook was made possible with the strong support of the following sponsors:

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