Solar Power
Safety & Awareness

Information for Emergency First Responders

Resources Utilized:

THE FIRE PROTECTION RESEARCH FOUNDATION

HEALTH & SAFETY The Only Choice

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Solar Energy Systems

There are different types of Solar Systems and Technologies

- **Passive Solar Design**
- **Solar Thermal Systems**
- **Solar Photo-voltaics (PV)**

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Building Systems: Solar Thermal

- Does not produce electricity – produces hot water
- Has 2 main parts: Solar collector and storage tank
- The sun is used to either directly heat the water – or a heat-transfer fluid – in the collector
- Can be used for pool heating, water heating, space heating

Building Systems: Solar Photovoltaic (PV)

Solar Photo-voltaic (PV)
(Our Focus)

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Solar Power - Safety & Awareness

Program Goals:

- ***To Provide Firefighters with an Awareness of Photovoltaic Systems so Informed Fire Ground Decisions can be Applied for Safe Fireground Operations***

Source:

NOTE: PSE&G is providing this information to assist in the awareness of potential hazards. Emergency responders must determine if/how this may apply to "Safe Fireground Operations".

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Program Agenda

SOLAR TECHNOLOGY OVERVIEW

- Types of systems and technologies common today
- Solar Applications

SOLAR - CONSIDERATIONS FOR FIREFIGHTERS & FIRST RESPONDERS

What's on the way – New Solar Technologies & Codes

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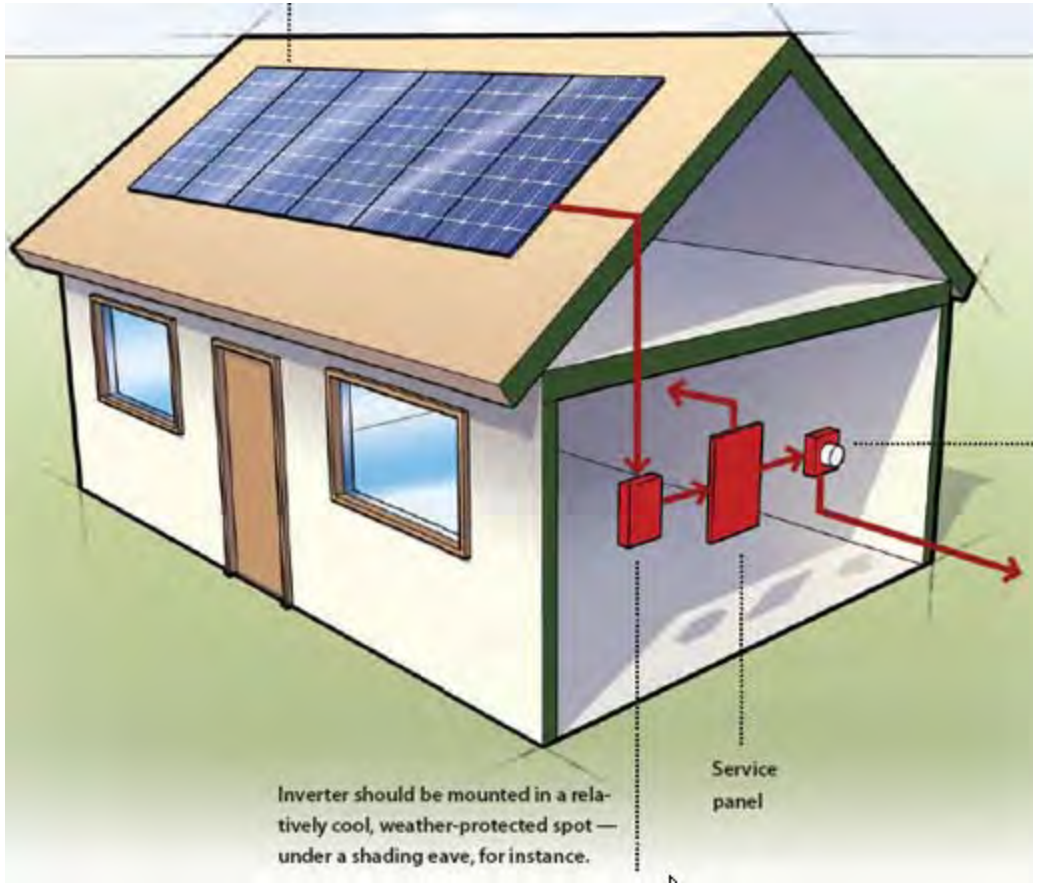
Grid-Tied Solar PV

Solar PV Systems - Configurations

Solar PV Systems - Configurations

Grid-Tied (grid-interconnected)



Grid-Tied "Behind the Meter"
(MOST COMMON)

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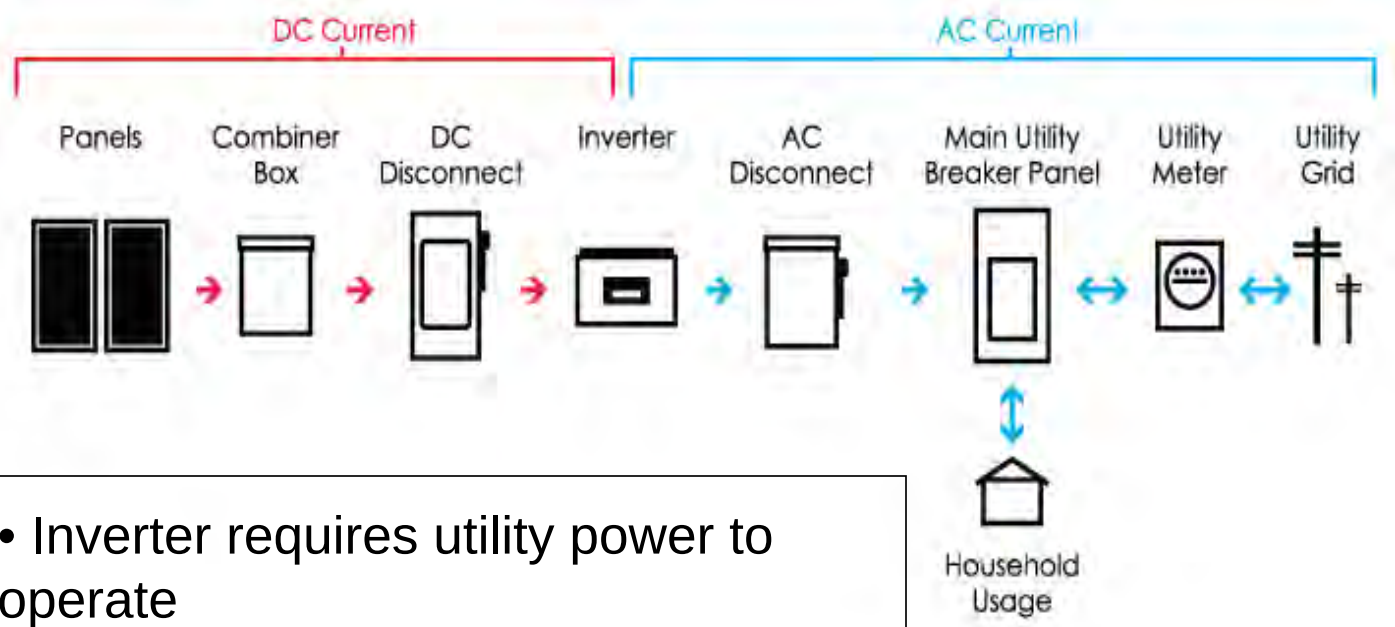
Grid-Tied PV – Today's Systems' Common Components



- Inverter requires utility power to operate
- If utility service is interrupted, inverter is designed to shutdown
- This prevents "islanding" to the grid – but the panels could still be generating DC current to the inverter

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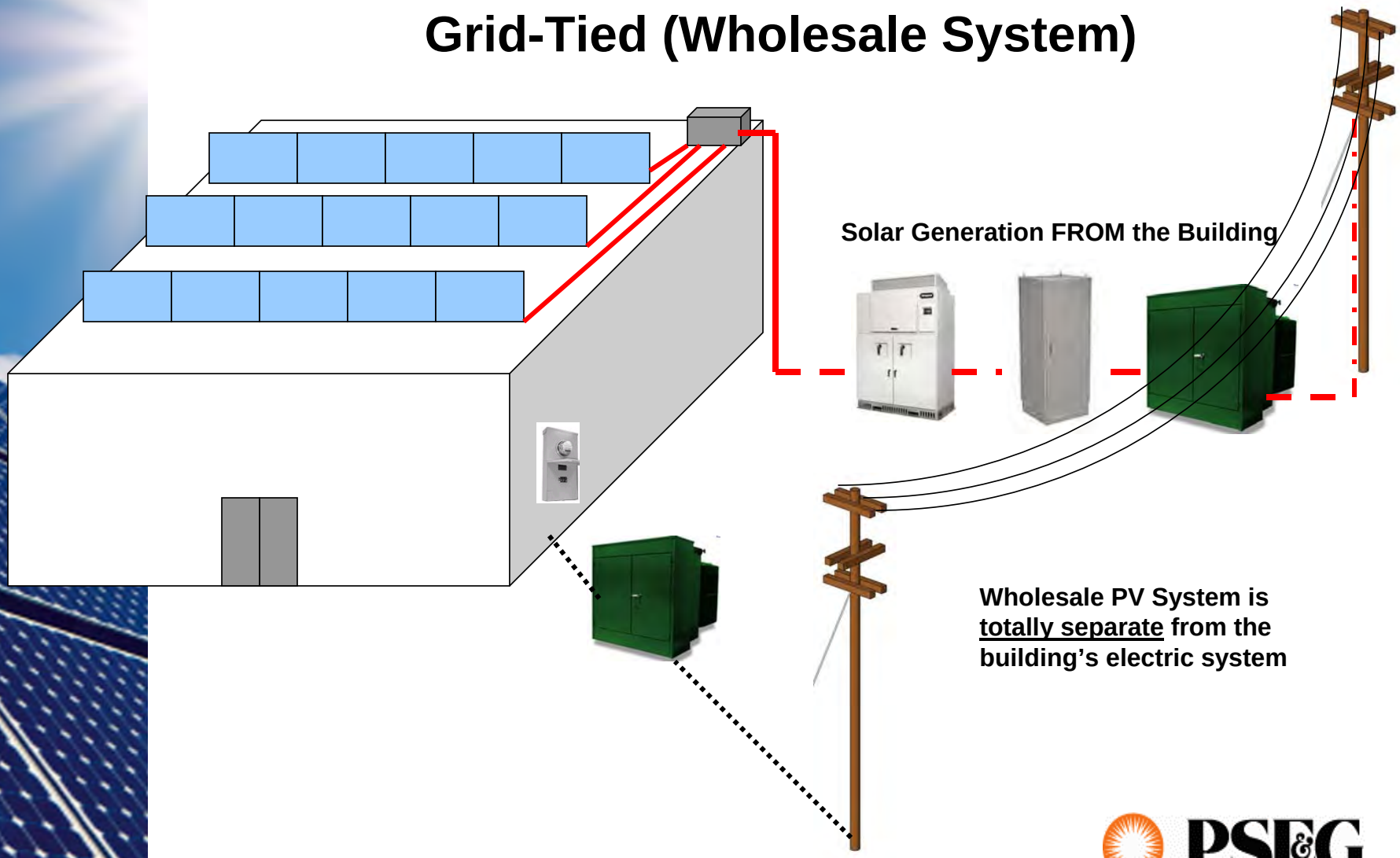
Solar PV Systems - Configurations

Grid-Tied (Wholesale System)

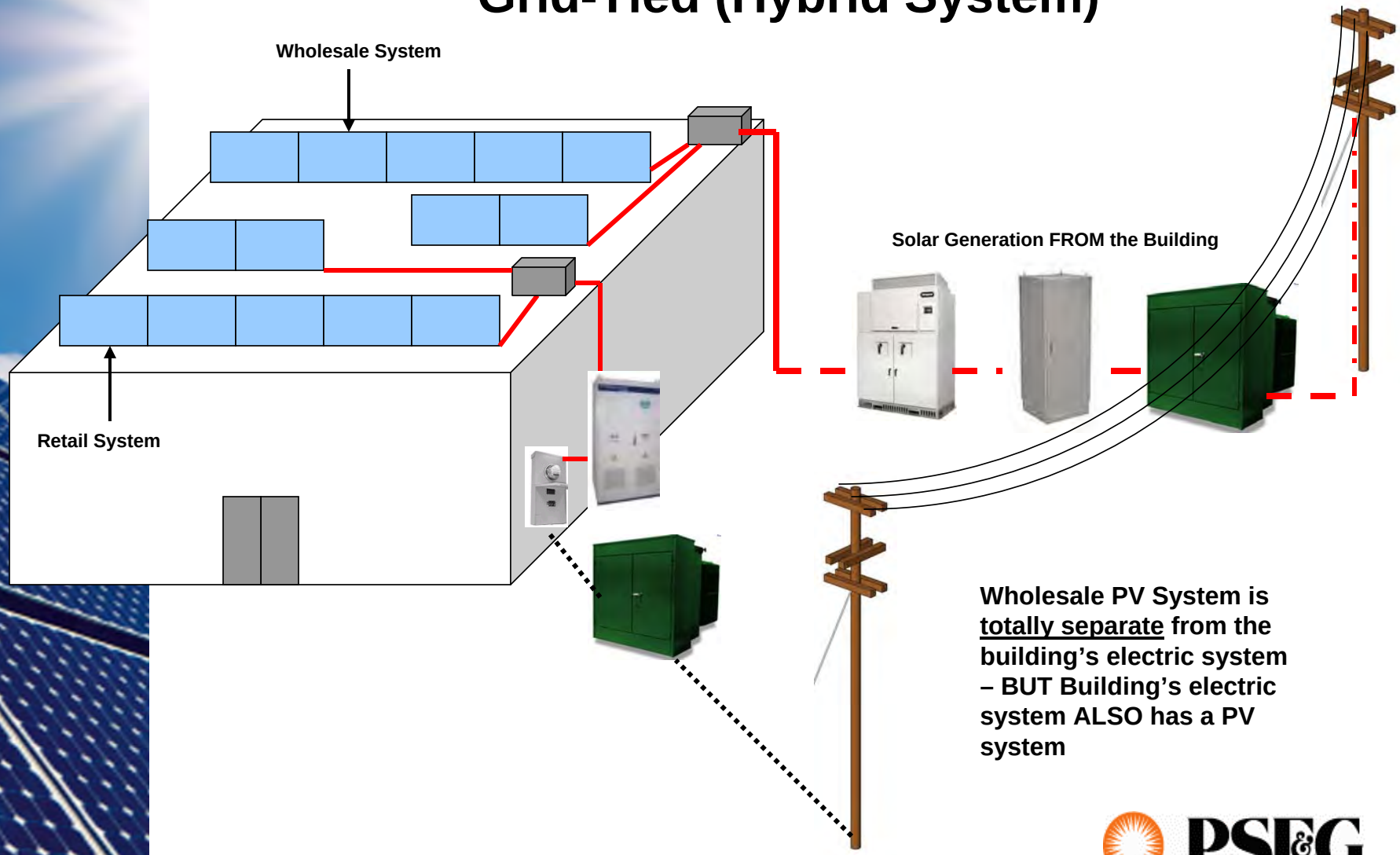


Solar PV Systems - Configurations

Grid-Tied (Wholesale System)

Solar PV Systems - Configurations

Grid-Tied (Hybrid System)



Wholesale PV System is totally separate from the building's electric system – BUT Building's electric system ALSO has a PV system

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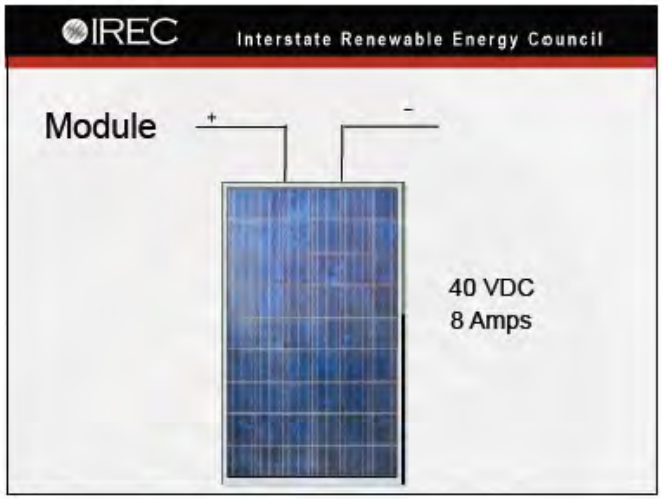
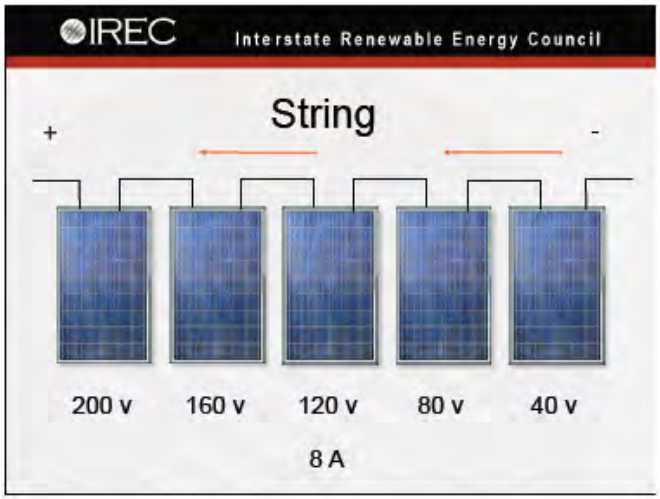
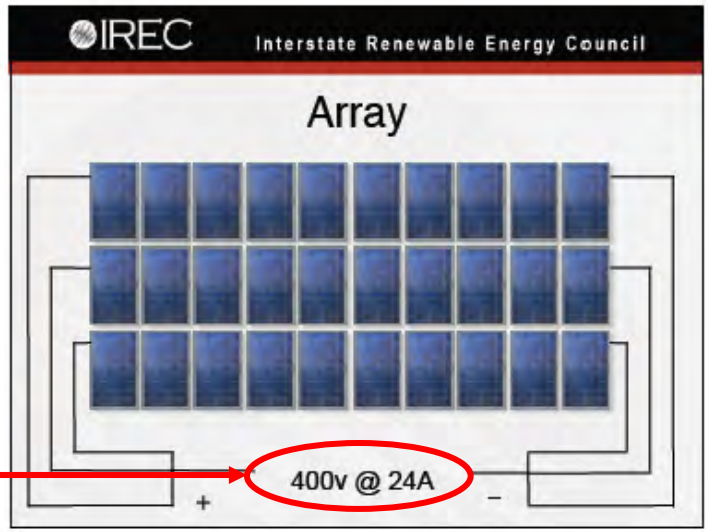
Solar PV Components & Terminology
Cells - Modules - Strings - Arrays







600v – 1000v MAX

High Voltage
High Current

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Solar PV - Panel Types - Crystalline

- Most common technology
- Tempered Glass, Aluminum Frames
- Built to last 20-25 years
- Size generally dictates output

Crystalline Modules

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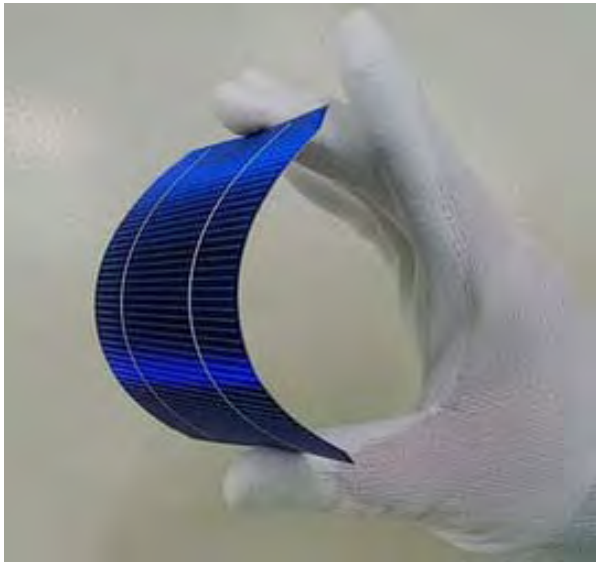
Solar PV - Panel Types – Thin Film

As compared to Crystalline Panels

- **Less expensive to produce**
- **More expensive (total system)**
- **Currently less efficient**
- **Provides a greater variety of applications**
- **Competing technologies (semi-conductors)**



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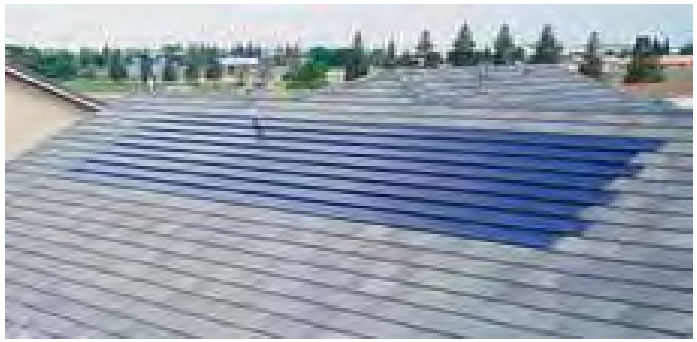
Solar PV - Panel Types – Thin Film (Residential BIPV)



Building Integrated Roof Systems

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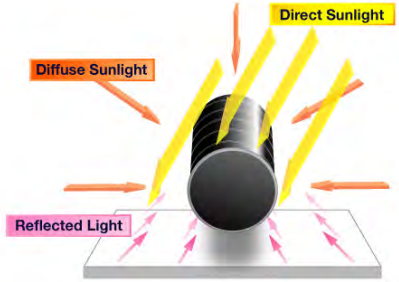
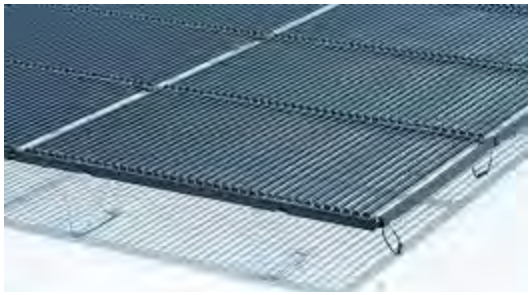
Solar PV - Panel Types – Thin Film (Commercial)





“Solyndra” Thin Film Modules

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Solar PV - Panel Types – Thin Film (Commercial)

Building Integrated Roof Systems

Solar PV Systems & Components

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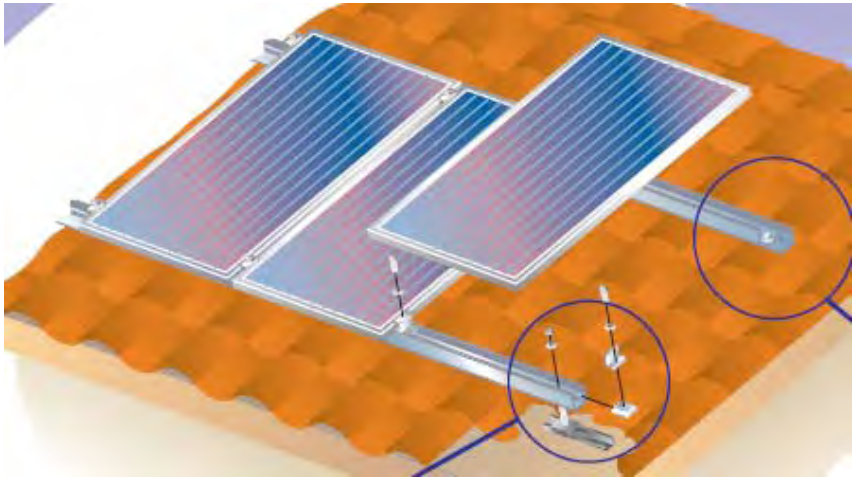
Mounting Systems - Residential

Mounting Bolts



Grid Tracks

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System Components - Residential

Combiner Box

DC Disconnect

Inverter

AC Disconnect

Electric Panel / Main Disconnect

Bi-Directional Meter

To Electric Grid

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Mounting Systems – Commercial Ballasted

Ballasted Systems

Mounting Systems – Commercial Louvered

- Interlocked Panels
- Weight: 2.5 lbs/ft^2 (w/o ballast)
- Louvering (deflector) prevents wind lift -ballasting may not be required – depending on local max wind conditions

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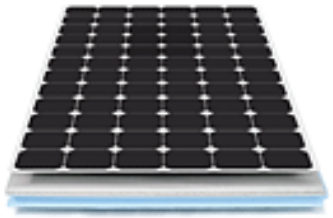
Mounting Systems – Interlocking Solar Tiles



Interlocking Solar Tiles

- Roof membrane not penetrated
- Provides an additional level of insulation to the roof
- Weight: 6lbs/ft^2

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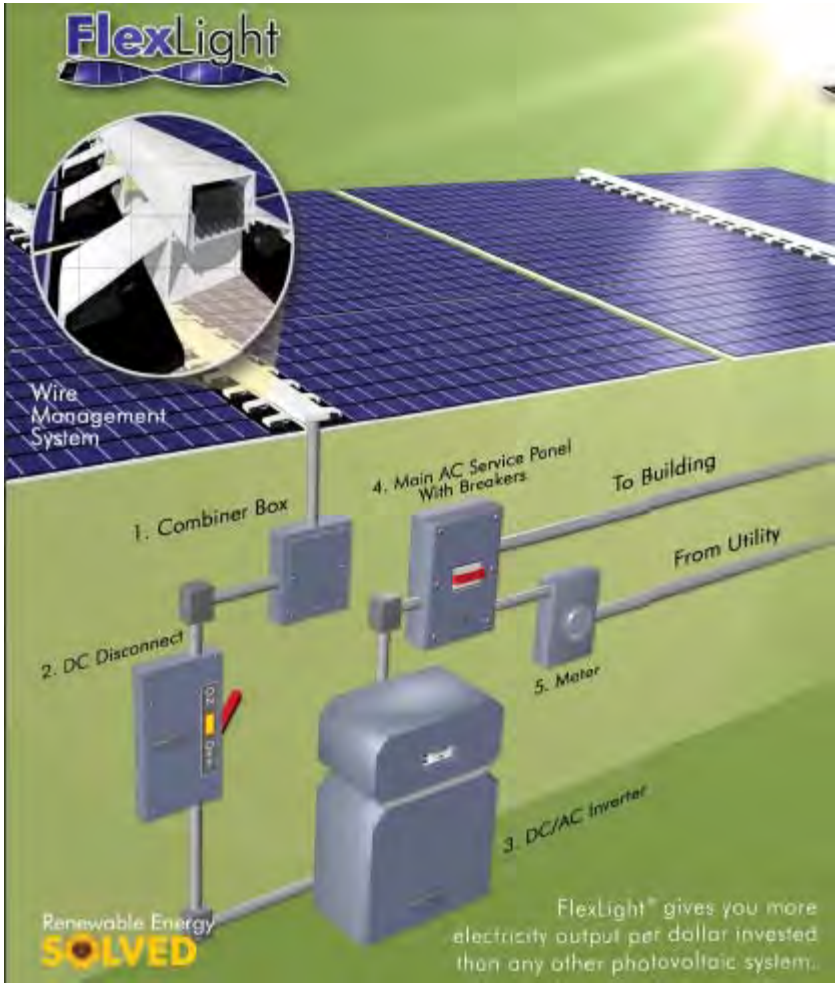
Mounting Systems – Thin Film Laminate



Thin Film Solar Laminate

- Adhesive used to attach to roof membrane
- Weight: 1lbs/ft^2

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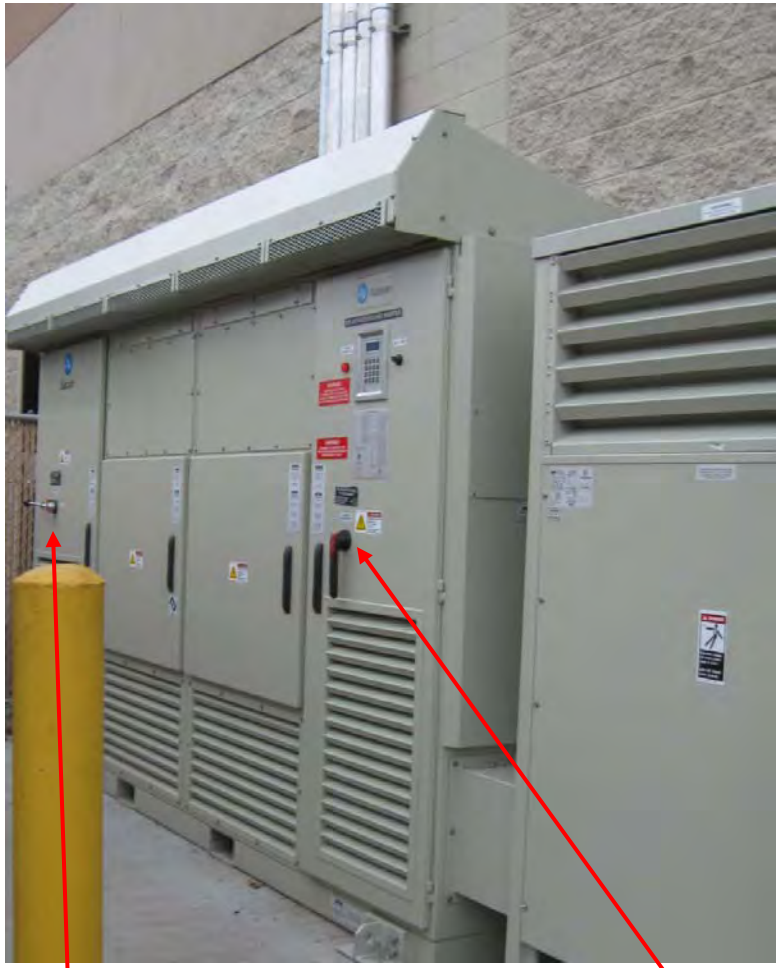
System Components – Commercial Inverters



DC Disconnect

AC Disconnect

Note: Above are just examples of installations/applications. Applications and actual installations vary.

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System Components – Commercial Inverters

Rooftop Commercial Inverter Application
Multiple Inverters

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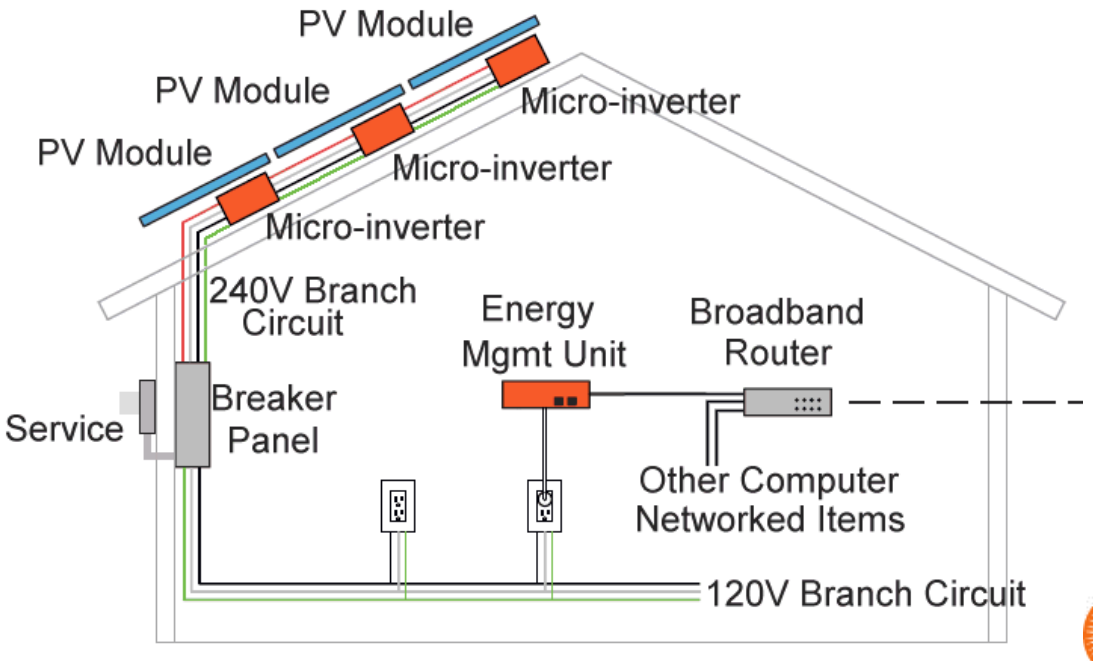
System Components – Commercial Inverters

Multiple Smaller Inverters / Multiple Disconnects

Micro-Inverters for residential and commercial



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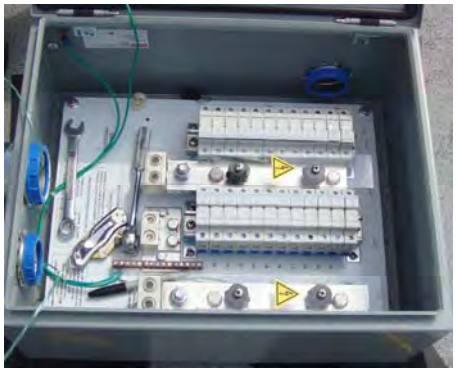
System Components – Commercial Combiners



Rooftop DC Disconnect (String of panels)

Rooftop DC Combiner Boxes

NOTE: Panel strings physically connected may be not be connected electrically in the same fashion

Note: Above are just examples of installations/applications. Applications and actual installations vary.

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Grid-Tied Solar PV Applications

How and Where is Solar PV Used?

Solar PV – Examples of Residential Applications

Solar PV – Examples of Residential Applications

Inverter (basement)

DC Conductors

DC Junction Box

120/240V service

DC Conduit

Bi-directional meter

DC Disconnect

Note: Above are just examples of installations/applications. Applications and actual installations vary.

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Solar PV – Examples of Commercial Applications

Technologies and applications can vary …
(only current is greater vs residential systems)

Roof-top Grid-Tied

Note: Above are just examples of installations/applications.
Applications and actual installations vary.

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Solar PV – Examples of Commercial Applications

Building Integrated - Vertical

Solar Canopies

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Solar PV – Examples of Commercial Applications

Ground Mount Solar

Solar PV – Examples of Commercial Applications

Raised Solar Arrays
Over Parking Areas

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Solar PV – Firefighting Considerations

Resources used in Presentation:

Courtesy of the San Jose CA Fire Dept

California Department of Forestry and Fire Protection

THE FIRE PROTECTION RESEARCH FOUNDATION

Fire Fighter Safety and Emergency Response for Solar Power Systems

NFPA

Final Report

Note: The information in this section is based on the above referenced sources.

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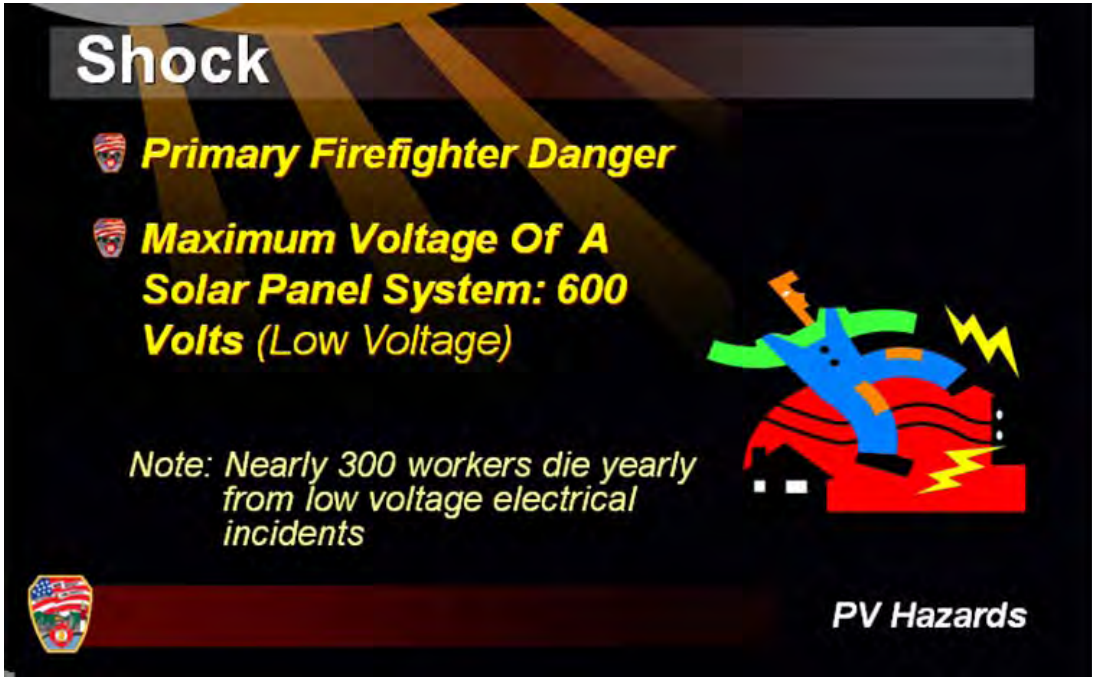
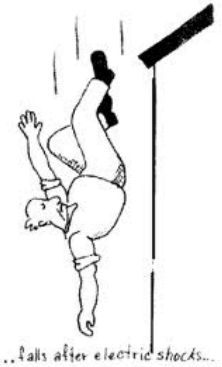
Solar PV – Firefighting Considerations

Solar PV – Firefighting Hazards to Consider

Solar PV – Firefighting Considerations

REVIEW – Solar PV - Shock Hazard





Source:

NOTE: Average Residential System generates 2-5 KW, 5-15 Amps

1000 Volt Systems are possible in the future (very large systems)

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Solar PV – Firefighting Considerations

Solar PV - Shock Hazard - Physiological Effects of Shock

DC Shock Thresholds and Effects

0 - 2 mA	2.1 - 40 mA	40.1 - 240 mA	> 240 MA
Safe	Perception	Lock On	Electrocution

AC Shock Thresholds and Effects

0 - 0.5 mA	0.5 - 6.0 mA	6.1 - 105 mA	> 105 mA

AC Current vs. DC Current – Differing thresholds

Source:

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – How Electric Shock Occurs

- An electric shock can be produced when electric current passes through the human body – and can range from minimal harm to death
- In general, the seriousness of an electric shock increases as the current increases through the body
- The amount of current that can pass through a person making direct contact with energized components is dependent upon **both** the amount of **voltage** present and the **resistance** in the current path

I = V/R

I = Current (similar to Gallons per Minute)

V = Voltage (similar to Pressure)

R = Resistance (Similar to Friction Loss)

- Water/FF Analogy:
  - A person is more likely to get hurt by high pressure line flowing 30 GPM, than a low pressure line flowing at 30 GPM
  - A higher operating pressure enables a pump operator to overcome friction loss. Similar to electric – a higher voltage will enable the current to 'overcome' the resistance of a person – increasing shock risk.

Source:

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard

AC “Hotsticks” will not detect DC

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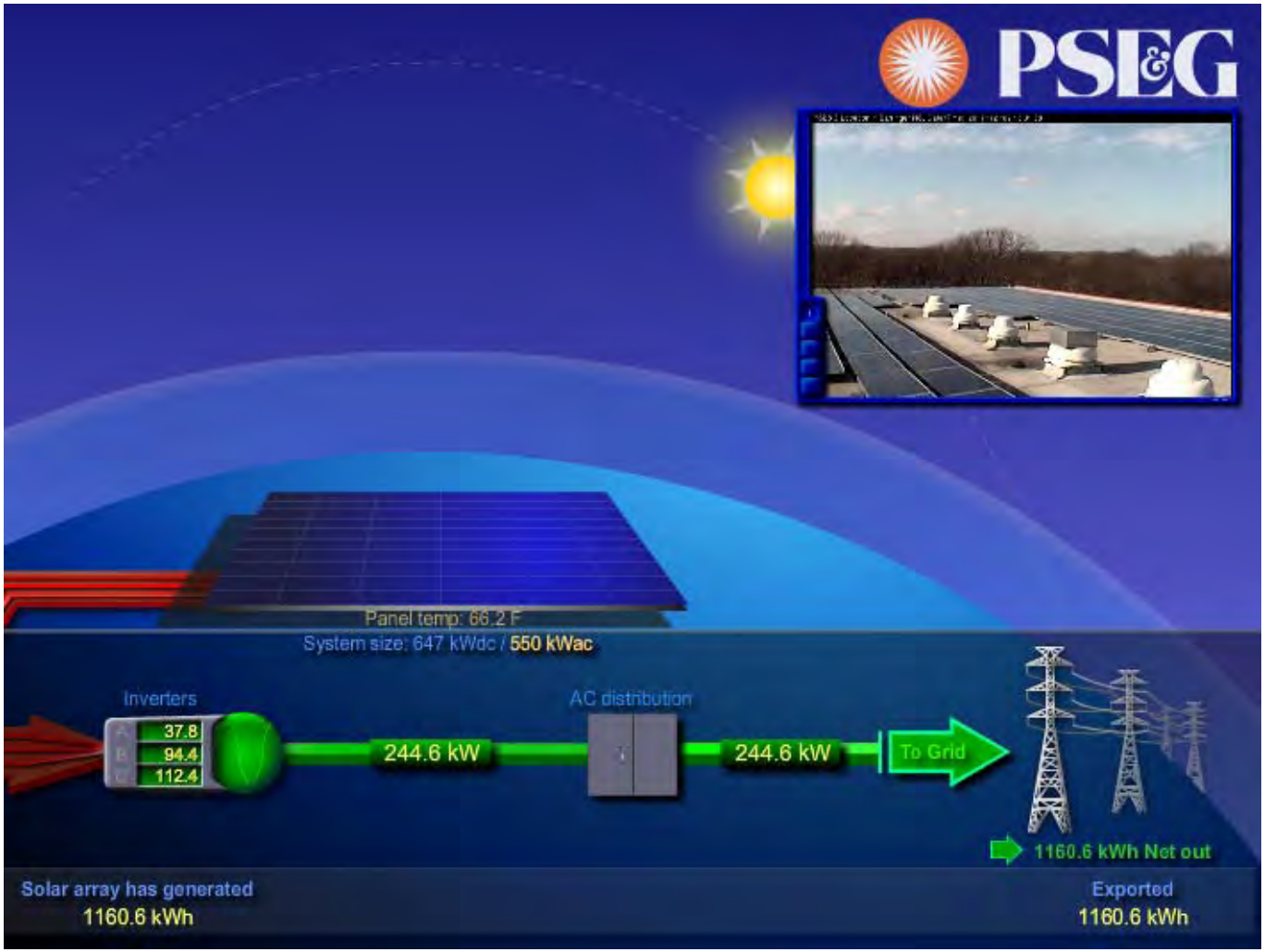
Solar PV – Firefighting Considerations

Solar PV – When is risk apparent (ie. time of day)? When is system producing energy?

Solar PV – Firefighting Considerations



Solar PV produces energy <u>when the sun is out</u>

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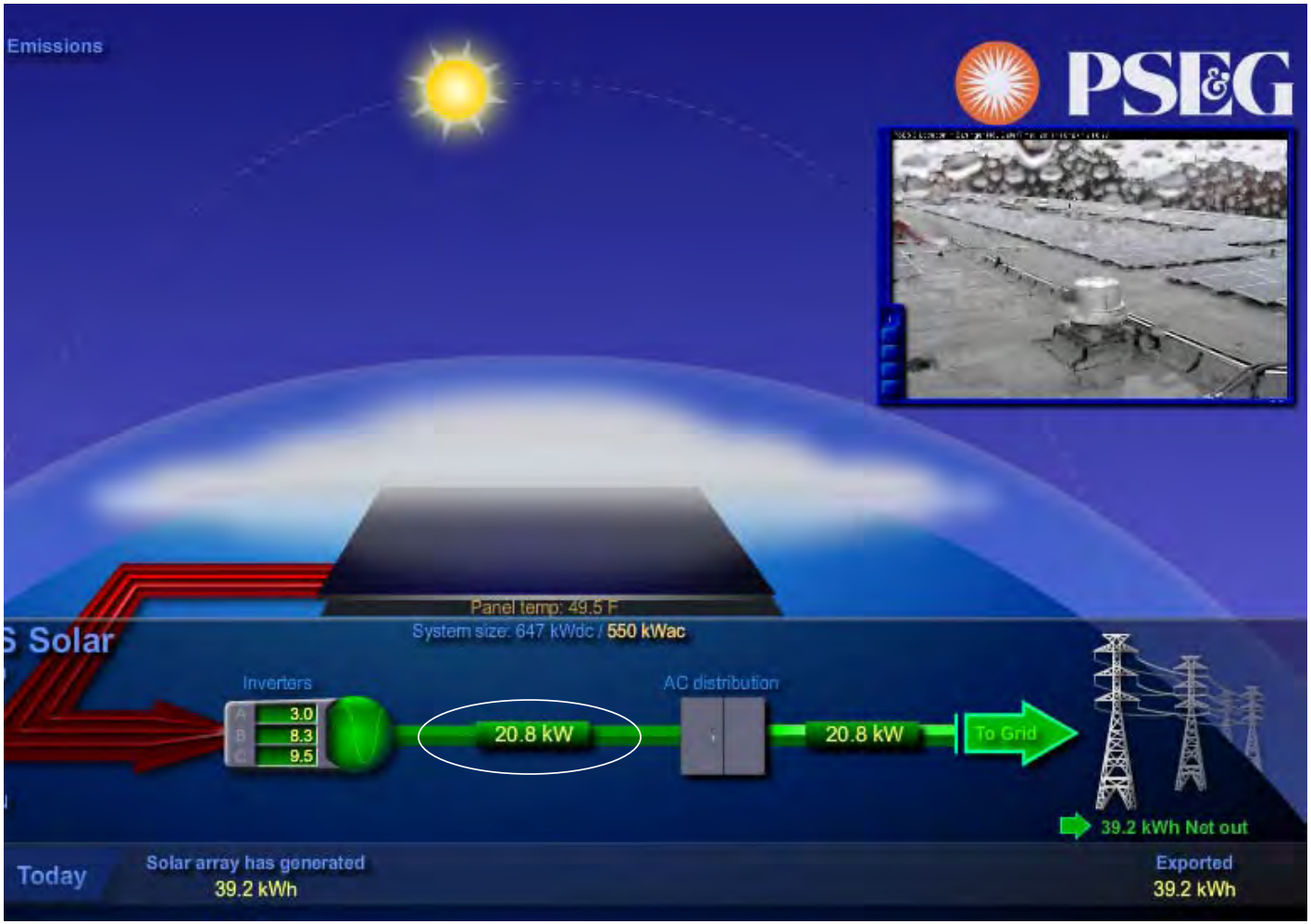
Solar PV – Firefighting Considerations

Solar PV produces energy on <u>Cloudy/Overcast Days</u>
(~50% reduction compared to a sunny day)

Solar PV – Firefighting Considerations



Solar PV produces energy <u>on Rainy Days</u>
(~90% reduction compared to a sunny day)

Solar PV – Firefighting Considerations

Scene Lights – Can cause energy to be produced at night

1000 Volt Array with Night-Time Illumination from Fire Truck(s) Lighting

Test	Truck #1 Bed 12 kW Boom 6 kW	Truck #2 Bed 6 kW Boom 4.5 kW	Total Lighting kW	Distance from Array (Feet)	Open Circuit Volts	Short Circuit MilliAmps	Hazard
			None		48	0	Safe
1	Bed + Boom		18	25	812	132	Lock On
2		Bed + Boom	10.5	38	780	88	Lock On
3		Boom	4.5	38	738	50	Lock On
4	Bed + Boom	Bed + Boom	28.5	25 & 38	836	212	Lock On
5	Partial Bed		3	25	657	22	Perception
6	Partial Bed		1.5	25	575	11	Perception
7	Bed + Boom		18	50	735	37	Perception
8		Bed + Boom	10.5	75	700	22	Perception
9	Bed + Boom	Bed + Boom	28.5	50 & 75	773	49	Lock On
10	Partial Bed		1.5	50	340	1.5	Safe

Source:

UL Study – Ability of Lighting to Generate Power

Solar PV – Firefighting Considerations

Light from a Fire – Activating Panels

Light from a Fire (Single Module)

Distance from Open Circuit Fire (Feet)	Short Circuit Volts	MilliAmps	Hazard
75	30	52	Lock On
50	31	57	Lock On
40	32	59	Lock On
15	33	62	Lock On
Full Sun	37	7500	

Source:

Solar PV – Firefighting Considerations

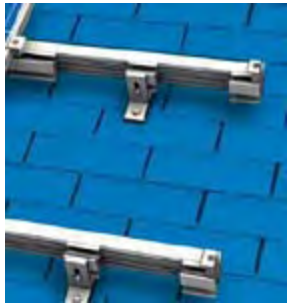
Solar PV – Where/What is the risk during firefighting operations?

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – Locations to be wary

DC Wiring - Roof

DC Wiring – Attic or in Walls



System Components Including Mounting System

External DC Wiring

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard –
Voltage may be present on both sides of a disconnect

Combiner Box Disconnect

DC Disconnect

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – Severing a Conductor with a Tool

- Cutting energized wires creates a dangerous **electric shock** hazard
- Danger would also include a **fall-hazard** – as a Roof Firefighter might not be expecting a possible shock – and could be thrown off balance
- the firefighter operating these tools is not often in contact with a metal portion of the tool that may become energized when contact with the energized conductor is made – BUT - these tools are not typically tested for their electrical insulation properties.
- If Energized PV conductors of opposite polarity are in the same raceway and severed, after the cutting takes place it is possible for the arcing to continue and result in open flaming and ignition of materials.

Source:

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – Damage to PV Components
UL Experiments

- A tool striking a PV module could make contact with internal energized components – presenting a shock risk
- There is also the potential for an electrical fire hazard if the metal tool penetrates the PV layers - creating arcing between live parts of opposite polarity. This arcing often resulted in ignition and open flaming.

Framed Module

Solar Shingle

Laminate

Source:

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – Making Contact with Damaged Panels

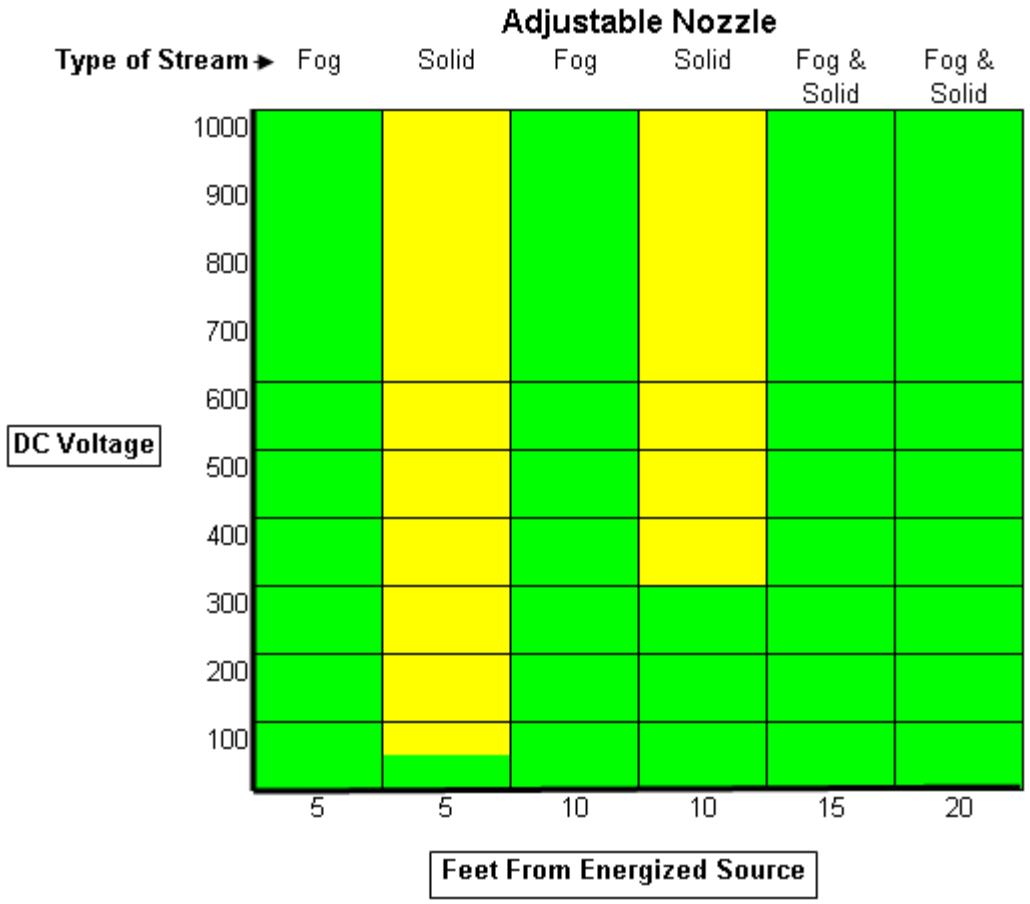
Making contact with fire-damaged panels

Making contact with fire-damaged panels – with a Hose Stream …

Source:

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard from Hose Streams – Adjustable Nozzles



The Adjustable nozzle was a piston-grip type for connection to a 1-1/2 inch hose. The nozzle was adjustable from a solid stream to a wide fog

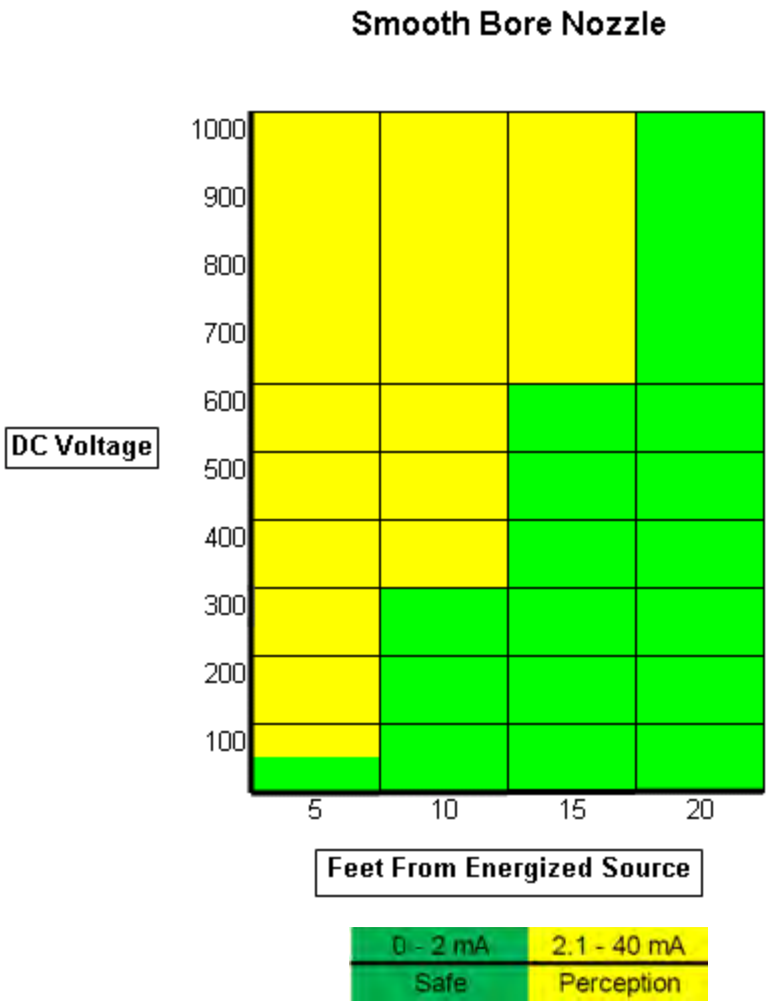
Conductivity of the water is also a factor.

Source:

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard from Hose Streams – Smooth Bore



The Smooth Bore nozzle was made of Aluminum with 3 stacked tips –

1 inch

1-1/8 inch

1-1/4 inch

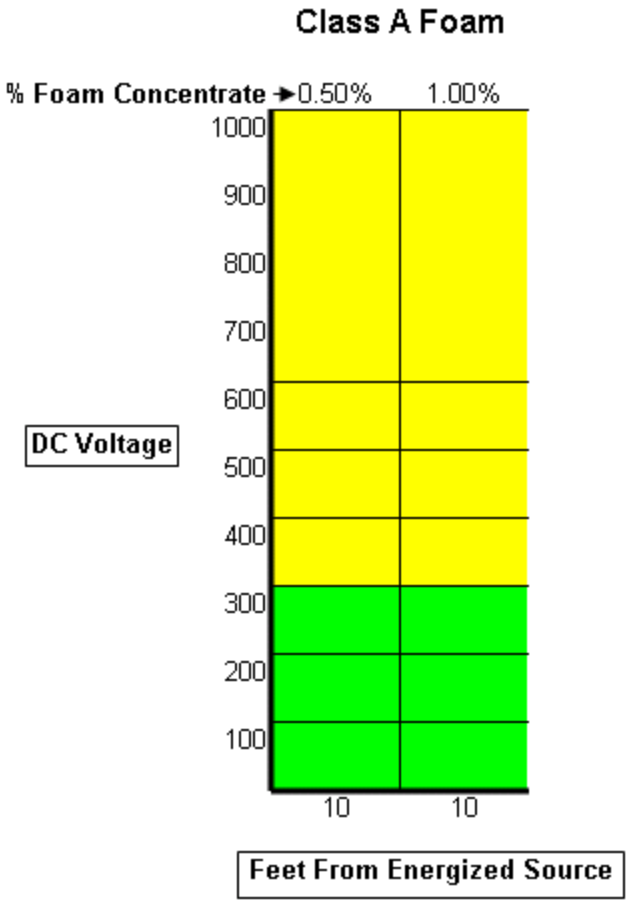
Connected to a saber-type shutoff valve for connection to a 1-1/2 inch hose

Source:

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard – Applying Class A Foam



Experiments were conducted with the Class A foam in concentrations of 0.5% and 1.0%. The testing conducted used the adjustable nozzle at full stream with a pressure of 35 psi.

Source:

0 - 2 mA	2.1 - 40 mA
Safe	Perception

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations

Roof Operations

- Communicate presence of PV System to IC
- Do NOT place ground ladders or aerial ladder on edges of panels or mounting system
- Beware of the tripping/slipping hazards
- Avoid Contact with all PV Components
- PV will limit vertical ventilation options
- If using saw/ax – shock hazard if wiring/conduit under roof surface if contacted
- Do NOT cut into or walk across panels
- Be Careful not to drop tools on panels and/or penetrate the covering on the panel
- Wear SCBA

Source:

Solar PV – Firefighting Considerations

Solar PV - Shock Hazard
Will Your PPE Protect You Against Shock?

To explore what protection standard gear may provide, experiments were conducted on gloves and boots in new, wetted, soiled and damaged conditions.

Test Results:

• **"**Under certain conditions firefighter's boots and gloves can provide some good electrical insulation and protect the body against electric shock, even up to 1000 volts DC"

• For Gloves, insulation properties degrade significantly when wet (to lethal levels).

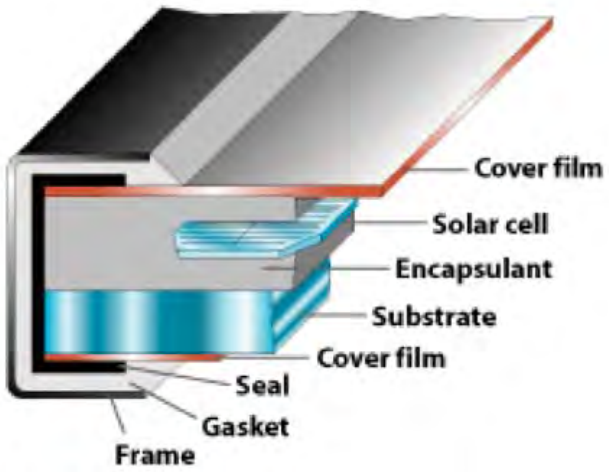
• For Boots – Out of the Box rubber boots provided the best protection. Insulation properties degraded significantly when the boot is worn-down. Leather boots did not provide sufficient protection from shock – especially when wet.

Conclusion: "The electrical insulation of firefighter gloves and boots could be of value when inadvertent contact with exposed energized PV system components occurs during firefighting operations"

Source:

See UL Study for detailed experiment-results

Solar PV – Firefighting Considerations



Source:

- **Polymers (encapsulant/frame)**
- **Phosphorus in Solar Cell**
- **Thin Film – Cadmium Telluride**
- **Thin Film – Gallium Arsenide**
- **Thin Film – Copper Indium (de)selenide**
- **Thin Film – Copper Indium Gallium (de)selenide**

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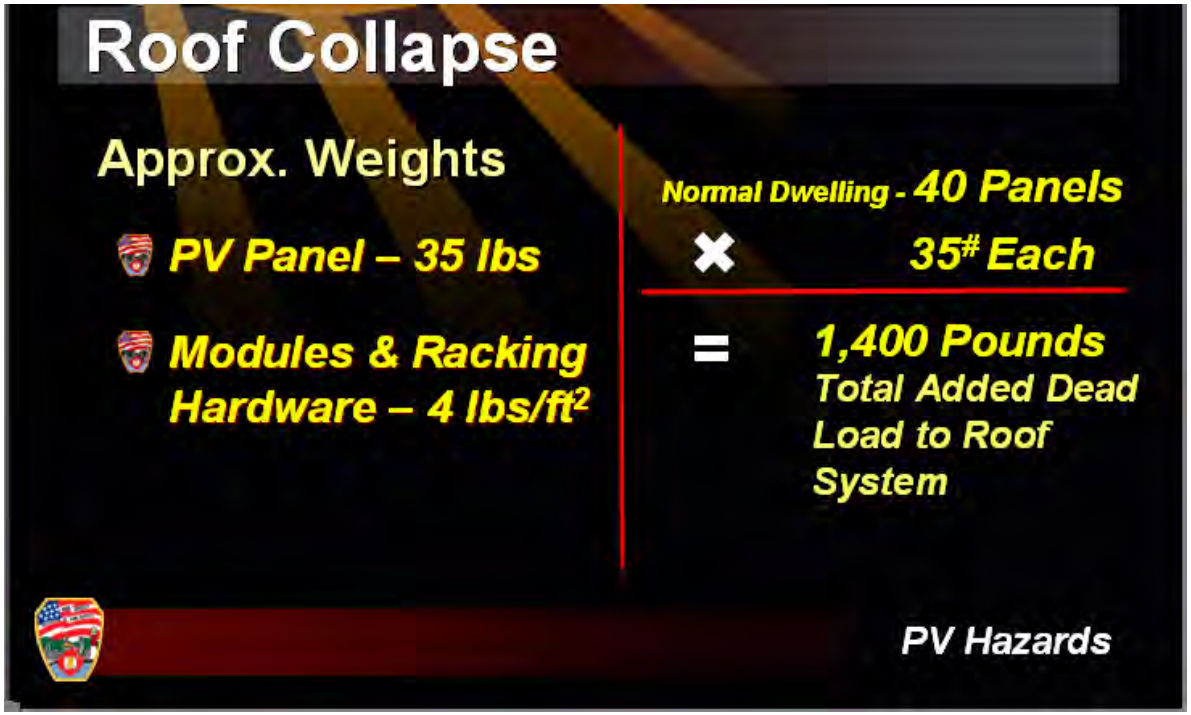
Solar PV – Firefighting Considerations

System Weight



The Number of Layers of Roofing Material will impact total loading on the roof (A single layer of 30 yr composition shingles is roughly 4 lbs/sq.ft)

Source:

Solar PV – Firefighting Considerations

Solar PV – Tactical Considerations

(In addition to the Hazards Previously Mentioned)

- **Is a Solar PV System Present?**
- **Is the PV System involved in the fire, or is the PV System present in a building involved in a structure/contents fire?**
- **Does an Exposure have Solar PV?**

Source:

Solar Thermal Systems – Firefighting Considerations

Solar System Identification – Solar PV or Solar Thermal?

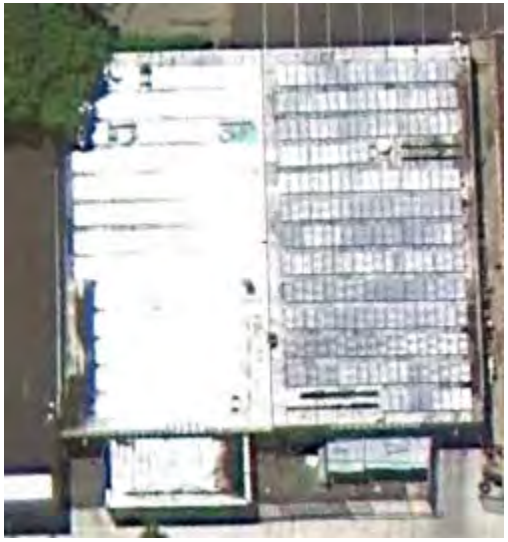
Which system is PV?

Solar Thermal systems normally have:

- **Presence of copper tubing or PVC**

Solar PV – Firefighting Considerations

PV System Identification



Not all Buildings with PV appear as “Green Buildings”

So how do you identify that a building has Solar PV?

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Solar PV – Firefighting Considerations

Disconnects & Lock & Tag Out

Source:

Opening (Shutting Off) AC Disconnects will shut down inverter (and current flow)

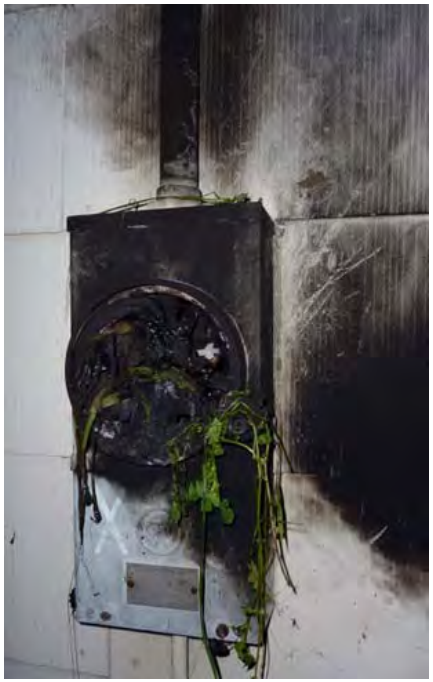
Opening (Shutting Off) DC Disconnects will limit presence of DC Voltage in the system

Solar PV – Firefighting Considerations

Disconnecting Service

Firefighters SHOULD NEVER pull a meter to attempt to disconnect service

FF's SHOULD notify their electric utility to safely disconnect service



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Solar PV – Firefighting Considerations

Scenario: Structure / Contents Fire (Fire NOT directly involving PV System Components)

- Electrical Shock Hazards
- Hazardous Atmosphere
- Weight of System on Structure (Collapse)
- Ladder Placement – access/egress to/from roof
- Trip / Slip / Fall
- Scene Lighting activating Solar PV
- Possible need to alter tactics

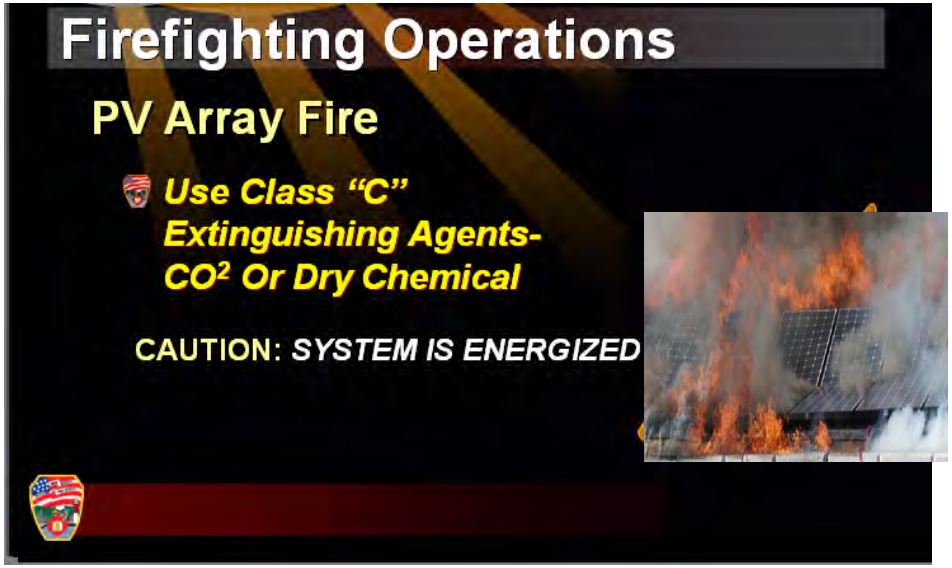
"The existence of a PV system will not necessarily prevent the initiation of offensive tactics; the system may have no impact on the fire whatsoever. Tactics necessary to perform rescues, exposure protection, confinement, extinguishment, salvage, ventilation and overhaul can and should still be initiated within buildings that have PV systems. However, the possible additional hazards that may be created by a PV system should always be considered before undertaking any of these operations".

Source:

Fire Operations for Photovoltaic Emergencies
November 2010

Solar PV – Firefighting Considerations

Scenario – Fire or Emergency involving the PV System



- **Slow Down**
- **Do Not come in contact with system components – they may be energized**
- **See UL Study Results regarding hose stream risks**
- **Be cautious of PV Arcing (water/dry-chem will not stop it)**
- **A Qualified PV technician should be called to the scene to de-energize the system**

Source:

Solar PV – Firefighting Considerations

Overhaul Considerations

- **Identify/locate DC conduit (insure all operating in area are aware)**
- **Be Wary of damaged modules – which may still be capable of producing energy**
- **Consider means of isolating system**
    - **Disconnects**
    - **Covering panels (tarps)**
- **Get Help from a qualified PV technician**

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UL Tests of PV systems exposed to fire

Experiment: PV System Exposed to Fire from Inside Strucuture

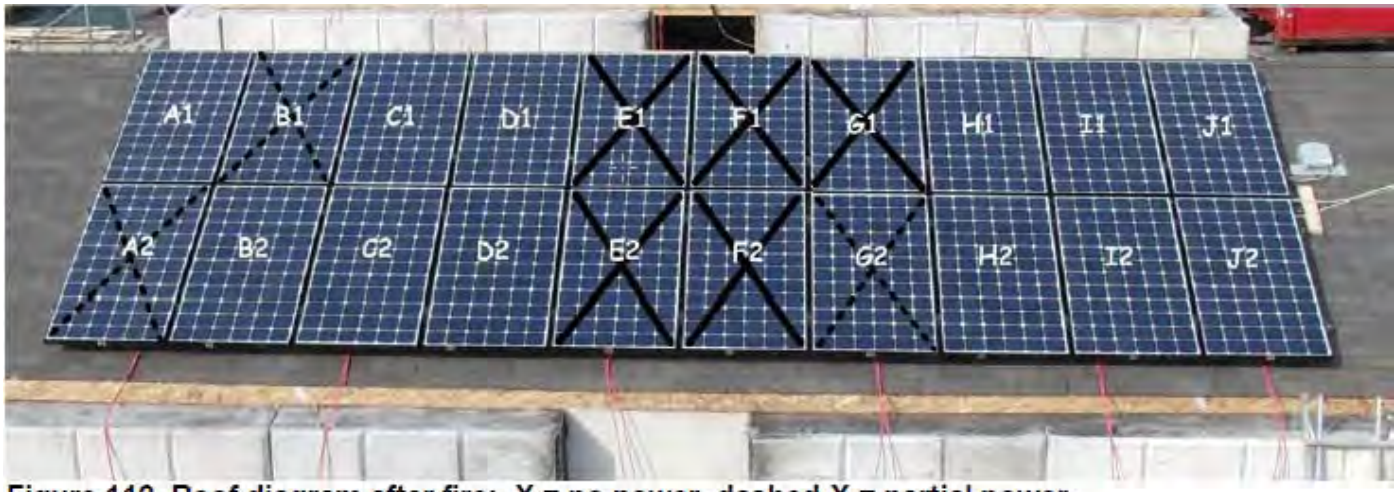

Figure 112 Roof diagram after fire: X = no power, dashed-X = partial power

Figure 117 - Module D1 – badly burnt on backside, but functional and producing full voltage

Figure 103 Roof and modules collapsing

Source:

UL Tests of PV systems exposed to fire

Experiment: Roof Fire Starting Under Modules

Figure 171 Pine straw and brand under module

Figure 175 Modules sagging from heat

Figure 176 Fire being extinguished

Source:

"Disassembling the array after the fire presented some challenges to the PV installer. Some options the installer considered was waiting until after dark, or using a tarp to block illumination to the modules. **With the DC disconnect opened, the installer measured about 2 amps of current still within some portions of the array**. This was likely the result of multiple ground faults."

Solar PV – Firefighting Considerations

Use of Tarps/Salvage Covers

- Can help to reduce risk on the fire ground
- Night-time calls involving PV components – could present issues when the sun comes up

Source:

THE FIRE PROTECTION RESEARCH FOUNDATION

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Solar PV – Firefighting Considerations

Use of Tarps/Salvage Covers

Table 17 Results of experiments with tarps

Tarp #	Cost	Tarp	Color	Layers	Open Circuit Volts	Short Circuit Amps	Hazard
1	$15	4.0 mil plastic film	Black	1	33	0	Safe
2	$16	5.1 mil all purpose plastic	Blue	1	126	2.1	Electrocution
3	$78	Fire Salvage Canvas	Green	1	3.2	0	Safe
4	$94	Fire Salvage Heavy Vinyl	Red	1	124	1.8	Electrocution
		Full Sun			148	8.1	

Tarp #1 –10 x 25 foot black plastic film sheet, 4 mils thick. Cost $15.

Tarp #2– 12 x 16 foot all-purpose tarp, 5.1 mil thick, blue in color. Cost $16.

Tarp #3 – Canvas fire salvage tarp, green in color. Claimed to meet NFPA 701[24]. Cost $78.

Tarp #4 – 12 x 14 foot heavy vinyl fire salvage tarp, red in color. Claimed to meet ASTM E-84[25] and UL 214[26]. Cost $94.

Source:

Solar PV – Firefighting – in the News

California – April 2009:
Solar Panels – Caused by electrical arcing
Membrane & Foam over metal roof deck

Source:
THE FIRE PROTECTION RESEARCH FOUNDATION

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Solar PV – Firefighting – in the News

The Bakersfield Fire

By Bill Brooks, PE

A Lesson in Ground-Fault Protection

On Sunday afternoon, April 5, 2009, smoke was seen rising from the roof of a big box store, home to a 383 kW PV array, in Bakersfield, California. The store manager quickly investigated, finding one row of eight modules on fire and a smaller fire some 200 feet away. Fire extinguisher in hand, the manager soon realized this was a job for the fire department. A 911 call was placed at 4:15 pm and first responders were on-site 5 minutes later.

The subsequent investigator's report, which is named after the retail store, is the most widely read incident report related to PV systems. The fact that this retail establishment, which has been very supportive of the PV industry, inadvertently lent its name to a two-alarm fire is both unfortunate and unwarranted. For this reason, I refer to this incident as the *Bakersfield Fire*. Similarly, the product manufacturer and installer, while not without fault, are also not ultimately to blame for this fire. Therefore, in the analysis that follows certain manufacturer and installer-specific details particular to the PV system in Bakersfield have intentionally been changed. The generic circuit diagrams used here represent the majority of PV systems deployed in North America.

It is important not to get lost in the details of this specific installation. Instead, I want to emphasize an underlying problem, one that is endemic to all grid-connected PV systems larger than 30 kW that have been built in the past 5 years. The "thermal event" that occurred on April 5, 2009, is clearly cause for alarm. More alarming, however, is the fact that it could happen again.

THE INVESTIGATOR'S REPORT

The investigator's report on the Bakersfield Fire is quite good, even if it does not tell the whole story. It is available on numerous websites, most notably the National Fire Protection Agency website (see Resources). The author of the report is Pete Jackson, an electrical specialist for Kern County, California, and the chief electrical inspector for the City of Bakersfield. Both the Kern County and the Bakersfield Fire Departments responded to the fire.

I had the pleasure of meeting Mr. Jackson. He was particularly familiar with this installation, since he was the person who performed the project plan review. His report on the roof fire provides a reasonable outline of the events that transpired and the fire department's response to those

62 SOLARPRO | February/March 2011

California – April 2009:

Solar Panels – Caused by electrical arcing

Membrane & Foam over metal roof deck

Source:

THE FIRE PROTECTION RESEARCH FOUNDATION

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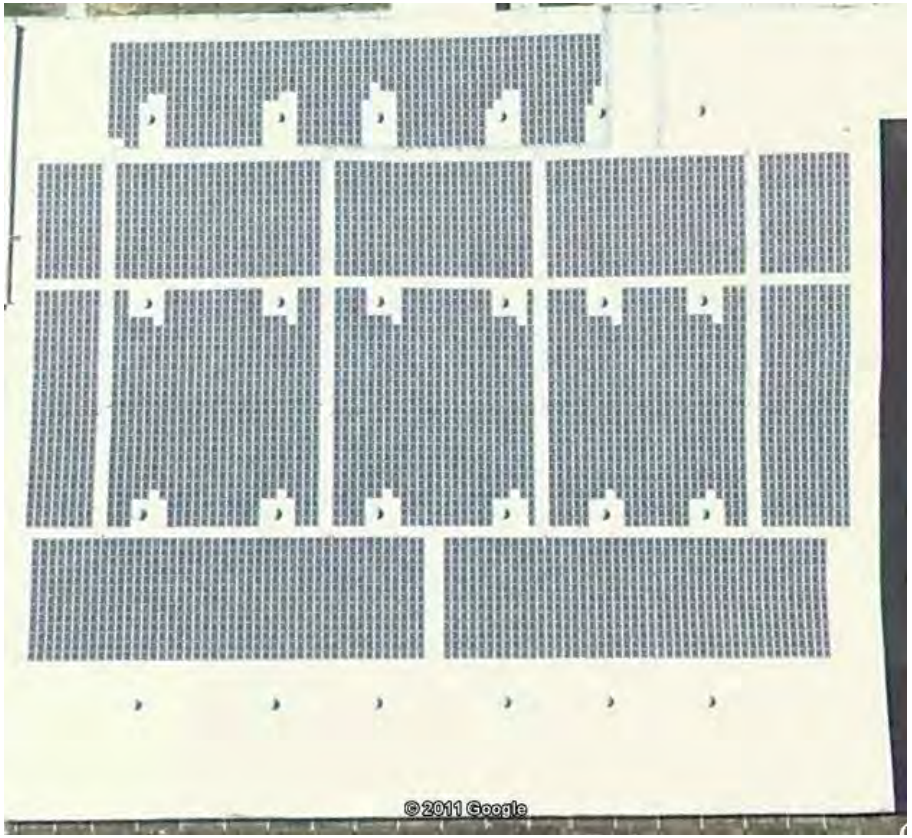
Solar PV – Firefighting – in the News

Solar panels cause fire at National Gypsum

Comments 2

April 17, 2011 11:07 PM

5100 panel
1,200 kW
“Wholesale System”



North Carolina – April 16, 2011

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Solar PV – Firefighting – in the News

Maryland – March 2010:
Leaves and debris under panels contributed to fire's ignition
Controlled from a hose stream on the ground

Source:
THE FIRE PROTECTION RESEARCH FOUNDATION

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Solar PV – Firefighting – in the News

West Amwell NJ, February 2011

Lumberton, NJ, 12/26/11

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Solar PV – Firefighting Considerations

Summary:

- Daytime = Danger Night-time = Less of a Hazard
- Identify the presence of a PV system – and notify the IC
- Understand the System 'type' – and locate components
- Isolate and shutdown as much of the solar power as possible
- **Assume PV system and all DC power is energized**
- Do not walk-on or cut through panels. Be cautious of tripping hazards
- Work around all solar power system components
- Adjust firefighting tactics (including ventilation) accordingly
- If PV System is impacted/involved – avoid making contact with system components, get a qualified PV installer to assist
- Pre-plan, & identify solar contractors that can assist you

Source:

THE FIRE PROTECTION RESEARCH FOUNDATION

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What's on the way …

- New Technologies

- UL Study: FF Safety and PV

- Codes and Requirements:
  - National Electric Code
  - International/NFPA Fire Code Changes

Solar PV – Codes/Requirements - NEC

National Electric Code

- **Current: NEC 2008** – covers PV arrays, over-current protection, electrical connections, charge controllers, disconnects, inverters, batteries, grounding, conductors, signage, etc.
  - Disconnects: AC/DC required. Required to be: **labeled**, **located** outside or inside nearest the point of entrance to building, manually operable and **lockable**
- **Pending NJ: NEC 2011 (<u>sample</u> of proposed amendments)**
  - Identification of PV conduit (labels) - “Photovoltaic Power Source”
  - Circuit Routing (along structural members)
  - Multiple Inverters (signage re: disconnects)
  - Attic Wiring (10” clearance (except under PV systems)
  - Installer Qualifications
  - Series DC Arc Fault Detection

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Solar PV – Codes/Requirements – NEC (2014)

- **Industry is working on the 2014 NEC**
- **A Proposal has been submitted by the NFPA Task Group on FF Safety:**

690.12 PV Arrays on Buildings Response to Emergency Shutdown.

For PV Systems installed on roofs of buildings, photovoltaic source circuits shall be deenergized from all sources within 10 seconds of when the utility supply is deenergized or when the PV power source disconnecting means is opened. When the source circuits are deenergized, the maximum voltage at the module and module conductors shall be 80 volts.

- **This would de-energize the system up to the panels (only panel wiring and internal wiring energized)**
- **DC-DC converters, micro-inverters and AC panels would satisfy this requirement**

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What's on the way - New Technologies …

Smart Modules (DC:DC "embedded electronics")

Tigo energy

Tigo Energy®
Module Maximizer™
MM-ES

Enhanced Safety

Tigo Energy™ PV-SAFE

Using Tigo Energy®
PV Safe™ Technology

solaredge
architects of energy™

- **Safe maintenance and firefighting:**
In the event of a grid power shutdown, the solar modules immediately stop producing power and revert to the "Safety Mode". This is beneficial to firefighters and to PV maintenance personnel working at the site. They need not worry about high DC voltages; once AC power is cut, all voltage shuts down and the roof is safe.

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Solar PV – Codes/Requirements – Fire Codes

CA Fire Marshal Code being adopted as the 2012 International Fire Code and the 2012 NFPA Fire Code

1.0 Markings

- Main Service Disconnect
- DC conduit, enclosures, cable assemblies, junction boxes, combiner boxes. Every 10 feet, at every turn, above/below penetrations
- Sign Requirement:
  - Red background / white lettering / All CAPS
  - ***"Warning: Photovoltaic Power Source"*** (NEC/IFC)

2.0 Access / Pathway / Venting

- Residential
  - 3' space along the ridge of roof

    Provides room to make a 2' wide vent cut
  - No rooftop disconnect requirement
  - Each roof face treated independently
  - 3' Pathways needed for FF's up to Ridge

Source:

IREC

PSE&G

Solar PV – Codes/Requirements – Fire Codes

PSE&G

Solar PV – Codes/Requirements – Fire Codes

IREC Interstate Renewable Energy Council

Access—Commercial (IFC 605.11.3.3.1)

- Commercial flat roof with no roof dimension more than 250 feet—4' space around perimeter wall.
- Commercial flat roof with a roof dimension more than 250 feet—6' space around perimeter wall.
- No rooftop disconnect requirement for fire fighters.

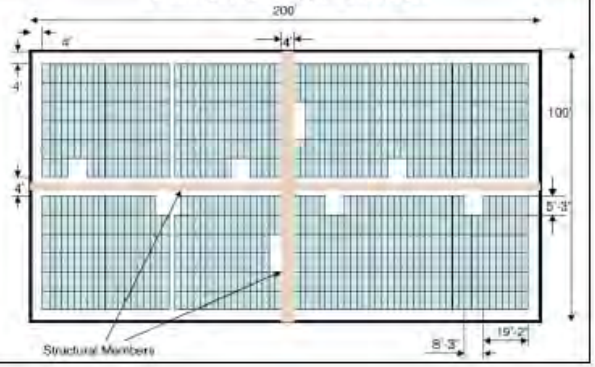
IREC Interstate Renewable Energy Council

Pathways and Ventilation—Commercial (IFC 605.11.3.3.2 & 605.11.3.3.3)

- Minimum 4' pathway on center access of building in both directions. A 4' access to skylights, roof hatches, and fire standpipes shall be provided to the perimeter wall.
- Commercial rooftop arrays shall be no greater than 150 by 150 feet in distance in either axis.
- Array off limits to fire fighters.

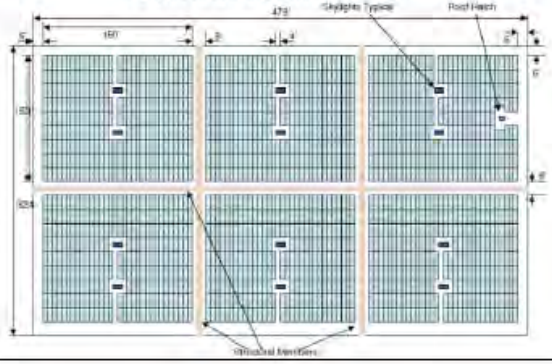
IREC Interstate Renewable Energy Council

Commercial < 250'



IREC Interstate Renewable Energy Council

Commercial > 250'



Source:

IREC

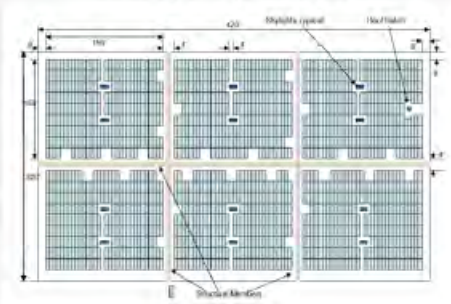
PSE&G

Solar PV – Codes/Requirements – Fire Codes

IREC Interstate Renewable Energy Council

Commercial > 250'

Vent openings every 20'



IREC Interstate Renewable Energy Council

LOCATION OF DC CONDUCTORS
(IFC 605.11.2)

- Conduit, wiring systems, and raceways for photovoltaic circuits should be located as close as possible to the ridge or hip or valley and from the hip or valley as directly as possible to an outside wall to reduce trip hazards and maximize ventilation opportunities.
- The DC combiner boxes are to be located such that conduit runs are minimized in the pathways between arrays.

IREC Interstate Renewable Energy Council

LOCATION OF DC CONDUCTORS
(IFC 605.11.2)

- To limit the hazard of cutting live conduit in venting operations, DC wiring should be run in metallic conduit or raceways when located within enclosed spaces in a building and should be run, to the maximum extent possible, along the bottom of load-bearing members.
  - Intent is to stay away from common ventilation locations near ridge. Staying under load-bearing members minimizes likelihood of saws cutting wiring system.

Source:

IREC

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Solar PV and Firefighter Safety

Questions??

HEALTH & SAFETY
The Only Choice

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Solar PV – Resources regarding FF Safety issues

To see the complete resource utilized as references in this presentation – please see the following:

http://www.state.nj.us/dca/dfs/

http://www.fire.ca.gov/

THE FIRE PROTECTION RESEARCH FOUNDATION

http://www.nfpa.org

On you-tube

IREC

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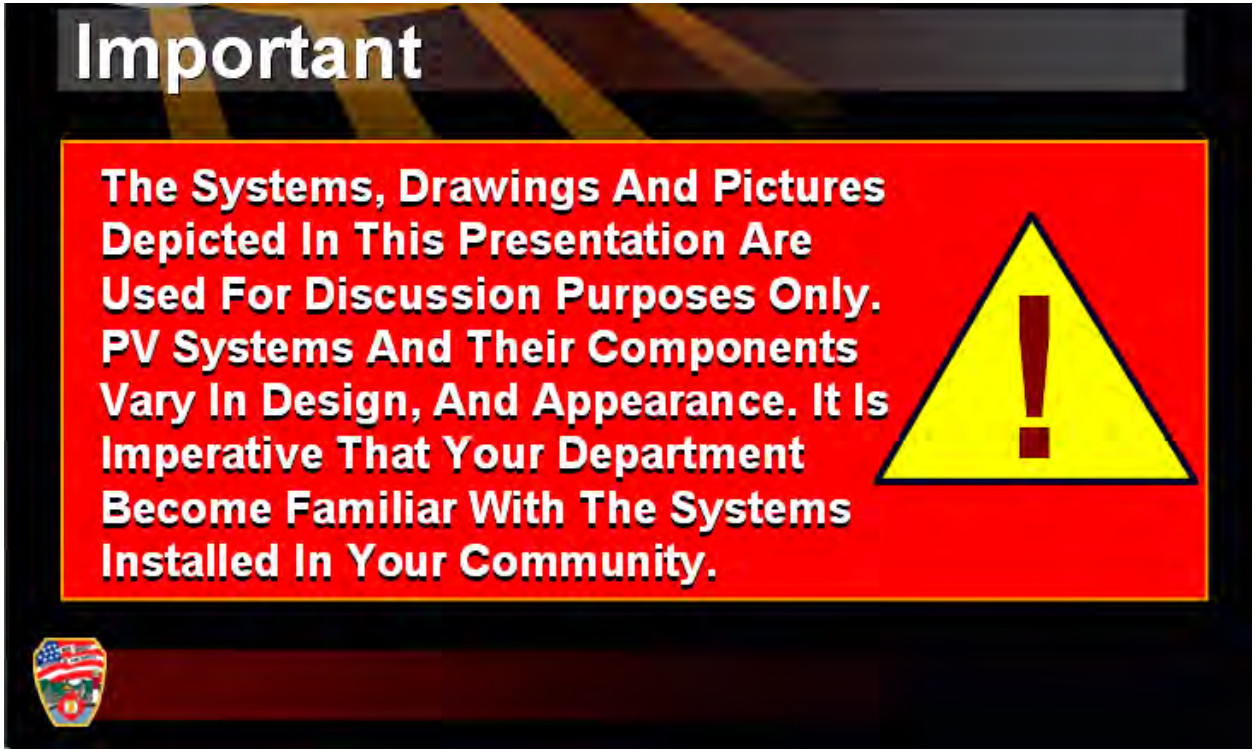
Solar PV – Firefighting Considerations



Source: