Firefighter Safety and Photovoltaic (PV) Systems

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U.S. Department of Energy

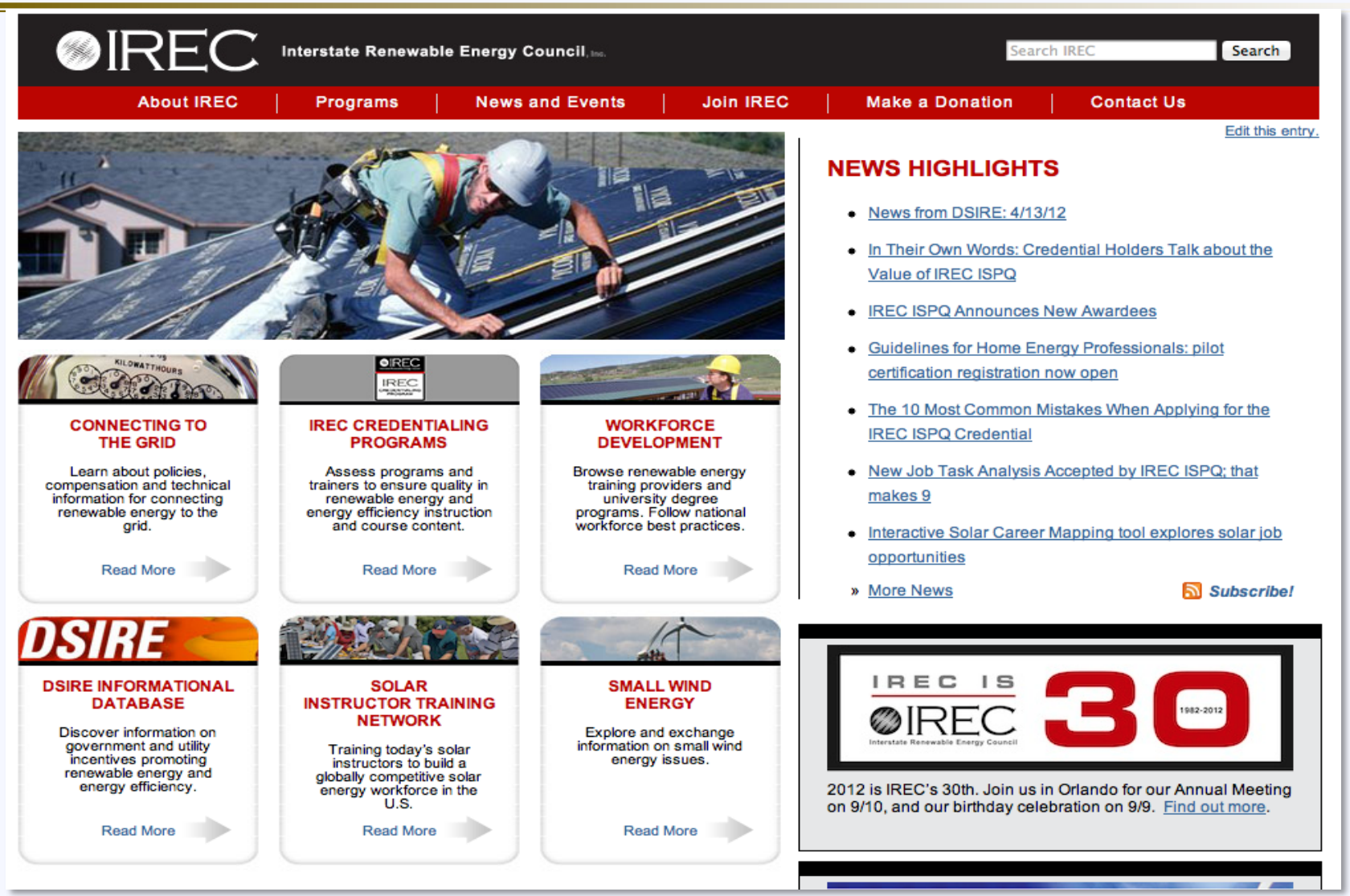
ICLEI's Mission

Our mission is to build, serve, and drive a movement of local governments to advance deep ***reductions in greenhouse gas emissions*** and achieve tangible ***improvements in local sustainability***.



About the Sunshot Solar Outreach Partnership

The SunShot Solar Outreach Partnership (SolarOPs) is a U.S. Department of Energy (DOE) program designed to increase the use and integration of solar energy in communities across the US.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Speakers

Bob is a Research Engineer with UL's Corporate Research Department. Bob graduated from Harper College with an Associates in Fire Science, the Illinois Institute of Technology with a Bachelor in Mechanical Engineering and from Worcester Polytechnic Institute with a Master in Fire Protection Engineering.
He is a member of the National Fire Protections Association and the Society of Fire Protection Engineers.

His employment experience with Underwrite Laboratories Inc. includes working with telecommunications, semiconductor, building materials and the textile industries. His special fields of interest includes reaction to fire subjects and changes in fire conditions due to deployment of new technologies.

Dennis is an Assistant Fire Marshal with Orange County Fire Authority in Southern California. Dennis graduated from Los Angeles City College with an Associates in Criminal Justice, and a Bachelor of Science Degree in Criminal Justice from August Vollmer University. Dennis is a member of the International Code Council, the National Fire Protection Association, and the National Fire Sprinkler Association.

His employment started in law enforcement, but evolved into the fire service. As an Assistant Fire Marshal for the last seven years he has oversee the Fire Departments Plans Examiners and works on special projects. He has participated in a number of committees including local, state and national, including the Flammability of Rated Roofs and Photovoltaic Panels.

Working With The Fire Service to Bring Science to the Street.

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Safety Considerations for Successful Deployment

- Engage all aspects of fire service in deployment of alternative energy
- Codes, standards and testing must take into consideration both public and fire firefighter safety
- The involvement of fire service operations, prevention and training are critical to the success of alternate energies

Tonya Hoover
State Fire Marshall, CA

What would you like the solar industry to do to address firefighter concerns?

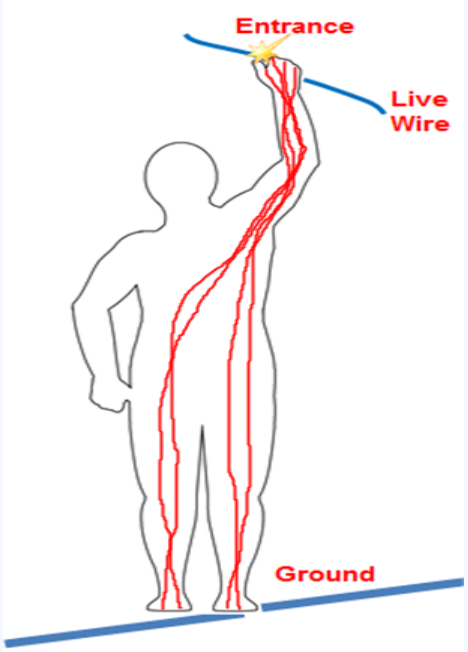
- #1 – Safety for firefighters
- Training both industry and fire service
- We were in a dangerous situation and didn't know that we were

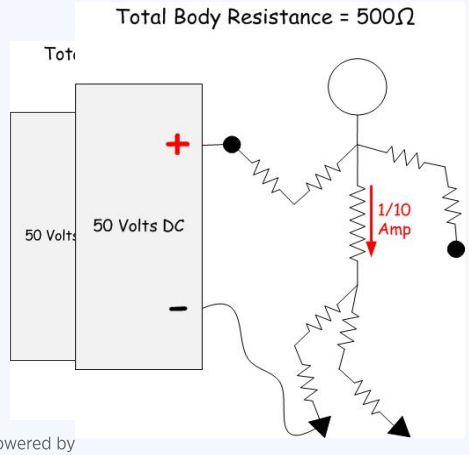
Captain Coby Wright
Kern County Fire Department, CA

Would you change your tactics knowing what you know now?

- Absolutely…..
- Due to the voltage and current present would not have cut individual conductors because of back feed
- Would have knocked down fire with water at a distance or with foam
- Isolate and bring in qualified technician to determine safe way to proceed

Levels of Electrical Hazard





DC Milliamps	Hazard / Response
< 2	Safe / None - No Perception
2 - 39	Perception / Startle Reaction
40 - 239	Body Freezes / Lock On
240 +	Heart Stops / Electrocution

Shock Hazard During Suppression Activities

- Factors Affecting Electric Shock Through
- Water:
  - Voltage
  - Diameter of Nozzle
  - Spray Pattern
  - Distance, Source to Nozzle
  - Water Conductivity
  - Water Pressure

Distance Feet	Smooth bore nozzle size	Pressure PSI	Voltage DC Volts	Leakage current Milliamps
10	1 inch	21	1000	5.7
10	1 inch	21	600	3.2
10	1 inch	21	300	1.6
10	1 inch	21	50	0.3
20	1 inch	23	1000	1.5

Shock Hazard and Fire Service Equipment

- Boots and gloves can provide some electrical insulation and protect against electric shock, up to 1000 volts DC.
- Must be dry and intact.
- FF PPE must not be relied on to protect against electrical shock.

Glove Sample	Soiled	Wetted Outside	Wetted Inside	Measured milliAmps, DC 50 Vdc	300 Vdc	600 Vdc	1000 Vdc
1	no	no	no				0
2	no	no	no				0
3	no	no	no				0
1	no	yes	no	91	>250		
2	no	yes	no	0.5	2	100	>250
2	no	yes	yes	38	89	>250	>250
3	no	yes	no	3	17	24	54
3	no	yes	yes	43	>250		
1	yes	no	no				0.5
2	yes	no	no				0
3	yes	no	no				0
1	yes	yes	no	91	>250		
1	yes	yes	yes	93	>250		
2	yes	yes	no	0	2	3	4
2	yes	yes	yes	64	>250		
3	yes	yes	no	0	0	0	0
3	yes	yes	yes	78	>250		

Safe | Perception | Lock On | Electrocution

Alternate Light Sources

Light from a Fire (Single Module)

Distance from Fire (Feet)	Open Circuit Volts	Short Circuit 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	

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

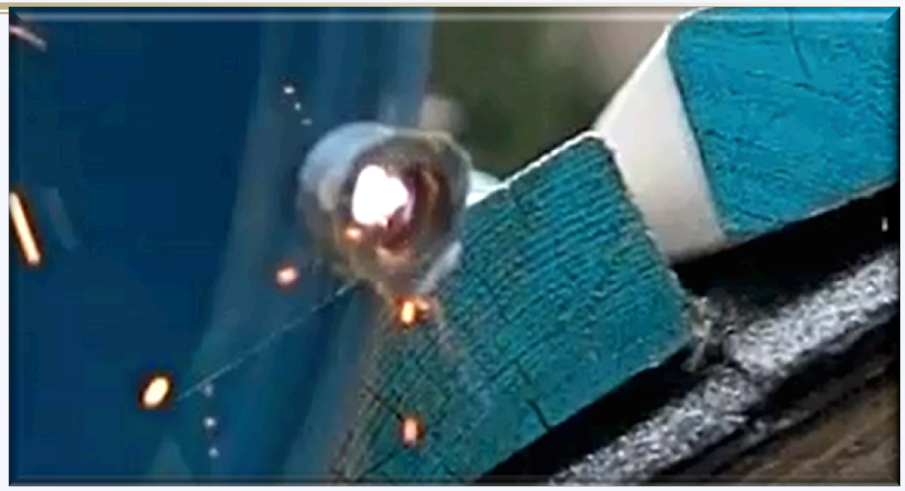
Test	Truck #1 Bed 12 kW Boom 6 kW	Truck #2 Bed 6 kW Boom 4.5 kW	Total Lighting kW	Distance from Array (Feet)	Open Circuit Volts	Short Circuit MilliAmps	Hazard
			None		48	0	Safe
1	Bed + Boom		18	25	812	132	Lock On
2		Bed + Boom	10.5	38	780	88	Lock On
3		Boom	4.5	38	738	50	Lock On
4	Bed + Boom	Bed + Boom	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

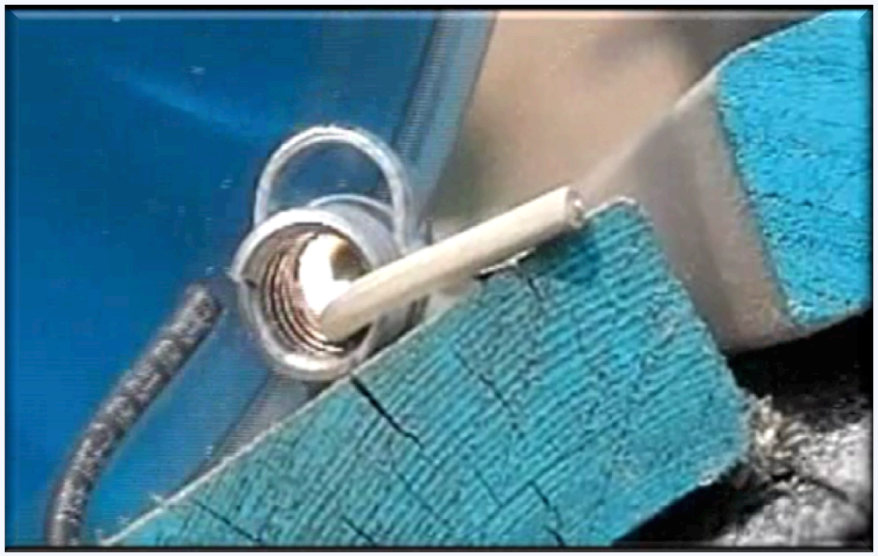
Near Miss Incident – Orange County, CA

- Experiments Conducted On Rigid & Flexible Metal and PV Conduit Using:
  - Axe
  - Chain Saw
  - Rotary Saw
  - Cable Cutters

Photos courtesy of Orange County Fire Authority (California)

Severing of Conductors





Shock From Mechanically Damaged PV

- Experiments Conducted on PV Modules:
  - Metal Framed Glass on Polymer
  - Laminate on Metal Roof
  - Building Integrated Shingle

Shock From Fire Damaged PV

- Live Array Fire Tests:
  - Three PV Technologies
    - Metal frame, glass on polymer
    - Laminate on metal roof
    - Building Integrated (Shingle)
  - Three Fire Scenarios:
    - Content > Structure Fire
    - Content > Window Vent
    - Debris Under Array

Fire Service Tactical Considerations

1. The electric shock hazard due to application of water is dependent on voltage, water conductivity, distance and spray pattern.

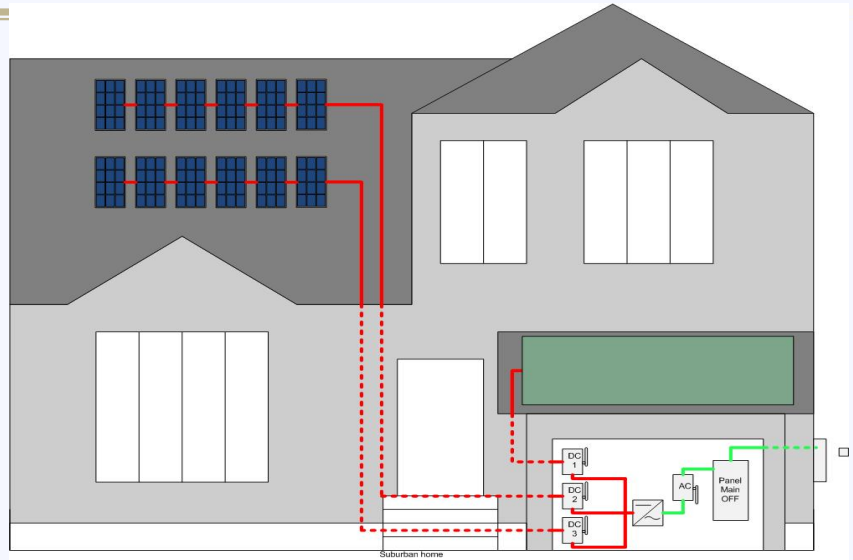
2. Outdoor weather exposure rated electrical enclosures are not resistant to water penetration by fire hose streams.

3. Firefighter's gloves and boots afford limited protection against electrical shock. They should not be considered equivalent to electrical PPE.

Fire Service Tactical Considerations (cont.)

4. Turning off an array is not as simple as opening a disconnect switch. Unlike typical electrical or gas utilities, there is no single point of disconnect for PV.

5. Tarps offer varying degrees of effectiveness to interrupt the generation of power from a PV array. Caution should be exercised during deployment of tarps on damaged equipment as a wet tarp may become energized.

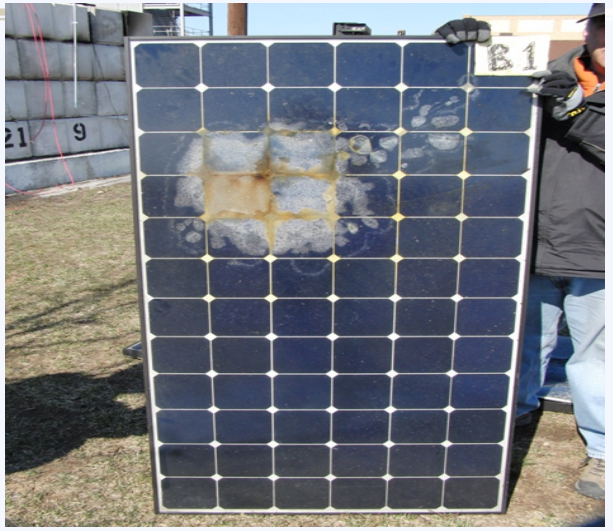


Fire Service Tactical Considerations

6. When illuminated by light sources such as fire department light trucks or an exposure fire, PV systems are capable of producing electrical power sufficient to cause a lock-on hazard.

7. Severely damaged PV arrays are capable of producing hazardous conditions ranging from perception to electrocution.

8. Damage to modules from tools may result in both electrical and fire hazards. The hazards may occur at the point of damage or at other locations. Metal roofs present unique challenges.



Fire Service Tactical Considerations

9. Severing of conductors in both metal and plastic conduit results in electrical and fire hazards. Care must be exercised during ventilation and overhaul.

10. Responding personnel must stay away from the roofline in the event of modules or sections of an array sliding off the roof.

11. Fires under an array may breach roofing materials and decking allowing fire to propagate into the attic space.

Fire Service Tactical Considerations

12. Firefighters must be aware of potential trip, slide and fall hazards while conducting roof operations.

13. Traditional ventilation operations may have to be altered due to PV installations.

Resources - www.ul.com/fireservice

PV & Firefighter Safety:

–Executive Summary

–Report

–On-line Training

Other Research Topics:

–Lightweight Construction

–Upholstered Furniture

–Firefighter Smoke Exposure

–Horizontal Ventilation

–Vertical Ventilation (current)

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Questions?