



THE  
FIRE PROTECTION  
RESEARCH FOUNDATION

## **Fire Service Workshop on** **Solar Power Systems**

*Part of the Research Project on:*

*“Fire Fighter Safety and Emergency Response in Pre-Planning and  
Fireground Tactics for Alternative Energy Technologies”*

**Workshop Location:**

**NextEnergy, 461 Burroughs St., Detroit, Michigan**

**Workshop Date: Wednesday 17 March 2010**

**Workshop Summary Prepared by :**

**Casey C. Grant, P.E.**

**Fire Protection Research Foundation**

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# Executive Summary

This is a summary report documenting a fire service workshop addressing “Solar Power System”. This one day workshop was held at the NextEnergy facility in Detroit Michigan on Wednesday 17 March 2010.

This workshop is a component of the research project on: “Fire Fighter Safety and Emergency Response in Pre-Planning and Fireground Tactics for Alternative Energy Technologies”. This project is funded through a DHS/FEMA Fire Grant to the NFPA, with the work administered through FPRF. This is a one year project scheduled for completion in the summer of 2010.

The workshop goal was to identify, review, and assemble best practice information for tactical and strategic decision-making by fire fighters and fire ground incident commanders, to assist in their decision-making process when responding to fire and/or rescue emergency events involving solar power systems.

The workshop included two working groups which, as part of the workshop, separately addressed a set of similar questions (Attachment D). Each working group reported their results to the entire workshop to support discussion among all attendees. The consolidated response from the working groups is included as Attachment D. Highlighting question 3(c), the following expresses the most important fire service messages on this topic:

1. Fire Ground Tactics
  - 1.1. “Components are always hot!” (in daytime)
  - 1.2. Operate normally, but don’t touch
  - 1.3. Size-up, identify and validate hazard
  - 1.4. Stress key message for tactical approach (especially large commercial systems)
  - 1.5. Leave the scene in a safe condition
2. Code Development
  - 2.1. Provide ability for electrical system isolation for emergency responders
  - 2.2. Create consistent placarding and labeling for emergency responders
  - 2.3. Address on-going maintenance oversight of installed systems (especially commercial)
  - 2.4. Require system contact information for emergencies
3. Education and Training
  - 3.1. This is energized electrical equipment like other equipment, but with in-ability to power down. Otherwise not much different.
  - 3.2. Systems are widespread: You probably have these systems in your 1st due jurisdiction
  - 3.3. Don’t underestimate electrical hazard; don’t be complacent

The following attachments are included in this information summary:

Attachment A	Workshop Overview and Agenda	Page 3 of 22
Attachment B	Workshop Attendees	Page 4 of 22
Attachment C	PowerPoint Slides with Workshop Background	Pages 5 thru 16
Attachment D	Working Group Questions	Page 17 of 22
Attachment E	Working Group Summary	Pages 18 thru 22

For additional information on this workshop or the overall project, contact:

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# THE FIRE PROTECTION RESEARCH FOUNDATION

## Fire Service Workshop on Solar Power Systems

**Location: NextEnergy, 461 Burroughs St., Detroit, Michigan**

**Date: Wednesday 17 March 2010**

*Part of the FPRF Project on: "Fire Fighter Safety and Emergency Response in  
Pre-Planning and Fireground Tactics for Alternative Energy Technologies"*

**Background:** Amongst the new challenges facing the U.S. fire service is the changing nature of emergency response to incidents where alternative energy sources are in use. One of these uses is the widespread introduction of solar power systems. Some fire service organizations are in the process of developing recommended emergency response procedures and best practices on a local or regional basis; in other jurisdictions basic information on the hazard and appropriate response is lacking or not readily available.

**Workshop Goal and Objectives:** The workshop goal is to identify, review, and assemble best practice information for tactical and strategic decision-making by fire fighters and fire ground incident commanders, to assist in their decision-making process when responding to fire and/or rescue emergency events involving solar power systems. This will be accomplished through an interactive approach involving subject-matter-experts that will focus on the following workshop objectives:

- collectively review the available baseline information (provided to participants prior to the workshop);
- identify the fundamental principles and key details involving fire/rescue tactics and strategy;
- address and clarify related issues such as training needs, areas needing further research, revisions to codes/standards, and other topics applicable to the overall workshop goal.

**Workshop Format:** The following format and agenda is planned for this workshop:

All Participants	<b>1) Welcome and Introductions</b>	9:00 am
All Participants	<b>2) Review of Research Project and Workshop Objectives</b>	9:10 am
All Participants	<b>3) Review of Available Baseline Information</b>	9:15 am
	(Break)	10:30 am
All Participants	<b>4) Presentations on Case Study Events</b>	10:45 am
	(Lunch)	11:45 am
Working Groups	<b>5) Identify Key Principles &amp; Details for Fire/Rescue Operations</b>	12:45 pm
Working Groups	<b>6) Identify and Address Other Concerns, i.e. Training, C&amp;S Revisions, etc</b>	2:00 pm
	(Break)	2:30 pm
All Participants	<b>7) Working Group Reports</b>	2:45 pm
All Participants	<b>8) Open Discussion and Summary Comments</b>	3:30 pm
All Participants	<b>9) Adjourn</b>	4:00 pm

**Further Information:** Workshop attendance will be limited to the first 30 individuals due to space limitations. If you are interested in participating, please contact [cgrant@nfpa.org](mailto:cgrant@nfpa.org) no later than 31 January 2009. After the workshop a report of the results will be available for interested parties.

## Firefighter Safety and Emergency Response in Pre-Planning and Fireground Tactics for Alternative Energy Technologies

Location: NextEnergy, 461 Burroughs St., Detroit, Michigan

### SOLAR PANEL WORKSHOP ATTENDEES (FOR 17/MAR/2010)

Last Updated: 10 March 2010

Last Name	First Name	Organization	City, State	Phone (O), Phone (C)	Email	
Bower	Ward	Sandia National Laboratories (CMP-04)	Albuquerque, NM	505-844-5206	<a href="mailto:wibower@sandia.gov">wibower@sandia.gov</a>	1
Brooks	Bill	Brooks Engineering (SEIA, CMP-04)	Vacaville, CA	707-332-0761	<a href="mailto:bill@brooksolar.com">bill@brooksolar.com</a>	2
Croushore	Tim	Allegheny Power (CMP-12 Chair)	Greensburg, PA	724-838-6198	<a href="mailto:tcroush@alleghenypower.com">tcroush@alleghenypower.com</a>	3
Dalton	James	Chicago Fire Dept.	Chicago, IL	312-747-7236	<a href="mailto:james.dalton@cityofchicago.org">james.dalton@cityofchicago.org</a>	4
Earley	Mark	NFPA	Quincy, MA	617-984-7400	<a href="mailto:mwearley@nfpa.org">mwearley@nfpa.org</a>	5
Frale	Dave	U.S. General Services Administration	Genera, IL	630-845-1623	<a href="mailto:Dave.Frale@gsa.gov">Dave.Frale@gsa.gov</a>	6
Grant	Casey	FPRF/NFPA	Quincy, MA	617-984-7284 617-594-1159	<a href="mailto:cgrant@nfpa.org">cgrant@nfpa.org</a>	7
Groden	Walter	Chartis Insurance	New York NY	646-857-1236	<a href="mailto:walter.groden@chartisinsurance.com">walter.groden@chartisinsurance.com</a>	8
Hollenstain	Tom	State Farm, Auto Technology Research	Champaign, IL	309-763-5688	<a href="mailto:tom.hollenstain.akbg@statefarm.com">tom.hollenstain.akbg@statefarm.com</a>	9
Kerber	Stephen	Underwriters Laboratories	Northbrook, IL	847-664-3329 847-224-4274	<a href="mailto:Stephen.Kerber@us.ul.com">Stephen.Kerber@us.ul.com</a>	10
Kreis	Timothy	Phoenix Fire Dept.	Phoenix AZ		<a href="mailto:Tim.kreis@phoenix.gov">Tim.kreis@phoenix.gov</a>	11
Layman	Jeff	BP Solar International	TN	423-506-8217 240-344-0591	<a href="mailto:jeff.layman@bp.com">jeff.layman@bp.com</a>	12
Lindsey	Travis	Travis Lindsey Consulting Services	Las Vegas NV	702-873-3530	<a href="mailto:traviscl@msn.com">traviscl@msn.com</a>	13
McCall	George	McCall & Son	Greenville, SC	864-908-9999	<a href="mailto:gmccall@McCallandSon.com">gmccall@McCallandSon.com</a>	14
McKenna	Larry	USFA	Emmitsburg, MD	301-447-1361	<a href="mailto:Larry.McKenna@dhs.gov">Larry.McKenna@dhs.gov</a>	15
Mentzer	Barbara	Hartford Fire & Rescue, IA Electrical Board	Hartford, IA	515-971-9775	<a href="mailto:ladychief500@g.com">ladychief500@g.com</a>	16
Murchie	Colin	Solarcity	Washington DC	202-590-8609	<a href="mailto:cmurchie@solarcity.com">cmurchie@solarcity.com</a>	17
Paiss	Matt	San Jose Fire Dept. (NGLB Training Group)	San Jose, CA	408-277-4444 831-566-3057	<a href="mailto:mpaiss@earthlink.net">mpaiss@earthlink.net</a>	18
Peterson	Eric	FPRF/NFPA	Quincy, MA	617-984-7281	<a href="mailto:epeterson@nfpa.org">epeterson@nfpa.org</a>	19
Roper	Ed	SC State Training Academy, (NAFTD)	Columbia, SC	803-896-9864 803-260-1688	<a href="mailto:ropere@lir.sc.gov">ropere@lir.sc.gov</a>	20
Sanfilippo	Tony	MI State Fire Marshal's Office	Lansing, MI	517-241-8847	<a href="mailto:sanfilippoa@michigan.gov">sanfilippoa@michigan.gov</a>	21
Sawyer	Steve	NFPA	Quincy, MA	617-984-7423 860-908-4454	<a href="mailto:ssawyer@nfpa.org">ssawyer@nfpa.org</a>	22
Scoble	William	Westwood Fire Dept.	Westwood, MA	781-320-1066	<a href="mailto:bscoble@townhall.westwood.ma.us">bscoble@townhall.westwood.ma.us</a>	23
Shaw	Ron	Extrication.com	Plymouth MA	508-747-0860	<a href="mailto:rshaw@extrication.com">rshaw@extrication.com</a>	24
Slaughter	Rodney	Dragonfly Communication. Network	Corning, CA	916-445-4518 916-203-6827	<a href="mailto:Dragonfyacres@hotmail.com">Dragonfyacres@hotmail.com</a>	25
Van de Velde	Marc	Global Asset Protection Services LLC	Frankfurt, Germany	49 172 6125027	<a href="mailto:Marc.vandevelde@xlgroup.com">Marc.vandevelde@xlgroup.com</a>	26
Varone	Curt	NFPA	Quincy, MA	401-295-9111	<a href="mailto:jcatlaw@aol.com">jcatlaw@aol.com</a>	27
Willse	Pete	XL Global Asset Protection Services	Hartford, CT	860-293-7900 860-460-1965	<a href="mailto:Peter.Willse@xlgroup.com">Peter.Willse@xlgroup.com</a>	28

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## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS



THE  
FIRE PROTECTION  
RESEARCH FOUNDATION

17 March 2010  
Detroit, Michigan


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## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS AGENDA

- 1) Welcome & Introductions
- 2) Project & Workshop Objectives
- 3) Review of Baseline Information
- 4) Working Groups Discussions
- 5) Working Group Reports
- 6) Open Discussion and Summary Comments


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## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS AGENDA

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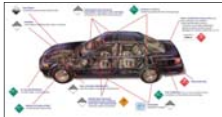
4




## 2) Project and Workshop Objectives

"Fire Fighter Safety & Emerg Response in Pre-Planning and Fireground Tactics for Alt-Energy Technologies"

- NFPA Project, with FPRF Assistance
- Focus: fire ground best practices for two alternative energy applications:
  - Electric and Hybrid Electric Vehicles
  - Solar Power Systems




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## 2) Project and Workshop Objectives

"Fire Fighter Safety & Emerg Response in Pre-Planning and Fireground Tactics for Alt-Energy Technologies"

- Collecting existing operational and training information
- Small one year project (Sept 2009 – Aug 2010)
- Funded by DHS/FEMA Fire Grant



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## 2) Project and Workshop Objectives

"Fire Fighter Safety & Emerg Response in Pre-Planning and Fireground Tactics for Alt-Energy Technologies"

- Overall Project Goal:
  - To assemble and widely disseminate best practice tactical information for fire fighters and fire ground incident commanders to assist in their decision making process when responding to emergency events involving these alt-energy applications
- Project Scope (for Solar Power Systems):
  - Types: Solar Thermal & Photovoltaics
  - Focus on Photovoltaics
  - Emergency events involving structures



## 2) Project and Workshop Objectives

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### Fire Service Workshop on Solar Power Systems

- Workshop Goal:
  - Identify, review, and assemble best practice information for tactical and strategic decision-making by fire fighters and fire ground incident commanders, to assist in their decision-making process when responding to fire and/or rescue emergency events involving these alt-energy applications.



## 2) Project and Workshop Objectives

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### Fire Service Workshop on Solar Power Systems

- Workshop Objectives:
  - Collectively review the available baseline information;
  - Identify the fundamental principles and key details involving fire/rescue tactics and strategy;
  - address and clarify related issues such as training needs, areas needing further research, revisions to codes/standards, and other topics applicable to the overall workshop goal.



## 2) Project and Workshop Objectives

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NFPA is the Lead Organization;  
FPRF is providing advisory support role

### FPRF: General Background on the Foundation

- Plan, manage and communicate research in support of the NFPA mission
- Independent charitable organization
  - Formed by NFPA in 1982
  - Intended to provide data to support the of NFPA codes & standards



## 2) Project and Workshop Objectives

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### FPRF: Process used for projects

- 1) Research Projects Initiation
- 2) Core Planning Meeting
- 3) Project Technical Panel(s)
- 4) Research Performed
- 5) Research Reports Published



--- Project is following FPRF Policies ---



## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS AGENDA

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- 1) Welcome & Introductions
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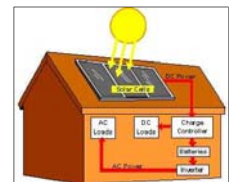


## 3) Review of Baseline Information

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(Information Based on Draft Report )

- A. Overview of Solar Power Systems (Chap 2)
- B. Photovoltaic Solar Power (Chap 3)
- C. Overview of Fire Service Operational Materials (Chap 4)
- D. Assembly of Best Practice Guidance for Emergency Response (Chap 5)




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### 3) Review of Baseline Information

A. Overview of Solar Power Systems (Chap 2)


- A1) Evolution of Technology for Harnessing Energy from the Sun
- A2) Types of Solar Power Systems
- A3) Marketplace Trends
- A4) Loss History and Data
- A5) Information Resources



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### 3) Review of Baseline Information

Overview of Solar Power Systems (Chap 2)  
A1) Evolution of Technology for Harnessing Sun's Energy

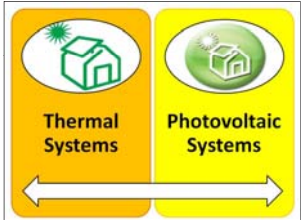


Basic Methods for Harnessing Solar Energy

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### 3) Review of Baseline Information

Overview of Solar Power Systems (Chap 2)  
A2) Types of Solar Power Systems



Types of Solar Power Systems of Interest to the Fire Service

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### 3) Review of Baseline Information

Overview of Solar Power Systems (Chap 2)  
A3) Marketplace Trends

Year	Import Shipments (thousand Sq Ft)	Export Shipments (thousand Sq Ft)	Total Shipments (thousand Sq Ft)	Number of Companies
1998	2,206	360	7,756	28
1999	2,352	537	8,583	29
2000	2,201	496	8,354	26
2001	3,502	840	11,189	26
2002	3,068	659	11,663	27
2003	2,986	518	11,444	26
2004	3,723	813	14,114	24
2005	4,546	1,361	16,041	25
2006	4,244	1,211	20,744	44
2007	3,891	1,376	15,153	60

Solar Thermal Collector Shipments Annually from 1998 - 2007

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### 3) Review of Baseline Information

Overview of Solar Power Systems (Chap 2)  
A3) Marketplace Trends

Year	Import Shipments (Peak Kilowatt)	Export Shipments (Peak Kilowatt)	Total Shipments (Peak Kilowatt)	Number of Companies
1998	1,931	35,493	50,562	21
1999	4,784	55,585	76,787	19
2000	8,821	68,382	88,221	21
2001	10,204	61,356	97,666	19
2002	7,297	66,778	112,090	19
2003	9,731	60,693	109,357	20
2004	47,703	102,770	181,116	19
2005	90,981	92,451	226,916	29
2006	173,977	130,757	337,268	41
2007	238,018	237,209	517,684	46

Photovoltaic Cell/Module Shipments Annually from 1998 - 2007

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### 3) Review of Baseline Information

Overview of Solar Power Systems (Chap 2)  
A3) Marketplace Trends

Year	Total Kilowatts	Year	Total Kilowatts
1981	37	1995	4,193
1982	75	1996	5,046
1983	86	1997	5,465
1984	1,231	1998	6,263
1985	1,245	1999	7,228
1986	2,217	2000	8,929
1987	2,217	2001	15,180
1988	2,221	2002	29,820
1989	2,280	2003	58,460
1990	2,285	2004	95,884
1991	2,312	2005	139,516
1992	2,801	2006	198,257
1993	4,064	2007	279,463
1994	4,606	2008	449,216

California Grid-Connected Photovoltaic Systems 1981 - 2008



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data

- Current data collection efforts (e.g. NFIRS, FIDO, etc) do not distinguish level of detail on this topic
- Fire fighter falls & shock data is available, but not clear on relationship/involvement with solar equipment
- Example: [www.FireFighterNearMiss.com](http://www.FireFighterNearMiss.com) details 32 shock specific events for 2005 & 2006
- We do have handle on magnitude of structural fire and FF injuries, and can roughly extrapolate to % with solar



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data

- Documentation on Specific Events
  - 1) Residential, Colorado, May 1980
  - 2) Educational, California, May 2008
  - 3) Residential, California, March 2009
  - 4) Mercantile, California, April 2009

Event	Date	Location	Type	Details
1	May 1980	Residential, Colorado	Shock	...
2	May 2008	Educational, California	Shock	...
3	March 2009	Residential, California	Shock	...
4	April 2009	Mercantile, California	Shock	...



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data



Fire at Educational Occupancy, California, May 2008



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data



Fire at Educational Occupancy, California, May 2008



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data



Fire at Educational Occupancy, California, May 2008



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A4) Loss History and Data



Fire at Educational Occupancy, California, May 2008



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Educational Occupancy, California, May 2008



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009



### 3) Review of Baseline Information

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Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A4) Loss History and Data



Fire at Mercantile Occupancy, California, April 2009

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A5) Information Resources

American Solar Energy Society (ASES)  
 Database of State Incentives for Renewables & Efficiency (DSIRE)  
 International Solar Energy Society (ISES)  
 Interstate Renewable Energy Council (IREC)  
 National Renewable Energy Laboratory (NREL)  
 Solar Alliance  
 Solar America Board of Codes and Standards (Solar ABCs)  
 Solar Electric Power Association (SEPA)  
 Solar Energy Industries Association (SEIA)  
 Solar Energy International (SEI)  
 Solar Living Institute (SLI)  
 Solar Nation  
 Vote Solar

Examples of Notable National Solar Power Organizations

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A5) Information Resources

Arizona Solar Energy Industries Association (ArISEIA)  
 California Solar Energy Industries Association (CALSEIA)  
 Florida Solar Energy Resource Center (FSEC)  
 Northeast Sustainable Energy Association (NESEA)  
 Texas Renewable Energy Industries Association (TREIA)

Examples of Notable Regional Solar Power Organizations

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A5) Information Resources

- IFC/TS 61836:2007, Solar Photovoltaic Energy Systems – Terms, Definitions and Symbols
- IEC 60364-7-712 (2002-05), Electric Installations of Buildings – Part 7-712: Requirements for Special Installations or Locations – Solar Photovoltaic (PV) Power Supply Systems
- ISO 9488:1999, Solar Energy – Vocabulary
- NFPA 70, National Electrical Code, 2008 edition (Article 690, Solar Photovoltaic Systems)
- NFPA 5000, Building Construction and Safety Code, 2009 edition

Examples of Directly Applicable Model Codes & Standards

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**3) Review of Baseline Information**

Overview of Solar Power Systems (Chap 2)  
A5) Information Resources

- ICC International Building Code, 2009 edition
- NFPA 1, Fire Code, 2009 edition
- ICC International Fire Code
- ICC-700, National Green Building Standard
- ICC International Energy Conservation Code
- ICC International Residential Code

Examples of Indirectly Applicable Model Codes & Standards



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A5) Information Resources

- 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, (California Energy Commission, effective 1 Jan 2010)
- Oregon Solar Energy Code, Draft Document dated September 2009

Examples of Applicable Regional Codes



### 3) Review of Baseline Information

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#### Overview of Solar Power Systems (Chap 2) A5) Information Resources

Case	Public Title	Author(s)	Date	Month	Day	Format	Fire Service Use
1	Solar energy codes and fire safety	Bark, W.A.	1976	Jun	13/16	\$1.52	Article
2	Fire experiments and field tests on the solar heat transfer through	Lark, B.F., Williams, W.D.	1979				Report
3	Fire occurs within solar panel	Haney, C.S.	1980	Apr	4/18	40-43	Article
4	Fire in a residential solar panel: a potential residential problem	International Fire Chief	1980	Sept	9/19	55-57	Article
5	Fire within a residential solar panel	Haney, C.S.	1980	Apr	4/18	40-43	Article
6	Solar collector fire incidents investigation	SBDR 61-2528	1981	Aug			Report
7	Fire testing of roof-mounted solar collectors by AIA/FAE 208	Warton, W.D.	1981	Aug			Report
8	Fire testing of solar collectors by AIA/FAE 208	Warton, W.D.	1982	Mar	3/13	174	Article

Literature Review Summary for Solar Power Systems & Fire Service

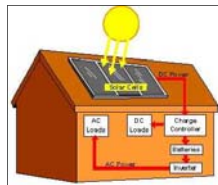


### 3) Review of Baseline Information

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#### (Information Based on Draft Report)

- A. Overview of Solar Power Systems (Chap 2)
- B. Photovoltaic Solar Power (Chap 3)
- C. Overview of Fire Service Operational Materials (Chap 4)
- D. Assembly of Best Practice Guidance for Emergency Response (Chap 5)



### 3) Review of Baseline Information

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#### B. Photovoltaic Solar Power (Chap 3)

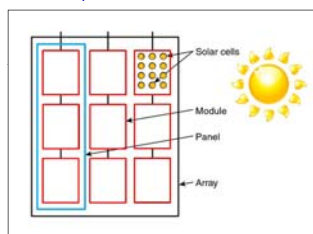
- B1) Photovoltaic Basics
- B2) Solar Cell Technology and Photovoltaic Systems
- B3) Background on Fireground Electrical Hazards



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B1) Photovoltaic Basics



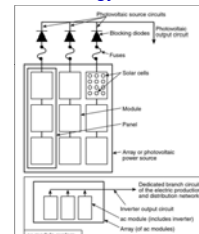
Basic Photovoltaic Components Used to Capture Solar Energy



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B2) Solar Cell Technology and Photovoltaic Systems



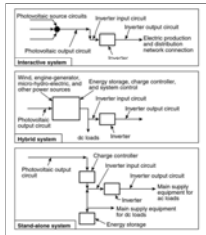
Basic Components of Photovoltaic Solar Power System



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B2) Solar Cell Technology and Photovoltaic Systems



Photovoltaic System Interrelationship with Conventional Elect Sys



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B2) Solar Cell Technology and Photovoltaic Systems

Monocrystalline	(single-crystal construction)
Polycrystalline	(semicrystalline)
Amorphous silicon thin film	

Basic Types of Photovoltaic Solar Cell Technologies



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B3) Background on Fireground Electrical Hazards

- Voltage – the electromotive force or potential difference, measured in volts. Voltage is the “pressure” that pushes an electrical charge through a conductor.
- Amperage or Current – The amount of electrical charge flowing past a given point per unit of time, measured in amperes or amps. Amperage is the measure of electrical current flow.

Clarification of “Voltage” and “Amperage”



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B3) Background on Fireground Electrical Hazards

Milliamperes	Observable Effect
15K/20K*	Common fuse or circuit breaker opens
1000	Current used by a 100-watt light bulb
900	Severe burns
300	Breathing stops
100	Heart stops beating (ventricular fibrillation threshold)
30	Suffocation possible
20	Muscle contraction (paralysis of respiratory muscles)
16	Maximum current an average man can release “grasp”
5	GFCI will trip
2	Mild shock
1	Threshold of sensation (barely perceptible)

\*Note: 15 to 20 Amps (15,000 to 20,000 Milliamperes) is current required to open a common residential fuse or circuit breaker.

Estimated Effect of 60 Hz AC Current on Humans



### 3) Review of Baseline Information

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#### Photovoltaic Solar Power (Chap 3) B3) Background on Fireground Electrical Hazards

##### Shock Hazard Levels

Effect of Current	AC Current in Amps–Men	AC Current in Amps–Women
Perception threshold (tingling sensation)	0.0010	0.0007
Slight shock–not painful (no loss of muscle control)	0.0018	0.0012
Shock–painful (no loss of muscle control)	0.0090	0.0060
Shock–severe (muscle control loss, breathing difficulty–onset of “let-go” threshold)	0.0230	0.0150
Possible ventricular fibrillation (3-second shock)	0.1000	0.1000
Possible ventricular fibrillation (1-second shock)	0.2000	0.2000
Heart muscle activity ceases	0.5000	0.5000
Tissue and organs burn	1.5000	1.5000

Human Body Reaction to Shock Hazards

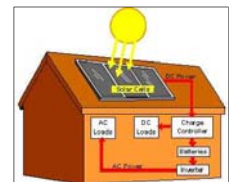


### 3) Review of Baseline Information

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#### (Information Based on Draft Report )

- Overview of Solar Power Systems (Chap 2)
- Photovoltaic Solar Power (Chap 3)
- Overview of Fire Service Operational Materials (Chap 4)
- Assembly of Best Practice Guidance for Emergency Response (Chap 5)



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### 3) Review of Baseline Information

C. Overview of Fire Service Operational Materials (Chap 4)

*Standard Operating Guideline:* A written organizational directive that establishes or prescribes specific operational or administrative methods to be followed routinely, which can be varied due to operational need in the performance of designated operations or actions. (Note: Standard operating guidelines allow flexibility in application.)


*Standard Operating Procedure:* A written organizational directive that establishes or prescribes specific operational or administrative methods to be followed routinely for the performance of designated operations or actions. (Note: The intent of standard operating procedures is to establish directives that must be followed.)

Clarification of SOPs and SOGs

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### 3) Review of Baseline Information

C. Overview of Fire Service Operational Materials (Chap 4)

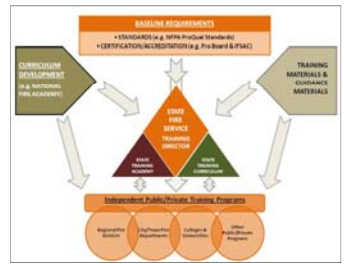


Background on Types of Training

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### 3) Review of Baseline Information

C. Overview of Fire Service Operational Materials (Chap 4)



Overview of External Sources of Fire Service Training

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### 3) Review of Baseline Information

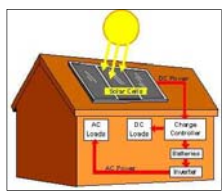
(Information Based on Draft Report.)

A. Overview of Solar Power Systems (Chap 2)

B. Photovoltaic Solar Power (Chap 3)

C. Overview of Fire Service Operational Materials (Chap 4)

D. [Assembly of Best Practice Guidance for Emergency Response \(Chap 5\)](#)




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### 3) Review of Baseline Information

D. [Assembly of Best Practice Guidance \(Chap 5\)](#)

- D1) Identification of Common Themes, Principals, & Core Basics
- D2) Target Application Workshop
- D3) Final Evaluation of Best Practices



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### 3) Review of Baseline Information

[Assembly of Best Practice Guidance \(Chap 5\)](#)

[D1\) Identification of Common Themes and Principals](#)

Grouped according to:

- Solar Thermal Hazards vs. Photovoltaic Hazards
- Roof-Top Fire Fighting Operations
- Other Roof-Top Concerns (e.g. exposure)
- Electrical Shock Considerations
- Battery Storage Components
- Overhaul and Post Fire Concerns
- General Safety Precautions



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### 3) Review of Baseline Information

Assembly of Best Practice Guidance (Chap 5)  
D1) Identification of Common Themes and Principals

Thermal Systems	Photovoltaic Systems
<ul style="list-style-type: none"> <li>• Tripping / Slipping</li> <li>• Structural Collapse due to Extra Weight</li> <li>• Flame Spread</li> <li>• Inhalation Exposure</li> <li>• Hot Fluid Scalds</li> </ul>	<ul style="list-style-type: none"> <li>• Tripping / Slipping</li> <li>• Structural Collapse due to Extra Weight</li> <li>• Flame Spread</li> <li>• Inhalation Exposure</li> <li>• Electrical Shock</li> <li>• Battery Hazards</li> </ul>

Primary Hazards of Solar Power Systems for Emerg Responders

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### 3) Review of Baseline Information

Assembly of Best Practice Guidance (Chap 5)  
D1) Identification of Common Themes and Principals

Sample Sign for Fire Fighter Safety Building Marking System

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### 3) Review of Baseline Information

Assembly of Best Practice Guidance (Chap 5)  
D1) Identification of Common Themes and Principals

- Daytime = Danger; Nighttime = No Hazard
- Inform the IC that a PV system is present
- Securing the main electrical does not shut down the PV modules
- At night apparatus mounted scene lighting does not produce enough light to generate an electrical hazard in the PV system
- Cover all PV modules with 100 percent light blocking materials to stop electrical generation
- Don't break, remove or walk on PV modules, and stay away from modules, components and conduit

Six Points of Safe Operation for Fire Fighters

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### 3) Review of Baseline Information

Assembly of Best Practice Guidance (Chap 5)  
D1) Identification of Common Themes and Principals

- Identify the existence of a solar power system
  - locate roof-top panels
  - clarify electrical disconnects
  - obtain system information
- Identify the type of solar power system
  - Solar Thermal System
  - Photovoltaic System
- Isolate and shutdown as much of the system as possible
  - Lock-out & Tag-out all electrical disconnects
  - Isolate the photovoltaic system at the inverter
- Work around all solar power system components

Fundamental Points for Handling Solar Power Systems

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## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS AGENDA

- 1) Welcome & Introductions
- 2) Project & Workshop Objectives
- 3) Review of Baseline Information
- 4) Working Groups Discussions
- 5) Working Group Reports
- 6) Open Discussion and Summary Comments

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### 4) Working Group Discussions

- Three working groups
  - Each with a facilitator & recorder
  - Assigned as white/green/blue; balanced by backgrounds and expertise
  - Meet for approximately 75 minutes and report back to entire group
- Three basic categories of questions:
  - Current practice
  - Future trends
  - Other issues

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**4) Working Group Discussions**

– Question Category 1, Current Practice:


- In terms of prioritized hazards, how should this topic be scoped (e.g. types of systems, incident type, etc)?
- What are the prioritized core basics for emergency responders to address this topic?
- What is specifically needed for (i) operational procedures and (ii) training materials?
- What are known or potential topics of technical debate (e.g. extinguishing certain battery fires, etc)?

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**4) Working Group Discussions**

– Question Category 2, Future Trends:

- Based on current technological trends, what are the greatest anticipated (prioritized) future hazards?
- How should fire service be addressing this topic in 5 years? 10 years?
- What constituent groups and/or organizations need to be involved?




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**4) Working Group Discussions**

– Question Category 3, Other Issues:

- What other case study events have not already been mentioned, and what are lessons learned?
- What specific updates/additions/changes need to be addressed in codes and standards?
- What single message should the fire service express on this topic?



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**FIRE SERVICE WORKSHOP  
ON  
SOLAR POWER SYSTEMS  
AGENDA**

- 1) Welcome & Introductions
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**FIRE SERVICE WORKSHOP  
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FPRF Website: [www.nfpa.org/foundation](http://www.nfpa.org/foundation)




## Firefighter Safety and Emergency Response in Pre-Planning and Fireground Tactics for Alternative Energy Technologies

Location: NextEnergy, 461 Burroughs St., Detroit, Michigan

### **WORKING GROUP QUESTIONS**

Last Updated: 15 March 2010

Each of the three working groups should individually address the following set of specific topics/questions, and report back to the whole group:

#### 4) Current Practice

- a. In terms of prioritized hazards, how should this topic be scoped (e.g. types of systems, incident type, etc)?
- b. What are the prioritized core basics for emergency responders to address this topic?
- c. What is specifically needed for (i) operational procedures and (ii) training materials?
- d. What are known or potential topics of technical debate (e.g. extinguishing certain battery fires, etc)?

#### 5) Future Trends

- a. Based on current technological trends, what are the greatest anticipated (prioritized) future hazards?
- b. How should fire service be addressing this topic in 5 years? 10 years?
- c. What constituent groups and/or organizations need to be involved?

#### 6) Other Issues

- a. What other case study events have not already mentioned, and what are lessons learned?
- b. What specific updates/additions/changes need to be addressed in codes and standards?
- c. What single message should the fire service express on this topic?

## FIRE SERVICE WORKSHOP ON SOLAR POWER SYSTEMS

Detroit, MI  
17 March 2010

### Working Group Summary

The following set of ten questions was addressed independently by two separate working groups at this workshop. This consolidated "Working Group Summary" provides their collective responses, and for each question is provided in a non-prioritized, harmonized summary-format.

#### **I. CURRENT PRACTICE**

##### **A. In terms of prioritized hazards, how should this topic be scoped?**

1. Solar Thermal vs. Photovoltaic
2. Solar Power System Types
  - 2.1. Residential (small in-grid systems, numerous)
  - 2.2. Commercial (large in-grid systems, less common)
  - 2.3. Utility scale power generation sites (very large systems, rare)
  - 2.4. Standalone off-grid systems
  - 2.5. Existing systems vs. new systems (for regulatory oversight)
3. Solar Power System Characteristics
  - 3.1. Hazard identification and labeling
  - 3.2. High voltage hazards (arcing, shock)
    - 3.2.1. Electrical component isolation (disconnects, how many?)
    - 3.2.2. Electrical conduit routing and location
    - 3.2.3. Batteries (integration, containment, isolation, etc)
  - 3.3. System Responsibility/Accountability (installation, maintenance, etc)
  - 3.4. Separate panels vs. integrated solar components (with structure)
4. Building Attributes
  - 4.1. Flammability hazard concerns
    - 4.1.1. Ignition
    - 4.1.2. Flame spread
    - 4.1.3. Products of combustion
  - 4.2. Building and roof assembly construction types
  - 4.3. Structural loads and related concerns (dead load, snow, wind, etc)
  - 4.4. Integration with building electrical system
  - 4.5. Personnel access
5. Event Characteristics
  - 5.1. Fire in solar array vs. structure fire not yet involving array
  - 5.2. Support of site personnel not fully trained on system
  - 5.3. Hazards related to configuration (trip, slip, fall, etc)
  - 5.4. Fire fighting ventilation tactics
  - 5.5. Products of combustion exposure (inhalation, air quality, etc)
  - 5.6. Older systems vs. newer systems
  - 5.7. Low frequency occurrence, but with potential high severity

##### **B. What are the prioritized core basics for emergency responders to address the topic?**

1. Identification
  - 1.1. Common identification and labeling format (solar panel, rooftop conduits, disconnects, etc)

- 1.2. Common location of control panels and disconnects
- 1.3. Establish and coordinate interface with local AHJ and fire department
2. Responder Guidance and Pre-Planning
  - 2.1. Provide universal fundamental set of tactics
  - 2.2. Develop emergency response plan
  - 2.3. Prepare to handle without outside support (e.g. utilities for shutdown)
3. Training
  - 3.1. Avoid complex training programs (instead promote inherent system design corrections)
  - 3.2. Concisely clarify what fire fighters can and can't do
4. Regulatory
  - 4.1. Establish an ongoing operation and maintenance process
  - 4.2. Consider regulatory oversight comparable with equivalent building systems (e.g. sprinklers, fire alarms, electrical, mechanical)

### **C. What is specifically needed for operational procedures and training materials?**

1. Operational Materials
  - 1.1. Need standardization to set baseline requirements for operational materials
  - 1.2. Clarify offensive vs. defensive tactics
  - 1.3. Clearly indicate what can and can't be done
  - 1.4. Stress need for awareness and identification
  - 1.5. Indicate personnel access requirements to components (e.g. PPE)
  - 1.6. Identify options when in trouble (e.g. Rapid Intervention Teams)
2. Training Materials
  - 2.1. Need standardization to set baseline requirements for training materials
  - 2.2. Focus on state fire training academies
  - 2.3. Develop audience specific materials (e.g. fire personnel, incident commanders, fire instructors, investigators, etc)
  - 2.4. Include non-fire service groups in developing training materials
    - 2.4.1. building owners and occupants
    - 2.4.2. industry

### **D. What are the known or potential topics of technical debate?**

1. NEC Related
  - 1.1. Controllers and disconnects
    - 1.1.1. String level disconnects
    - 1.1.2. Module level controllers
  - 1.2. Electrical conductor features and location
    - 1.2.1. Wiring that is grounded vs. ungrounded
    - 1.2.2. Ground indicators
  - 1.3. Allowing DC power into building envelope
  - 1.4. Number and size of access points
  - 1.5. Effect of exterior conditions on system and components (e.g. contraction and expansion due to ambient roof temperatures, etc)
2. Fire Fighting Tactics
  - 2.1. Tactics for large commercial systems
  - 2.2. Firefighting with water vs. other agents
  - 2.3. Products of combustion and implications of letting it burn during daytime fire
  - 2.4. Support and response of system installer
  - 2.5. Overhaul and post-fire situation

- 2.6. Myth vs. reality (inherent dangerous characteristics)
- 3. Regulatory
  - 3.1. Flammability (as well as electrical) (e.g. fire resistance ratings)
  - 3.2. Building construction and roof classifications
  - 3.3. Non-OEM installations (e.g. non-listed products)

## **II. FUTURE TRENDS**

### **A. Based on current technological trends, what are the greatest anticipated future hazards?**

- 1. System Operating Features
  - 1.1. Inability to power down system
  - 1.2. Securing the system in post-fire
  - 1.3. Micro-inverters and AC panels
  - 1.4. Systems with integrated components, or integrated with building
  - 1.5. Module level control (mitigation)
  - 1.6. Issues involving arc fault
- 2. Material Properties and Configurations
  - 2.1. Solar panels installed vertically
  - 2.2. Solar powered shingles
  - 2.3. Vertical surfaces (e.g. curtain walls, thin films)
  - 2.4. Tempered vs. non-tempered glass
  - 2.5. Solar concentrators and hot thermal fluids
- 3. Other system Concerns
  - 3.1. After-market and non-OEM installations
  - 3.2. Maintenance and upkeep requirements
  - 3.3. Solar power use with vehicle
  - 3.4. Mobile or portable equipment used to back feed building
  - 3.5. Roof configurations with “green” buildings

### **B. How should fire service be addressing this topic in 5 years? 10 years?**

- 1. Standardization
  - 1.1. Isolate systems through module level controllers
  - 1.2. Ventilation tactics (horizontal vs. vertical)
  - 1.3. Building and system labeling
- 2. Data Collection
  - 2.1. Establish better data collection process
- 3. Other Issues
  - 3.1. Sharp increase in solar
  - 3.2. Increase in distributed power supply

### **C. What constituent groups and/or organizations need to be involved?**

- 1. Public Organizations
  - 1.1. Emergency responder representatives
    - 1.1.1. Fire service
      - 1.1.1.1. Membership organizations (e.g. IAFC, IAFF, NVFC, etc)
      - 1.1.1.2. Training organizations (e.g. NAFTD, NFA, etc)
    - 1.1.2. EMS and law enforcement
  - 1.2. Federal government
    - 1.2.1. DOE and NREL (and other DOE related organizations)
    - 1.2.2. OSHA

- 1.3. Authorities Having Jurisdiction (AHJs)
  - 1.3.1. Building officials
  - 1.3.2. Electrical inspectors (e.g. IAEL, etc)
  - 1.3.3. Fire Marshals (IFAM, NASFM, etc)
2. Private Organizations
  - 2.1. Conformity assessment and product approval organizations (e.g. UL, etc)
  - 2.2. Industry
    - 2.2.1. Associations and membership organizations (e.g. Solar ABCs, etc)
    - 2.2.2. Manufacturer representatives (e.g. NEMA)
    - 2.2.3. Integrator representatives (e.g. NEMA, IECL, etc)
  - 2.3. Building users/owners
  - 2.4. Insurance
  - 2.5. Architects
3. Others
  - 3.1. Utility representation (e.g. EEI, etc)
  - 3.2. Labor union groups (e.g. IBEW, etc)
  - 3.3. International representation
  - 3.4. Codes and standard developing organizations (NFPA, ICC, ISO, IEC, etc)

### III. OTHER ISSUES

#### A. What other case study events have not already mentioned, and what are lessons learned?

1. Investigation process
  - 1.1. Clarify cause and origin information for investigators
  - 1.2. Establish investigation team process (for noteworthy incidents)
2. Data Collection Methods
  - 2.1. Better utilize industry organizations (e.g. Solar ABCs, etc)
  - 2.2. Better define data elements with existing data collections (e.g. NFIRS, FIDO, etc)
3. Other Issues
  - 3.1. Clarify possible approaches with non disclosure agreements

#### B. What specific updates/additions/changes need to be addressed in codes and standards?

1. Electrical Codes
  - 1.1. String level disconnects
  - 1.2. Module level controllers
  - 1.3. Electrical conductor location
  - 1.4. Ground fault indicators
  - 1.5. Non grounded system
2. Building and Fire Prevention Codes
  - 2.1. Building markings and pre-incident planning info (in standardized format)
  - 2.2. Operation and maintenance for the upkeep of building marking
  - 2.3. Address flammability characteristics for exposure fires (e.g. NFPA 1144 Reducing Structure Ignition Hazards from Wildland Fire, etc)
  - 2.4. System commissioning (NFPA 3, etc)
3. Fire Service Standards
  - 3.1. Fire ground tactics and strategy
    - 3.1.1. Residential
    - 3.1.2. Commercial and other large systems
  - 3.2. Overhaul and post-fire situations
  - 3.3. Update emergency responder professional qualification standards

4. Other Codes and Standards
  - 4.1. Data collection systems (e.g. NFIRS, FIDO, etc)
  - 4.2. Fire investigations (e.g. NFPA 921, etc)
5. Other Issues
  - 5.1. Aging and weathering
  - 5.2. Non-OEM installations (e.g. non-listed products)
  - 5.3. Proliferating use of applicable model code (e.g. Oregon, Cal Fire Guidelines, etc)

**C. What single message should the fire service express on this topic?**

1. Fire Ground Tactics
  - 1.1. "Components are always hot!" (in daytime)
  - 1.2. Operate normally, but don't touch
  - 1.3. Size-up, identify and validate hazard
  - 1.4. Stress key message for tactical approach (especially large commercial systems)
  - 1.5. Leave the scene in a safe condition
2. Code Development
  - 2.1. Provide ability for electrical system isolation for emergency responders
  - 2.2. Create consistent placarding and labeling for emergency responders
  - 2.3. Address on-going maintenance oversight of installed systems (especially commercial)
  - 2.4. Require system contact information for emergencies
3. Education and Training
  - 3.1. This is energized electrical equipment like other equipment, but with in-ability to power down. Otherwise not much different.
  - 3.2. Systems are widespread: You probably have these systems in your 1st due jurisdiction
  - 3.3. Don't underestimate electrical hazard; don't be complacent