FUNDAMENTALS OF PHOTOVOLTAICS FOR THE FIRE SERVICE

TOPIC: 4: Photovoltaic Applications

TIME FRAME: 1:00

LEVEL OF INSTRUCTION: Level 1

BEHAVIORAL OBJECTIVE:

Condition: Given a written test

Behavior: The student will confirm their knowledge of the application and location of photovoltaic systems by completing the written test.

Standard: With a minimum 80% accuracy according to the information contained in:

- Fundamentals of Photovoltaics for the Fire Service, Rodney Slaughter, September 2006

MATERIALS NEEDED:

- Writing board or pad with markers/erasers
- Appropriate audiovisual equipment
- Appropriate audiovisual materials

REFERENCES:

- Fundamentals of Photovoltaics for the Fire Service, Rodney Slaughter, September 2006

PREPARATION: The PV design choice is dependent on the building site and the building owner's expectations. All of which will all be considered to determine the type of PV equipment that will be installed at a given site. The obvious advantage of a solar energy system is that it produces clean and reliable energy that can be used in a wide range of applications. In fact the application of solar electric is so prevalent in your life today that you probably don't even think about it.

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PRESENTATION	APPLICATION
	Slide 1 - Agenda "PV Applications"
I. OBJECTIVE	Slide 2 – Behavioral Objective
A. At this end of the section you will be able to identify PV applications and the components associated with each application	
	Slide 3 – PV Application
II. Day Use	
A. Even if you don't use PV directly you are doing so indirectly	
1. Communication systems and satellites with integrated PV systems provide power that improves the efficiency of our everyday lives even though you may not be aware of it!	
	Slide 4 – Day Use & Integrated
B. Day use solar technology is applied when PV cells or modules are wired directly to solar generated appliances like	
1. Calculators 2. Toys 3. Fans 4. Blowers 5. Pumps	

PRESENTATION	APPLICATION
C. These are simple and inexpensive solar electric applications D. These appliances operate when the solar cell is exposed to the sun or a bright light **III. Integrated Photovoltaic With Battery Back-Up** A. Other applications include integrated photovoltaic with battery back-up B. Solar energy is stored in rechargeable batteries so that the appliance can be used when the sun isn't shining C. These appliances include 1. Watches 2. Radios 3. Flashlights 4. Telecommunication equipment 5. Railroad lights 6. Low voltage landscape lighting D. These are fairly simple, inexpensive and specific applications of the photovoltaic technology 1. Imagine the cost of running electrical wires to all of the thousands of solar-powered call boxes along California's freeways?	

PRESENTATION	APPLICATION
E. Even if you don't use PV directly you are doing so indirectly via communication systems and satellites with integrated PV systems	
	Slide 5 – DC Systems
IV. Direct Current (DC) Systems	
A. RVs, boats and buildings in rural areas use PV systems with storage batteries and direct current appliances B. Batteries as part of the system allows PV energy generated during the day for use when the sun isn't shining	
C. Components used in a direct current system include; 1. Photovoltaic module or array 2. Battery charge controller 3. Batteries and 4. Direct current appliances	
	Slide 6 – DC to AC Array
V. Direct Current to Alternating Current Systems (DC to AC)	
A. In rural areas people can power their homes by converting the direct current (DC) generated from the PV system to alternating current (AC)	
	Slide 7 – DC to AC Controller

FUNDAMENTALS OF PHOTOVOLTAICS FOR THE FIRE SERVICE

PRESENTATION	APPLICATION
B. Still independent from the utility power grid, homeowner can take advantage of a wider range of affordable electrical appliances	
	Slide 8 – DC to AC Battery
C. These PV systems would include similar components found in the DC system, such as: 1. Solar modules or array 2. Battery charge controller 3. Batteries 4. Plus the addition of an inverter (to convert DC to AC)	
	Slide 9 – DC to AC Inverter
D. PV works best when the sun is shining 1. Fog and rainy days can last for several weeks longer than most battery systems can store energy 2. PV systems can also be backed-up with generators (commonly) or other alternative devices such as micro-hydroelectric or wind powered generating systems 3. Battery backed-up PV systems are designed to provide electricity for a specific period of time without sunshine	

PRESENTATION	APPLICATION
	Slide 10 – Grid-Tied Array
VI. Grid-Tied Systems	
A. Another option, and one of the most prevalent for homeowners and businesses, is the grid-tied system	
B. This system allows the building owner to generate and use PV power during the day and deliver excess power directly to the utility grid	
C. When the system is not generating enough electricity for the home or business, electricity is imported from the electric grid	
D. Net metering is achieved when the utility billing practices, or "tarrifs," allow for a "netting out" of these electrical flows and corresponding costs at the end of a month or year - "net metering"	
	Slide 11 – Grid-Tied Inverter
E. In this type of system the utility grid provides the back-up and eliminates the need for batteries in the system	
F. System components would include a PV array and a grid-tied inverter	

FUNDAMENTALS OF PHOTOVOLTAICS FOR THE FIRE SERVICE

PRESENTATION	APPLICATION
	Slide 12 – Grid-Tied Disconnect
G. Grid-tied systems automatically shut-down when there is no utility grid power present 1. Loss of power from the grid will disconnect electricity in the building including the ability to use the electricity generated from the PV system 2. The electrical lines from the PV panels to the inverter are still energized! 3. Electric power from the inverter to the rest of the building's wiring system and to the grid becomes isolated during a power outage 4. This protects utility company personnel from electrical shock while working on the lines during power outages — ensuring that the solar electricity is not being back-fed into the system H. ***Important Note:*** *When you lock out the main electrical power to the building you are disabling the power from the grid, simulating a power outage, which isolates the power from the PV array at the inverter*	

PRESENTATION	APPLICATION
1. *Remember, high voltages are still present from the PV panels to the inverter* I. As an extra measure of safety, fire personnel can also use the manual disconnect on the inverter to ensure that the PV system is in fact isolated from the rest of the building J. In many cases, PV systems can be identified with warning stickers and labels at the main electrical panel next to the inverter	Slide 13 – Commercial Application
K. ***Important Note:*** *It may not be possible to see a PV system on a flat roofed building from street level* 1. *It is incumbent on the building owner/operators to label solar electric systems at the main electrical panel* 2. *The fire department must preplan for structural emergencies on specific commercial and industrial buildings in their jurisdiction*	Slide 14 – BID Skylight

FUNDAMENTALS OF PHOTOVOLTAICS FOR THE FIRE SERVICE

PRESENTATION	APPLICATION
VII. Building Integrated Design	
A. The developing trend is to incorporate PV systems into the building's exterior finish	Slide 15 – BID CAL Expo
B. These systems appear as PV roofing systems, windows, skylights or patio covers	
C. These systems are more expensive, and therefore not as prevalent as roof or ground mounted systems	
D. But they do pose new design opportunities for building designers and owners	
E. ***Important Note:*** *Solar electric panels look a lot like solar thermal panels. Solar thermal panels are used to heat water for pools and domestic hot water*	
1. *Solar electric and solar thermal panels look like skylights*	
2. *Using skylights to ventilate a building should only be an option if you know that it is truly just a skylight!*	
F. PV glazing for windows and skylights can be installed in the curtain wall of a high rise or designed into a skylight or atrium	

PRESENTATION	APPLICATION
G. This technology uses a film attached to electric leads and sandwiched between panes of glass H. The PV panel functions to not only generate electricity but also filters the harsh sunlight coming through the window I. This type of PV system is less effective in generating electricity than the solar panels on the roof, so a number of south facing windows are covered to generate the required amount of energy for the building J. ***Important Note:*** *It is not recommended that you break the glass protecting any type of solar cell, whether it is a panel, window or skylight* 1. *Breaking through the glazing can potentially unleash all of the inherent energy in the system instantaneously at once, posing a significant shock hazard to the fire fighter* K. A design trend in Europe is to find clever ways of incorporating PV systems into the architecture or landscape of the building site	Slide 16 – BID Solar Cube

FUNDAMENTALS OF PHOTOVOLTAICS FOR THE FIRE SERVICE

PRESENTATION	APPLICATION
L. As PV becomes more prevalent in American planning, you can expect to see PV incorporated into fountains, sculpture, sheltering structures and lighting systems in landscaping projects M. Building design may incorporate PV sun shades or appear as shutters around multiple windows—or even be installed in the window itself! N. Blending this technology into traditional building and landscape design is one of the many challenges designers are involved in and presents new challenges for emergency responders in identifying PV technology when sizing-up an emergency O. Pre-fire planning residential and commercial buildings will help you identify where building integrated designs are located P. Roofs on residential building integrated PV systems are still fairly easy to identify by the shiny surface when compared to the rest of the roofing material that surrounds it	

PRESENTATION	APPLICATION
Q. ***Important Note:*** *Emergency responders can no longer assume that once the main electrical disconnect has been shut off that it will automatically ensure that all power to the building has been disconnected* 1. *The wiring and connections from the photovoltaic panel to the inverter are still energized and caution should be taken not to cut into these conductors*	
	Slide 17 – Summary
VIII. SUMMARY	
A. PV is used in a wide range of applications were electricity is needed; from simple and inexpensive appliances to high end satellites	
B. The future trend will be to integrate PV seamlessly and unobtrusively into buildings and building sites	
C. This trend will make PV system identification a little more challenging for emergency responders	