AGENDA

- INTRODUCTION
- CELLS AND COMPONENTS
- PV PERFORMANCE
- PV APPLICATIONS
- CODES AND STANDARDS
- EMERGENCY RESPONSE

"Give me the splendid silent sun with all its beams full-dazzling."
Walt Whitman, 1865

OBJECTIVE

To recall the principles of photovoltaics

To identify the components of a photovoltaic system

PV CELLS & COMPONENTS

SOLAR FACTS

One day of sunshine could supply all the world's energy for 4 to 5 years

The Sun's full intensity and brightness is 1,000 watts per meter squared (referred to as insolation)

This intensity can be diminished according to the micro climate and site specific conditions (shade)

PV CELLS & COMPONENTS

SOLAR FACTS

In the Northern Hemisphere, most photovoltaic systems are orientated towards true south to maximize the amount of light falling on the photovoltaic panels

Peak sun per day is about 5 hours, between 10 am and 3 pm (peak energy production)

PV CELLS & COMPONENTS

Anatomy of a Solar Cell

The solar cell is the smallest unit of the PV system

There are two types of manufactured PV's:

- Silicon cell or
- Amorphous silicon

PV cell has a thin layer of silicon 1/100th of an inch

Silicon is layered with other materials to create the photoelectric reaction

PV CELLS & COMPONENTS

Anatomy of a Solar Cell

Boron is used for the positive layer

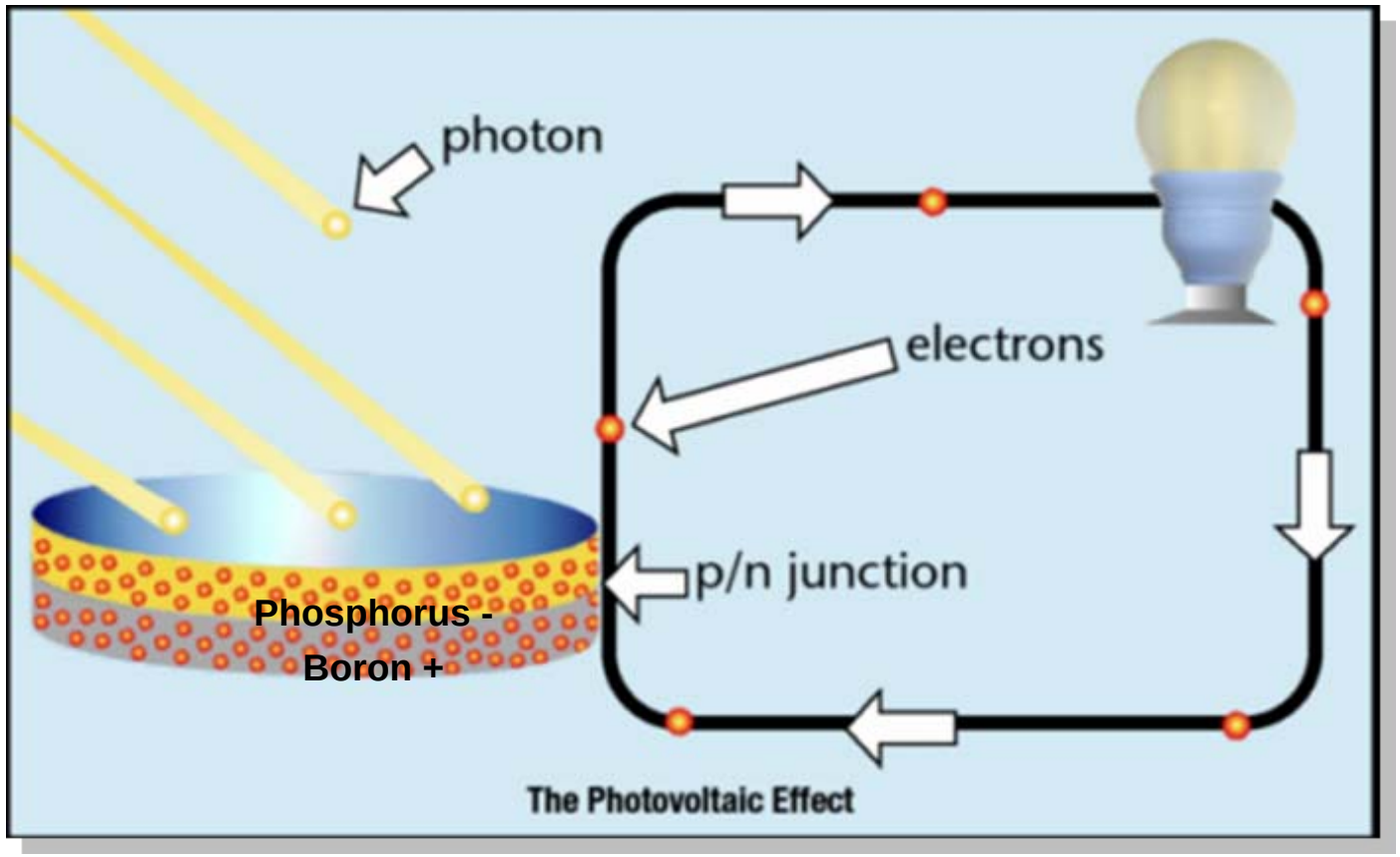
Phosphorus is used for the negative layer

Photons generated from the sun energize and knock loose the extra phosphorus electron which crosses the P/N junction to fill the hole on the boron atom

The energy released in the process produces .5 volt of direct current (DC)

PV CELLS & COMPONENTS

The Photovoltaic Effect



PV CELLS & COMPONENTS

MANUFACTURING PROCESSES

The purest silicon structure comes from the growth of a single crystal, monocrystalline, cut in to thin wafers

Multiple crystals cast together and sliced into thin wafers form polycrystalline structures

A chemical process that deposits silicon on a substrate material like glass or stainless steel as a thin film is referred to as amorphous

PV CELLS & COMPONENTS

MANUFACTURING PROCESSES

To improve PV efficiency and reduce cost, the industry is using materials such as cadmium telluride and gallium arsenide

Toxic and hazardous chemicals are used in the PV manufacturing process

When a module is exposed to fire or an explosion, trace chemicals can be released into the atmosphere

PV CELLS & COMPONENTS

Monocrystalline

Modules have output capacities of 14 to 15%

Monocrystalline achieves the highest efficiency in electric energy production

Its production cost is higher than other silicon types

PV CELLS & COMPONENTS

Polycrystalline

Pure molten silicon is cast into molds, then sliced into wafers, doped and assembled

Installation of polycrystalline modules on a rack system.

Polycrystalline is lower in conversion efficiency compared to Monocrystalline, averaging about 12 to 14% output capacity

PV CELLS & COMPONENTS

Amorphous

Made by vaporizing silicon and depositing it on a glass, steel or flexible surface

Some are flexible and are able to be rolled and used for remote electricity generation

The flexibility of amorphous technology allows it to be used in a wider range of applications

PV CELLS & COMPONENTS

A semitransparent amorphous silicon product used as a gas station canopy in Fairfield, California

Top - looking down on the canopy

Bottom – looking up through the canopy

PV CELLS & COMPONENTS

Amorphous

Production costs less than other production techniques, but the output capacity, is reduced to 5 to 7%

A square foot of amorphous silicon averages about 5 watts, monocrystalline or polycrystalline average about 10 watts per square foot

PV CELLS & COMPONENTS

The Photovoltaic System Includes

Modules/Array (Tiles or Shingles)

Optional Batteries

Battery Controller

Inverter

Mounting Systems

PV CELLS & COMPONENTS

Photovoltaic Modules

PV cells connected in series and parallel – the voltage and amperage is accumulated to achieve the desired electrical output

Photovoltaic cells connected together form a PV module

Weather-proof electrical connections connect modules together

In rare occasions junction boxes can overheat and can lead to roof damage and potential fire

PV CELLS & COMPONENTS

Photovoltaic Modules

Modules have a variety of sizes and rated output, with the standard size module at 24-volts, consisting of 72 solar cells

An average size crystalline module weighs between 30 and 35 pounds

Photovoltaic panels have no moving parts and require little maintenance

PV CELLS & COMPONENTS

Photovoltaic Array

Two or more modules connected together form a photovoltaic array

Residential system outputs of 600 volts are not uncommon

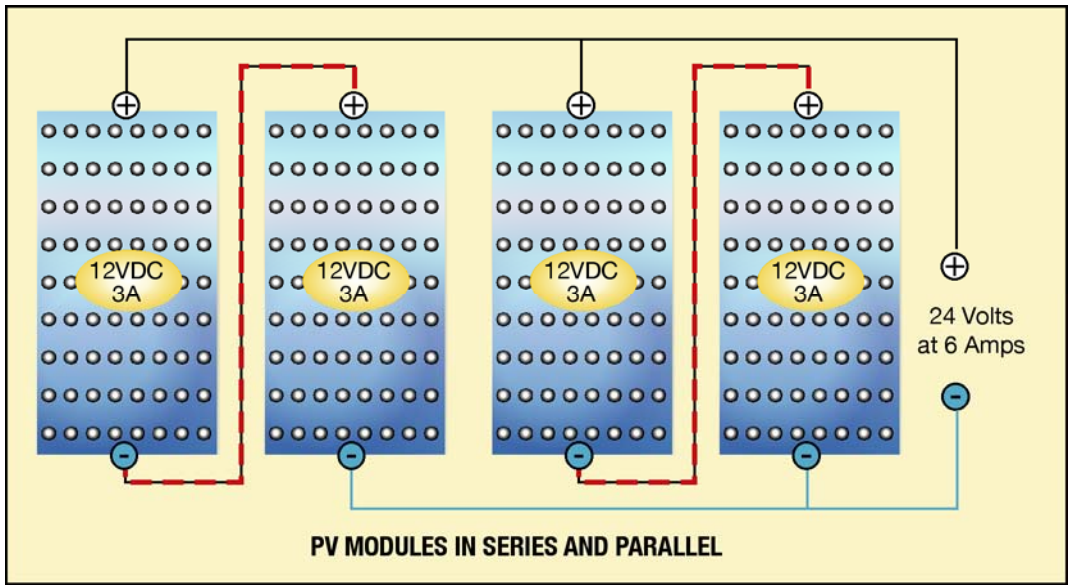
The average household in California uses about 6,500 kilowatt-hours per year

PV CELLS & COMPONENTS

Photovoltaic Array

The modules wired together in series to accumulate voltage, and the strings are wired together in parallel to Increase amperage, collectively they form the array

Array in Series and Parallel



PV MODULES IN SERIES AND PARALLEL

PV CELLS & COMPONENTS

Photovoltaic Array

A PV system in the 3 to 4 kilowatt range would meet most homeowner's electricity needs

A 30 module array would operate at over 4,000 watts and weigh approximately 900 to 1,050 pounds

This weight spread equally over a 420 square foot area of the roof would result in a roof weight load of 2.5 pounds per square foot

PV CELLS & COMPONENTS

Photovoltaic Tiles and Shingles

PV tiles or shingles can be integrated into the home's roof covering

It takes more time, wiring individual tiles or shingles together

PV tile or shingle roofing system is less obtrusive but costs more

In High Fire Hazard Severity Zones, roofing systems must meet Class A of Title 24 CCR

PV CELLS & COMPONENTS

Photovoltaic Tiles and Shingles

Some manufacturers of PV roofing tiles have tested their products and meet the standard for Class A roofing

Manufacturers of PV shingles have achieved a Class A rating by using a fire resistant underlayment beneath the PV shingles

PV CELLS & COMPONENTS

Batteries

Lead acid batteries are used
to store PV-generated electricity

Batteries are used in off-grid PV systems, although battery back-up can be used in grid-connected applications

Without batteries, a grid-tied PV system cannot provide PV electricity when the utility grid is not energized

PV CELLS & COMPONENTS

Batteries

Pinnacles National Monument in California installed a 9.6-kilowatt photovoltaic system. It eliminates the fuel bill for a diesel generator that produced 143 tons of carbon.

PV CELLS & COMPONENTS

Batteries

A battery is an electrochemical cell

The electrical potential between the positive and negative electrodes is about 2 volts direct current (DC)

The battery can off-gas oxygen from the positive electrode and hydrogen from the negative electrode

Escaping gases are highly flammable, sparks and open flames are not allowed near the batteries

PV CELLS & COMPONENTS

Batteries

Like the PV modules, batteries are wired in series and parallel to provide the voltage and amperage necessary for the operation of the electrical system

PV CELLS & COMPONENTS

Battery Charge Controllers

To keep battery charge levels in check, a charge controller is used in the PV system

The battery charge controller prevents over charging reducing the danger of off-gassing

Many controllers also protect the battery from over-discharges as well

PV CELLS & COMPONENTS

Battery Charge Controllers

Battery charge controllers are found in off-grid systems and grid-tied systems that have a battery back-up.

PV CELLS & COMPONENTS

PV Inverters

The PV array, batteries and charge controllers all function on direct current (dc)

Most household appliances run on alternating current (ac)

The inverter changes the direct current to alternating current at 60 hz

PV CELLS & COMPONENTS

PV Inverter

This sine wave inverter is used on a grid-tied system.

A look inside an inverter during the installation process.

PV CELLS & COMPONENTS

PV Inverters

There are three types of inverters; square wave, modified square wave and sine wave

Sine wave inverters produce a high quality waveform used to operate sensitive electrical equipment

Sine wave inverters are required for grid-tied PV systems

Grid-tied inverters are designed to shut down when there is no grid power

PV CELLS & COMPONENTS

Mounting Systems

PV modules can be mounted directly on the roof, in many cases specialized roof racks lift the array from the roof deck allowing air to circulate under the modules.

Many PV systems are designed to withstand 80 mile per hour winds.

PV CELLS & COMPONENTS

Mounting Systems

PV systems can also be mounted on the ground using customized racks, or they can be mounted on poles.

PV CELLS & COMPONENTS

Other Solar Technologies

Two solar hot water panels are on the left of this roof and 44 modules of this 7 kw PV array on the right of this 3,000 sq. ft. home. The system is backed-up with a generator.

Solar thermal panels (solar water heating collectors) are used to heat water for the swimming pool or for domestic hot water

The long rectangular panel at the bottom of this array is a solar water heating panel.

PV CELLS & COMPONENTS

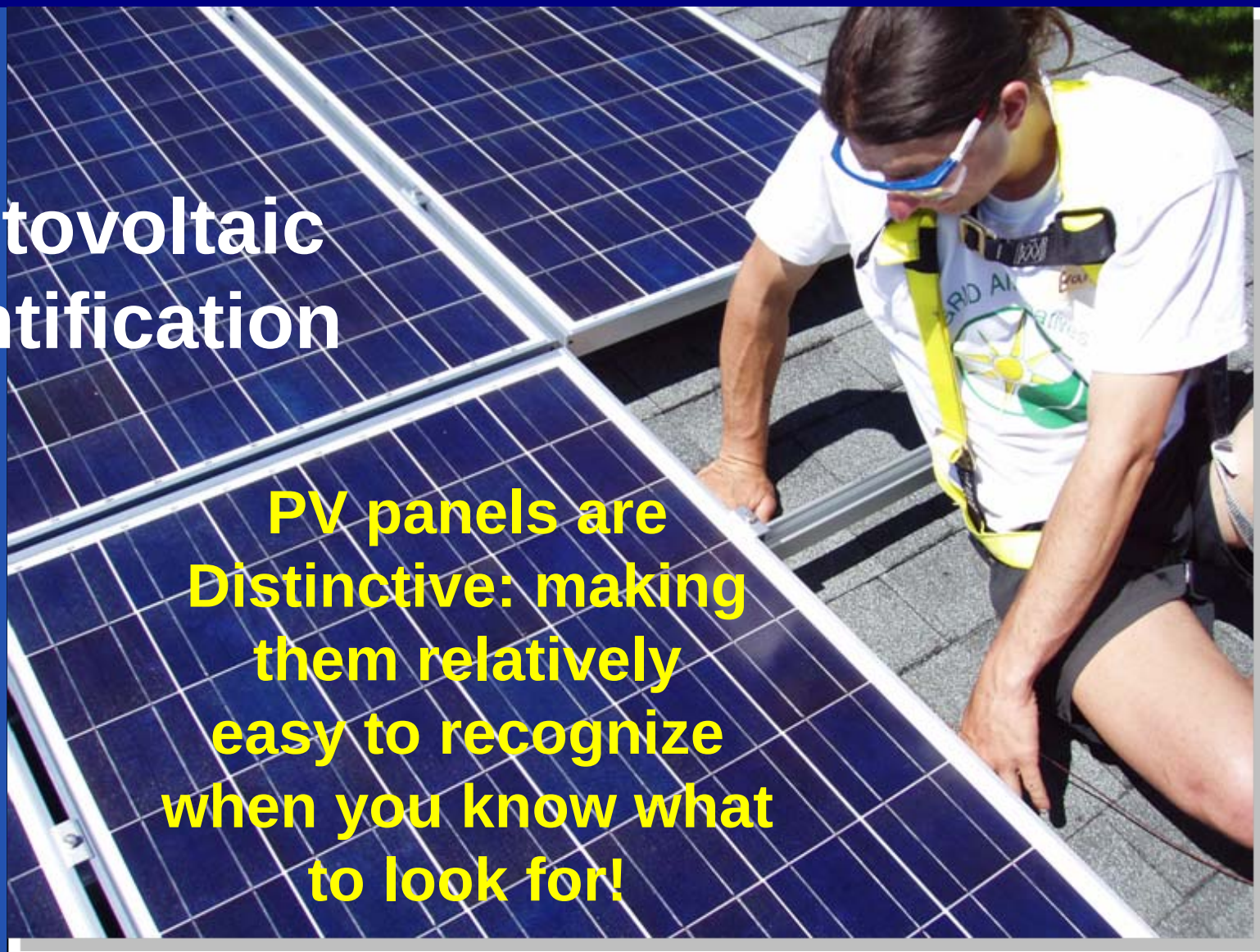
Other Solar Technologies

Skylights are a function of passive solar design, allowing natural light to enter the interior of the building

A skylight with integrated photovoltaic will have a distinctive amorphous rectangular pattern in the glass

PV CELLS & COMPONENTS

Photovoltaic Identification



SUMMARY

The greatest danger for emergency responders is the lack of PV knowledge needed to safely operate around this emerging technology

This section provided you with an introduction to the photovoltaic system

Identification of the PV array and all the related components is critical in an emergency response