



**ENERGY STORAGE  
SYSTEMS**  
SAFETY TRAINING PROGRAM

# **PHOTOVOLTAIC & BATTERY ENERGY STORAGE SYSTEMS SAFETY TRAINING**

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## **PHOTOVOLTAIC SYSTEMS (PV)**

## Program Goal

### **Prepare first responders to:**

- Properly identify the presence of PV and battery energy storage systems
- Understand the different types of battery chemistries used and their related hazards
- Identify and implement proper response procedures based on the type of incident

# Program Modules

BESS Safety Training for First Responders



**Introduction**



**Basic Electrical Theory**



**PV (Solar)**



**Battery Energy Storage Systems (BESS)**



**Pre-Incident Planning**



**Emergency Response Operations**

# Photovoltaic Systems

## OBJECTIVES

**Following instruction, the student shall be able to:**

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- Identify three (3) components of a PV system.
- List two (2) locations for installations
- Describe three (3) different disconnect switch types
- Identify the two (2) most common types of PV faults

# System Locations – Residential

## Photovoltaic Systems

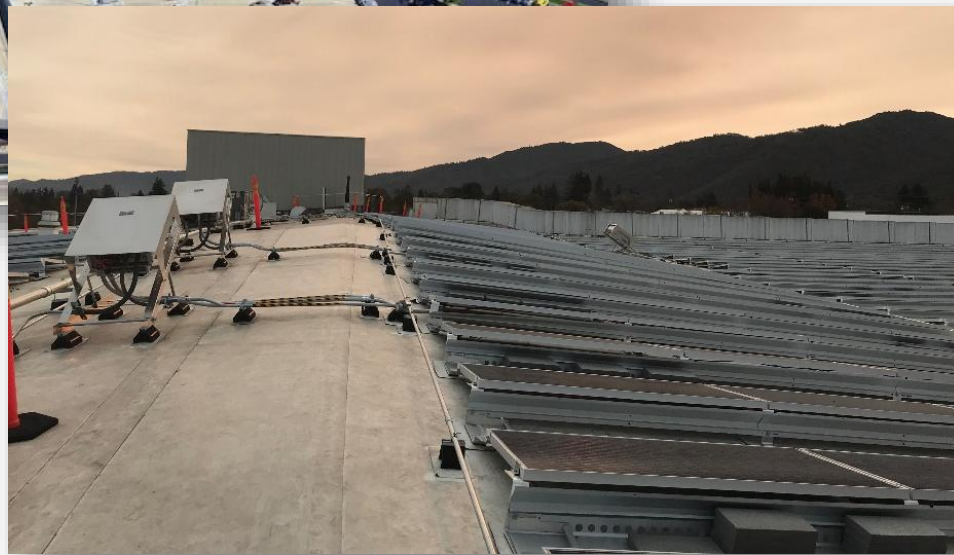


- Most often on south side of roof and may not be visible from street
- Systems may or may not have ESS
- Voltages up to 600 V
- 3 kW – 15 kW size ranges



# System Locations – Rooftop Commercial

## Photovoltaic Systems



- Often flat roof, system may not be visible
- Covering large portions of roof
- Up to 1,000 Vdc
- Disconnect locations may be confusing.
- 50 kW – 2 MW sizes

# System Locations – Covered Parking

## Photovoltaic Systems



- May be as low as 9 feet
- Car fires may damage components
- Disconnect locations may be remote or local
- Up to 1,000 Vdc

# System Locations – Utility Scale

## Photovoltaic Systems

- Large fenced facilities
- Treat as power plant
- Farms, landfills, brownfields
- Up to 1,500 Vdc and 35,000 Vac
- 1-500 MW sizes



# System Components

Photovoltaic Systems

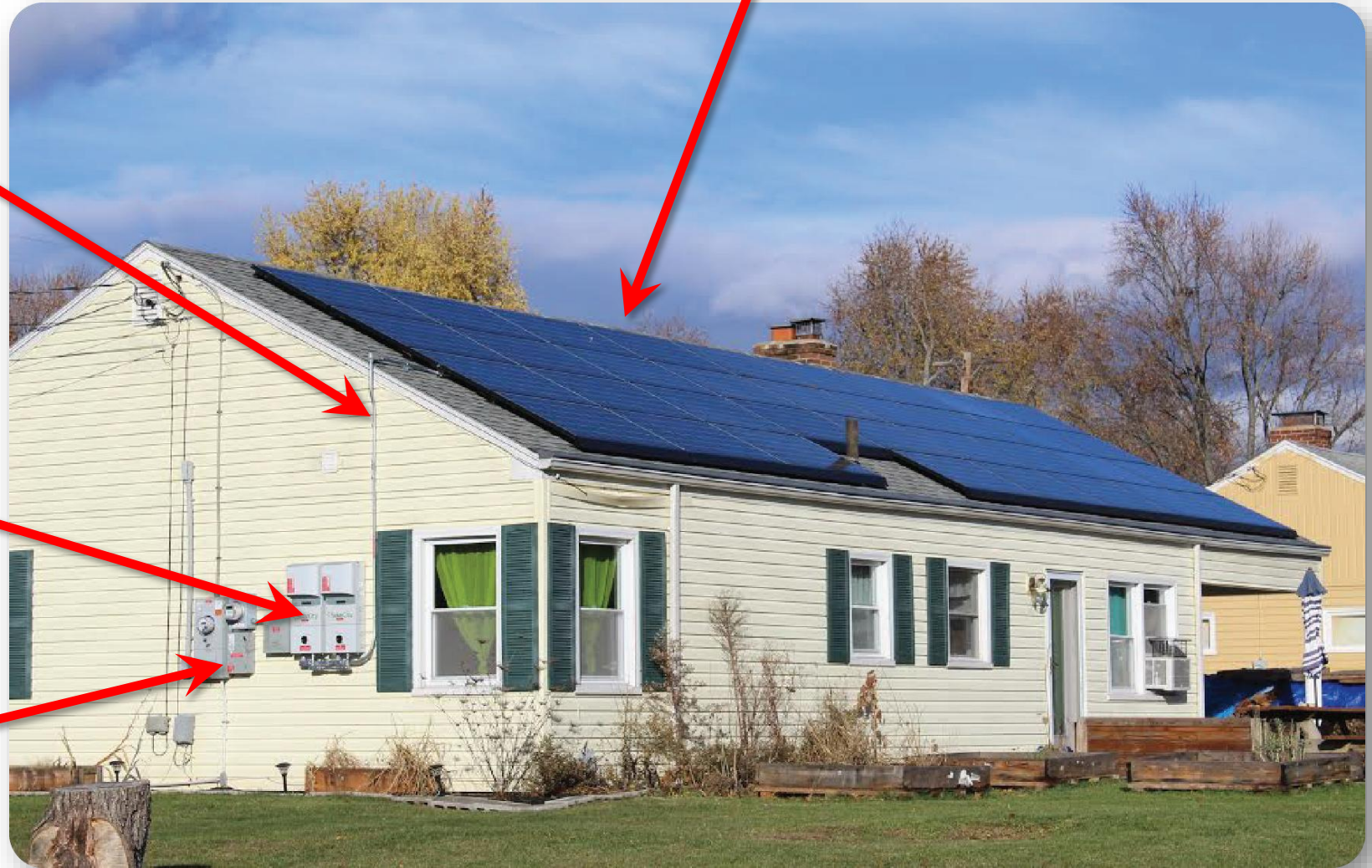
Modules

Conduit

Disconnects

Inverters

Marking & Labeling



# System Components

## Photovoltaic Systems

### PV Modules

- Rack mounted
- BIPV (Building integrated)



- Does not store power
- Turns light into electricity
- Typically, 20-40 Vdc
- BIPV may be hard to identify
- Snow will challenge roof operations

# System Components

Photovoltaic Systems

## Inverters

- Changes DC into AC (and reverse to charge batteries)
- Shut off to stop flow of AC power into building
- Microinverters shut down at module level (safer)

## Three Types:

**Microinverter**



**Central**

**String**



# System Components

Photovoltaic Systems

## Disconnects

- Main breaker
- PV system disconnect
- Rapid shutdown switch



# System Components

## Photovoltaic Systems

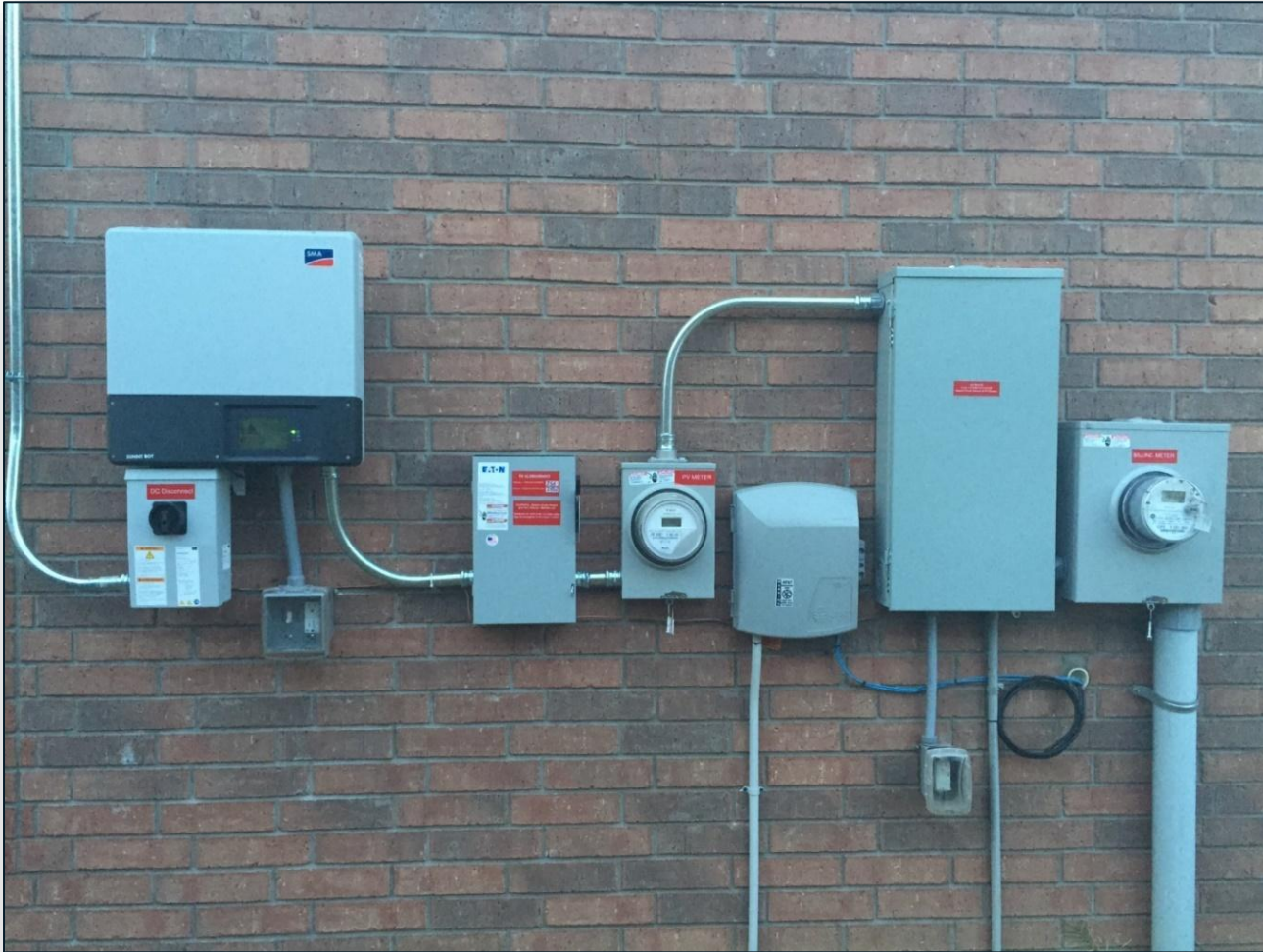
### Conduit

- Metal or PVC
- Protect wire
- Provides path to ground if wires damaged (metal conduit)



# System Components

## Photovoltaic Systems



## Marking & Labeling

- Dependent on code cycle
- May or may not be present
- Used to identify system presence and locate disconnects
- May be confusing with many labels

# PV Failure Modes

Photovoltaic Systems

## Ground Fault (GFDI)



- An energized wire touches a grounded component (wire or metal framing)
- Typically lead to shock but can result in fire



Fire caused by arc fault at loose connector



## Arc Fault (AFDI)

- A wire breaks or separates at a connector
- Results in a fire

# Hazards – Electrical Shock

Photovoltaic Systems

## PV Voltage

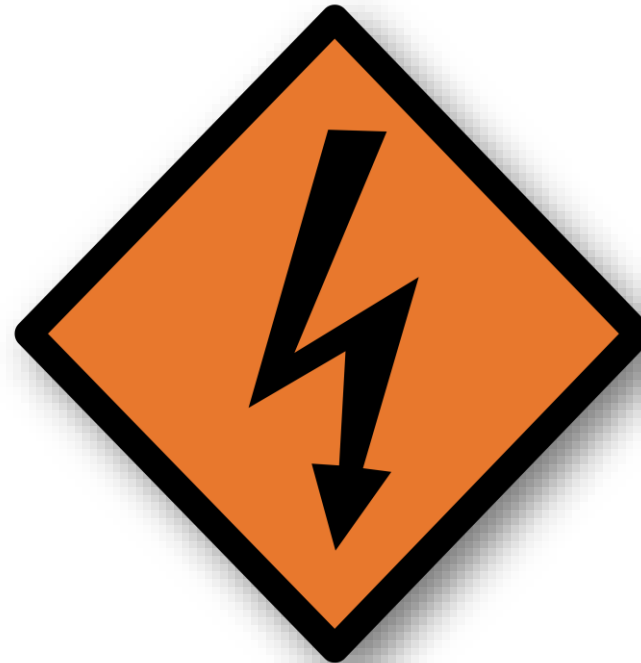
### Commercial

- Up to 1,000 Vdc



### Residential

- Up to 600 Vdc



These voltages can exist after utilities are shutdown

# Review

## Photovoltaic Systems



**Where are PV systems installed?**



**How can you identify a PV system is present?**



**What are the three (3) types of inverters?**

# Review

## Photovoltaic Systems



**What should you shut off to make a building safe?**



**What are the two types of PV failure modes?**