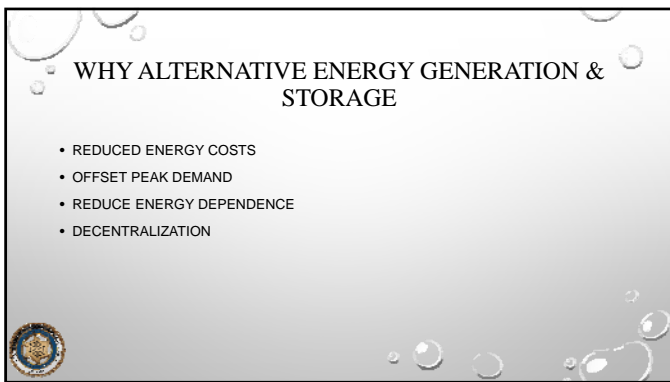
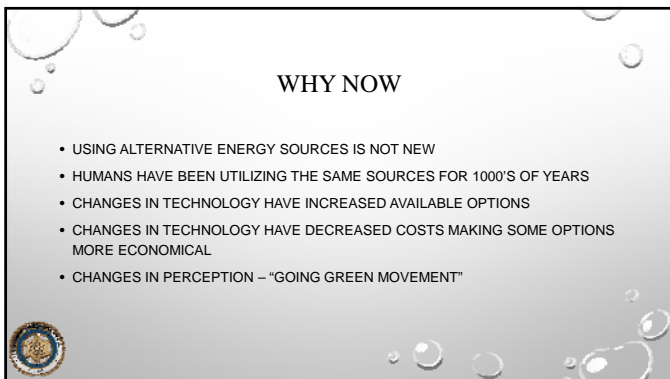


SOLAR ENERGY SYSTEMS, HAZARD RECOGNITION & MITIGATION



WHY ALTERNATIVE ENERGY GENERATION & STORAGE

- REDUCED ENERGY COSTS
- OFFSET PEAK DEMAND
- REDUCE ENERGY DEPENDENCE
- DECENTRALIZATION




WHY NOW

- USING ALTERNATIVE ENERGY SOURCES IS NOT NEW
- HUMANS HAVE BEEN UTILIZING THE SAME SOURCES FOR 1000'S OF YEARS
- CHANGES IN TECHNOLOGY HAVE INCREASED AVAILABLE OPTIONS
- CHANGES IN TECHNOLOGY HAVE DECREASED COSTS MAKING SOME OPTIONS MORE ECONOMICAL
- CHANGES IN PERCEPTION – "GOING GREEN MOVEMENT"


WHY DOES THE FIRE SERVICE CARE?

- CAN BE THE SOURCE OF FIRES
- CAN HURT OR KILL US




TYPES OF ALTERNATIVE ENERGY

- MECHANICAL
- THERMAL
- ELECTRICAL
- CHEMICAL






MECHANICAL ENERGY




COMMON SOURCES

- WIND – WINDMILL OPERATES A PUMP TO MOVE WATER ON A FARM
- WATER – A WATER WHEEL TURNS ROTATING A SHAFT THAT POWERS EQUIPMENT DIRECTLY OR THROUGH A SERIES OF BELTS AND PULLEYS




STORAGE OPTIONS

- DIFFICULT TO STORE
- NOT VERY PRACTICAL
- FLYWHEEL SYSTEMS



THERMAL ENERGY






COMMON SOURCES

- COMBUSTION – FURNACE
- SOLAR – RADIANT HEAT OF THE SUN




STORAGE OPTIONS

- OBJECTS WITH MASS – CONCRETE/MASONRY WALLS (TROMBE WALL) AND FLOORS
- FLUID TANKS



ELECTRICAL ENERGY



COMMON SOURCES

- GENERATOR
- WIND
- SOLAR - PHOTOVOLTAIC







STORAGE OPTIONS

- BATTERIES
- ELECTRICAL GRID






CHEMICAL ENERGY




COMMON SOURCES

- BATTERIES
 - DRY CELL – ELECTROLYTE PASTE
 - WET CELL – LIQUID ELECTROLYTE



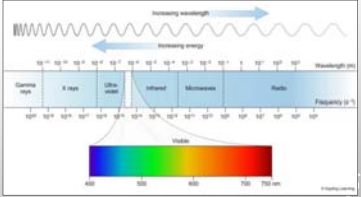
SOLAR ENERGY BASICS



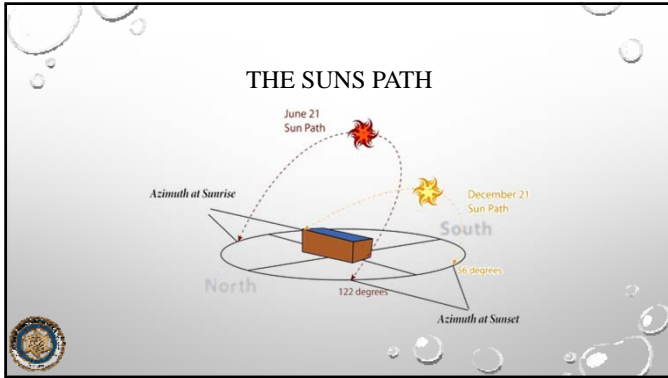
WHAT IS SOLAR ENERGY

ELECTROMAGNETIC RADIATION

- RADIANT HEAT
- VISIBLE LIGHT



The diagram illustrates the electromagnetic spectrum with wavelength in meters (m) on the top axis and frequency in Hz on the bottom axis. It is divided into regions: Gamma rays, X-rays, Ultraviolet, Infrared, Microwaves, and Radio. A visible light spectrum is shown below, with colors ranging from violet (400 nm) to red (700 nm). Arrows indicate that wavelength increases to the right and energy increases to the left.



THE SUN'S ENERGY

- THE MOST INTENSE RAYS OF THE SUN ARE EXPERIENCED BETWEEN 9 AM AND 3 PM
- SURFACES PERPENDICULAR TO THE SUN'S RAYS EXPERIENCE THE MOST ENERGY
- ORIENTATIONS OF SOUTH TO SOUTHWEST ARE MOST EFFICIENT FOR HARVESTING THE SUN'S ENERGY

A small circular logo is in the bottom-left corner.

SYSTEM CLASSIFICATION

SYSTEMS ARE CLASSIFIED BASED ON HOW THEY CAPTURE, CONVERT, DISTRIBUTE, AND USE THE SUNS ENERGY

- PASSIVE – THE SUN'S ENERGY IS CAPTURED, AND DISTRIBUTED BY NATURAL METHODS WITHOUT GATHERING OR TRANSFORMATION THROUGH MECHANICAL, ELECTRICAL, OR ELECTRONIC MEANS
- ACTIVE – USES MECHANICAL, ELECTRICAL, OR ELECTRONIC MEANS TO CAPTURE AND REDISTRIBUTE THE SUN'S ENERGY

A small circular logo is in the bottom-left corner.

PASSIVE SOLAR

- SKYLIGHTS/SUN TUNNELS
- WATER COLUMNS
- TROMBE WALLS
- MASS ELEMENTS (FLOORS/WALLS)
- ARCHITECTURAL CONFIGURATIONS
 - GLAZING
 - BUILDING ORIENTATION
 - BUILDING SHADING






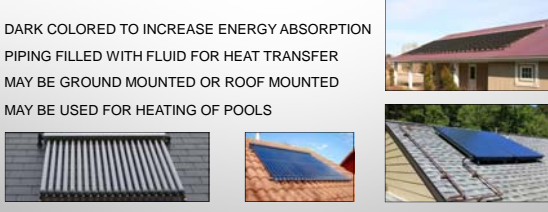
ACTIVE SOLAR

- HYDRONIC SOLAR PANELS
 - CONVERT ELECTROMAGNETIC ENERGY TO HEAT
 - UTILIZES A FLUID FOR HEAT TRANSFER
- PHOTOVOLTAIC SOLAR PANELS
 - CONVERTS ELECTROMAGNETIC ENERGY TO ELECTRICITY




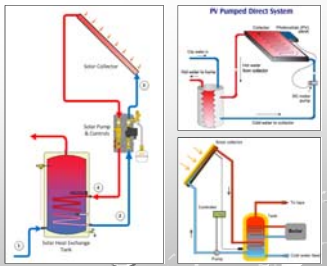
HYDRONIC SOLAR PANELS

- DARK COLORED TO INCREASE ENERGY ABSORPTION
- PIPING FILLED WITH FLUID FOR HEAT TRANSFER
- MAY BE GROUND MOUNTED OR ROOF MOUNTED
- MAY BE USED FOR HEATING OF POOLS



HYDRONIC SOLAR PANELS


- MAY INCLUDE HEAT STORAGE
- MAY INCLUDE PUMPS PLACING FLUIDS UNDER PRESSURE
- MAY HAVE HIGH TEMPERATURE FLUIDS



HYDRONIC SOLAR PANELS

DANGERS

- INCREASED ROOF LOADS
- SNOW ACCUMULATION
- SLIP TRIP AND FALL HAZARDS
- INCREASED BUILDING WEIGHTS FOR STORAGE SYSTEMS
- FLUID FOR HEAT TRANSFER MUST RESIST FREEZING
 - SALT WATER
 - PROPYLENE GLYCOL
 - ETHYLENE GLYCOL – FLAMMABLE IN CERTAIN CONCENTRATIONS, ENVIRONMENTAL HAZARD

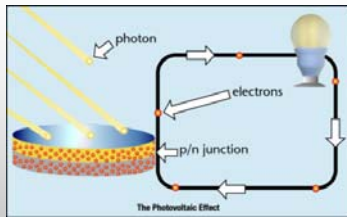


PHOTOVOLTAIC PANELS

- HAVE BEEN USED SINCE 1958
- A RESULT OF THE SPACE RACE
- DARK COLORED TO INCREASE ENERGY ABSORPTION
- USES THE PHOTOVOLTAIC EFFECT TO CONVERT LIGHT TO ELECTRICITY
- **ANY** VISIBLE LIGHT WILL CONVERT TO ELECTRICITY
- AS THE INTENSITY INCREASES THE OUTPUT INCREASES LINEARLY



PHOTOVOLTAIC EFFECT




PHOTOVOLTAIC PANELS


- MAY BE BUILDING MOUNTED
- MAY BE GROUND MOUNTED
- MAY BE STATIONARY
- MAY BE SUN TRACKING
- MAY BE INTEGRATED INTO OTHER BUILDING SYSTEMS




PHOTOVOLTAIC PANELS




The first image shows solar panels mounted on the deck of a ship. The second image shows solar panels on a modern building. The third image shows solar panels on a house in a rural setting.



PHOTOVOLTAIC PANELS




The first image is an aerial view of a large building with a significant portion of its roof covered in solar panels. The second image shows solar panels on a brick house.




PHOTOVOLTAIC PANELS

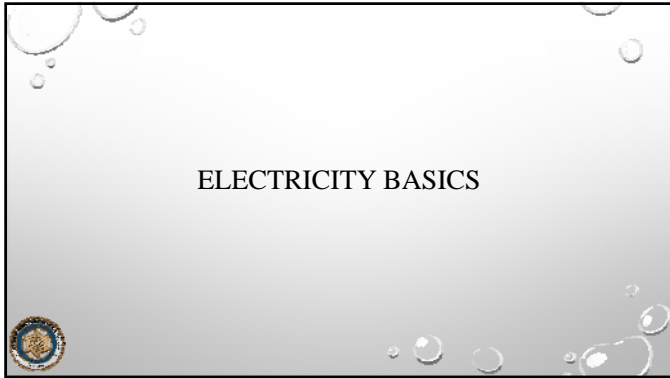
DANGERS

- INCREASED ROOF LOADS
- SNOW ACCUMULATION
- SLIP TRIP AND FALL HAZARDS
- ELECTRICAL HAZARDS

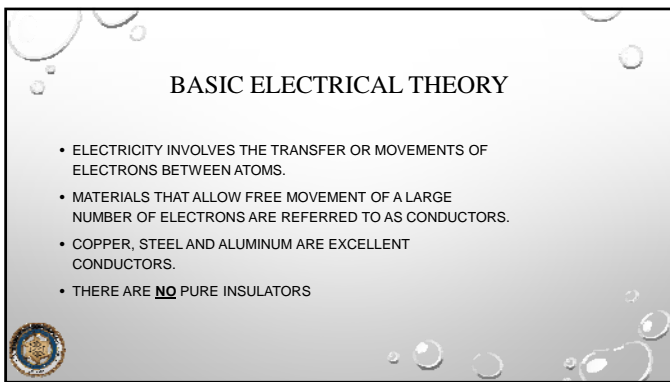


The image shows a close-up of solar panels on a roof that is heavily covered with snow, illustrating the hazard of snow accumulation.



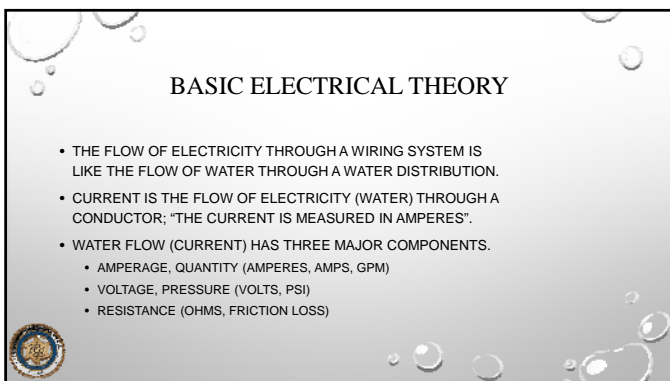


ELECTRICITY BASICS



BASIC ELECTRICAL THEORY

- ELECTRICITY INVOLVES THE TRANSFER OR MOVEMENTS OF ELECTRONS BETWEEN ATOMS.
- MATERIALS THAT ALLOW FREE MOVEMENT OF A LARGE NUMBER OF ELECTRONS ARE REFERRED TO AS CONDUCTORS.
- COPPER, STEEL AND ALUMINUM ARE EXCELLENT CONDUCTORS.
- THERE ARE **NO** PURE INSULATORS




BASIC ELECTRICAL THEORY

- THE FLOW OF ELECTRICITY THROUGH A WIRING SYSTEM IS LIKE THE FLOW OF WATER THROUGH A WATER DISTRIBUTION.
- CURRENT IS THE FLOW OF ELECTRICITY (WATER) THROUGH A CONDUCTOR; "THE CURRENT IS MEASURED IN AMPERES".
- WATER FLOW (CURRENT) HAS THREE MAJOR COMPONENTS.
 - AMPERAGE, QUANTITY (AMPERES, AMPS, GPM)
 - VOLTAGE, PRESSURE (VOLTS, PSI)
 - RESISTANCE (OHMS, FRICTION LOSS)


BASIC ELECTRICAL THEORY

- THE AMOUNT OF RESISTANCE WILL VARY DEPENDING ON THE QUALITY OF THE CONDUCTOR AND IF A CIRCUIT OR SWITCH IS OPEN.
- IF A CIRCUIT OR SWITCH IS OPENED, THE RESISTANCE IS INFINITE, AND NO CURRENT CAN FLOW, JUST AS IF A VALVE IN A WATER SYSTEM WERE CLOSED.




BASIC ELECTRICAL THEORY

- DIRECT CURRENT
 - CHARGE FLOWS IN A SINGLE DIRECTION
 - LARGE TRANSMISSION LOSSES
 - REQUIRES LARGE TRANSMISSION LINES DUE TO LOSSES
 - TYPICAL USES: AUTOMOBILES, CELL PHONES, BATTERIES
- ALTERNATING CURRENT
 - CHARGE ALTERNATES DIRECTION REGULARLY
 - RELATIVELY LOW TRANSMISSION LOSSES AT HIGH VOLTAGES
 - TYPICAL USES: HOUSEHOLD APPLIANCES, MOTORS




BASIC ELECTRICAL THEORY

- A GENERAL RESIDENTIAL PV SYSTEM IS IN THE 10 AMP RANGE, WITH 600 VOLTS DC.
- **REMEMBER, IT IS THE ELECTRICAL CURRENT THAT IS DANGEROUS, NOT THE ELECTRICAL SYSTEM.**



DAMAGE FROM ELECTRICAL CONTACT


Amount of Current	Area of Contact
Path of Current	Pressure of Contact
Length of Time	Clothing & Jewelry
Body Size & Shape	



ELECTRICAL SHOCK


THERE ARE SEVERAL 'PERCEPTION' LEVELS THAT A FIRST RESPONDER MAY EXPERIENCE WHEN DEALING WITH ANY ELECTRICAL EQUIPMENT THEY MAY HAVE CURRENT RUNNING THROUGH IT AND THUS CONSIDERED 'ENERGIZED' OR 'LIVE.'

- **STARTLE REACTION LOW:** THIS TERM DESCRIBES THE SENSATION EXPERIENCED WHEN TOUCHING ENERGIZED EQUIPMENT THAT HAS A LOW VOLTAGE CURRENT RUNNING THROUGH IT. THE SENSATION IS TYPICALLY DESCRIBED USING THE TERMS 'BUZZ' OR 'TINGLE.'
- **STARTLE REACTION HIGH:** THIS TERM DESCRIBES THE INTERMEDIATE SENSATION EXPERIENCED WHEN YOU COME IN CONTACT WITH ENERGIZED ELECTRICAL EQUIPMENT. THE SENSATION WILL CAUSE A MORE INTERMEDIATE DEGREE OF 'DISCOMFORT' TO THE FIREFIGHTER - SO MUCH SO THAT IN SOME CASES IT MAY BE DEBILITATING TO HIM OR HER.
- **LOCKON:** THIS TERM DESCRIBES HUMAN CONTACT WITH ENERGIZED EQUIPMENT THAT CAUSES THE VICTIM TO NOT BE ABLE TO 'PULL AWAY' FROM THE EQUIPMENT ON HIS OR HER OWN.




ELECTRICAL SHOCK

- AN ELECTRICAL SHOCK INVOLVING HIGH VOLTAGE (PRESSURE) BUT VERY LOW CURRENT (AMPS) WOULD BE LESS DANGEROUS THEM LOW VOLTAGE (PRESSURE) AND HIGH CURRENT (AMPS).
- THE CURRENT (AMPERAGE) REQUIRED TO LIGHT A 7 1/2 WATT, 120 VOLT LAMP, IF PASSED ACROSS THE CHEST, IS ENOUGH TO CAUSE A FATALITY.




ELECTRICAL SHOCK

AMP	Physiological Effect
6-30mA	Painful shock, muscle control is lost. This is called the freezing current or let go range.
50-150mA	Extreme pain, respiratory arrest, and severe muscular contractions, individual cannot let go. Death is possible.
1 to 4 amps	Ventricular fibrillation, muscular contraction, and nerve damage occur. Death is likely.
10 amps	Cardiac arrest, severe burns, and probable death.




ELECTRICAL SHOCK

- CAN TRIGGER A FALL FROM A ROOF
- CAN KILL



ELECTRICAL SHOCK

- ALTHOUGH CURRENT (AMPERAGE) IS WHAT CAUSES DAMAGE TO A PERSON'S BODY, THE VOLTAGE IS WHAT DRIVES THAT CURRENT THROUGH THE BODY.
- THE HIGHER THE VOLTAGE, THE HIGHER THE AMOUNT OF CURRENT IS FORCED THROUGH THE BODY IN AN ELECTRICAL SHOCK
- THE SIMPLE RULE IS THAT IF IT IS POSSIBLE TO SEE OUTDOORS EASILY WITHOUT THE NEED FOR ARTIFICIAL LIGHT, THEN THE PV ARRAY IS GENERATING DANGEROUS VOLTAGE.



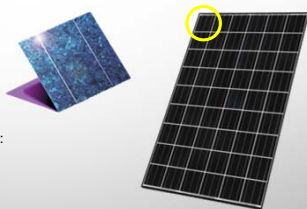
SERIES AND PARALLEL CONNECTIONS

- SOURCES CONNECTED IN SERIES INCREASE VOLTAGE (VOLTS) (CONSTANT CURRENT)
- SOURCES CONNECTED IN PARALLEL INCREASE CURRENT (AMPS) (CONSTANT VOLTAGE)

PHOTOVOLTAICS

SOLAR CELL

- THE SMALLEST UNIT AND THE FOUNDATION OF THE PV SYSTEM.
- EACH CELL GENERATES APPROXIMATELY 0.5 VOLTS
- TWO COMMON TYPES OF PV CELLS:
 - SILICON
 - AMORPHOUS SILICON





AMORPHOUS SILICON

A CHEMICAL PROCESS THAT DEPOSITS SILICON ON A HARD BACKING LIKE GLASS OR STAINLESS STEEL AS A THIN FILM.




PHOTOVOLTAIC MODULE

- SOLAR CELLS ARE ENCAPSULATED TOGETHER WITHIN AN ANTI-REFLECTIVE GLASS AND A PLASTIC BACK COVER.
- A COMMON SIZE IS 3'X5' AND CONTAINS 50 - 70 CELLS
- GOAL IS TO CREATE A CONSTANT OUTPUT
 - CELLS ARE CONNECTED TOGETHER IN SERIES TO ACHIEVE THE DESIRED VOLTAGE
 - STRINGS OF CELLS AT CONSTANT VOLTAGE ARE CONNECTED IN PARALLEL TO ACHIEVE THE DESIRED CURRENT



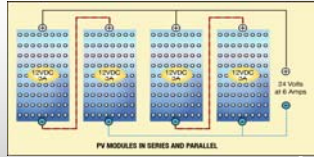
PHOTOVOLTAIC MODULE

- PV MODULES COME IN THREE BASIC TYPES:
 - ALUMINUM FRAMED GLASS ON POLYMER
 - BUILDING INTEGRATED (BIPV) SHINGLES
 - FLEXIBLE LAMINATE ADHERED TO THE BUILDING'S SURFACE
- WEATHER-PROOF ELECTRICAL CONNECTIONS ARE MOUNTED ON THE BACK OF THE MODULE.
- MODULES COME IN A VARIETY OF SIZES AND RATED OUTPUTS.



PHOTOVOLTAIC ARRAY

- SIMILAR TO THE MODULE FORMATION, MODULES ARE CONNECTED IN SERIES TO ACHIEVE A DESIRED CONSTANT SYSTEM VOLTAGE (STRINGS)
- STRINGS ARE CONNECTED IN SERIES TO INCREASE CURRENT
- CURRENT WILL VARY WITH LIGHT INTENSITY



PHOTOVOLTAIC INVERTER

- SYSTEM INVERTERS: RECEIVE CURRENT AND VOLTAGE FROM ARRAY.
- CAN BE LOCATED ON THE ROOF NEAR THE ARRAY, ON AN EXTERIOR WALL, OR INSIDE THE BUILDING.
- INVERTERS CONTAIN CAPACITORS WHICH STORE ENERGY. ONCE DE-ENERGIZED, THE CAPACITORS BEGIN TO DISCHARGE THEIR STORED ENERGY.
- HOWEVER, THEY MAY BE CAPABLE OF ELECTRIC SHOCK UNTIL THEIR VOLTAGE HAS DIMINISHED.

PHOTOVOLTAIC INVERTER

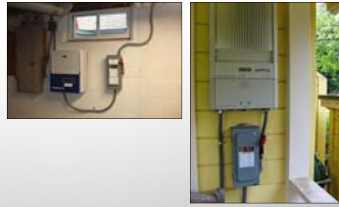
- CONVERTS POWER GENERATED BY THE PV ARRAY FROM (DC) TO (AC) FOR USE IN THE BUILDING
- WILL SHUT DOWN IF UTILITY POWER IS LOST (CAUTION THIS CAN BE COMPROMISED AND SHOULD NOT BE RELIED ON) (MAY NOT BE ON ALL EQUIPMENT BASED ON DATE OF MANUFACTURE)



PHOTOVOLTAIC INVERTER

THREE TYPES OF CONVERTERS:

- MICRO INVERTER
- SYSTEM(STRING) INVERTER
- CENTRAL INVERTERS.



PHOTOVOLTAIC INVERTER

MICRO-INVERTERS:

A SINGLE INVERTER THAT IS NEXT TO OR BUILT INTO THE INDIVIDUAL PV MODULES. THE MICRO-INVERTER CONVERTS THE DC POWER AT THE MODULE RATHER THAN AT A SINGLE LARGE INVERTER SERVING MANY MODULES.

SYSTEM/STRING INVERTERS:

THESE INVERTERS RECEIVE CURRENT AND VOLTAGE FROM MANY STRINGS OR ARRAYS. THIS TYPE OF INVERTER CAN BE LOCATED ON THE ROOF NEAR THE ARRAY OR INSIDE THE BUILDING IN A LOCATION SUCH AS A UTILITY ROOM.

CENTRAL INVERTERS:

THESE INVERTERS ARE SIMILAR TO SYSTEM/STRING INVERTERS BUT ARE USED IN A COMMERCIAL SETTING RATHER THAN RESIDENTIAL. ADDITIONALLY, IT IS TYPICAL FOR THERE TO BE MANY/NUMEROUS CENTRAL INVERTERS IN A COMMERCIAL PV SYSTEM.

DISCONNECTS

- DISCONNECT AND INVERTER LOCATIONS
- MAY BE AT THE BUILDING BEING SERVED OR, MAY BE AT THE ARRAY



DISCONNECTS



CAPACITORS

CAPACITORS IN INVERTERS CAN STORE POWER FOR 10 SECONDS TO 30 MINUTES AFTER SHUT DOWN



SYSTEM SHUTDOWN

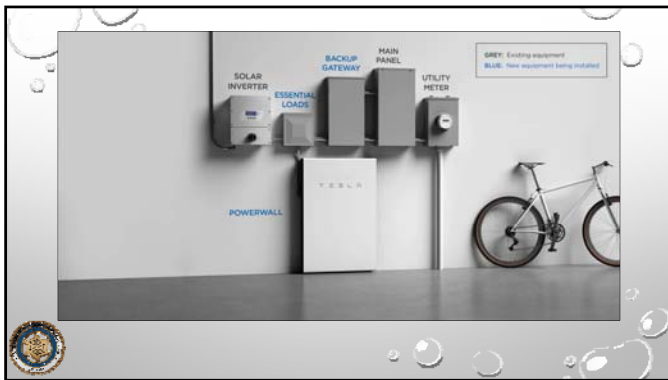
- ACCORDING TO UL® MERELY SHUTTING DOWN THE DC DISCONNECT DOES NOT DE-ENERGIZE THE DC SIDE OF THE PV SYSTEM. THE ARRAYS IN THEIR ENTIRETY HAVE TO BE COVERED IN ORDER TO INHIBIT ENERGY PRODUCING LIGHT FROM BEING COLLECTED BY THE PANELS.
- IT IS IMPORTANT TO NOTE THAT SHUTTING OFF THE INVERTER ONLY SHUTS OFF POWER TO WHAT IT IS SUPPLYING, EITHER THE STRUCTURE OR THE POWER GRID.
- THE PANELS CONNECTED TO THE INVERTER WILL BE "LIVE" IF NATURAL SUNLIGHT OR OTHER LIGHTING IS PRESENT!

SYSTEM SHUTDOWN

PROPER SEQUENCE OF SHUTTING DOWN PV SYSTEM COMPONENTS:

1. SHUT DOWN AC DISCONNECT
2. SHUT DOWN MAIN BREAKER IN BREAKER BOX
3. SHUT DOWN ANY/ALL DC DISCONNECTS
4. ACTIVATE THE FRSS SWITCH – IF PRESENT
5. COVER THE ARRAY(S) WITH LIGHT INHIBITING TARPS
6. WAIT THE APPROPRIATE TIME FOR POWER BLEED DOWN

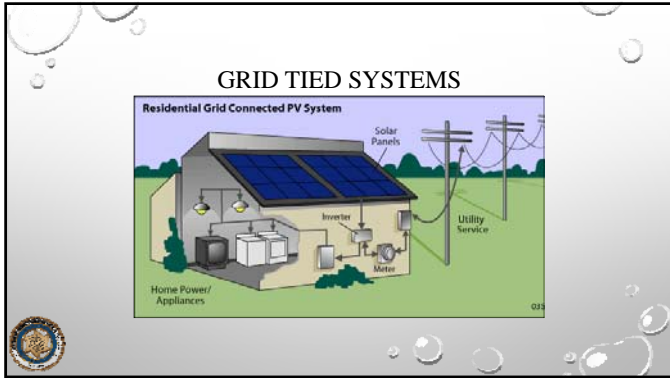


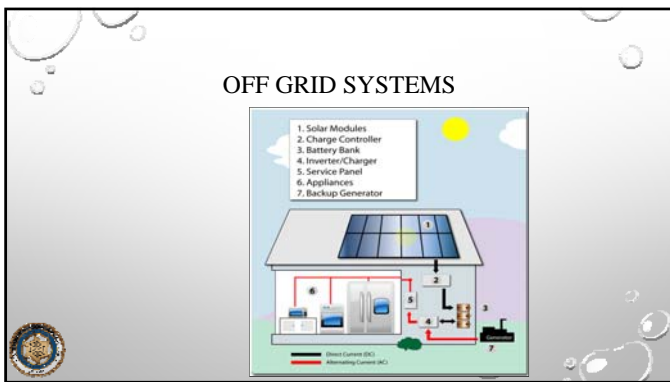


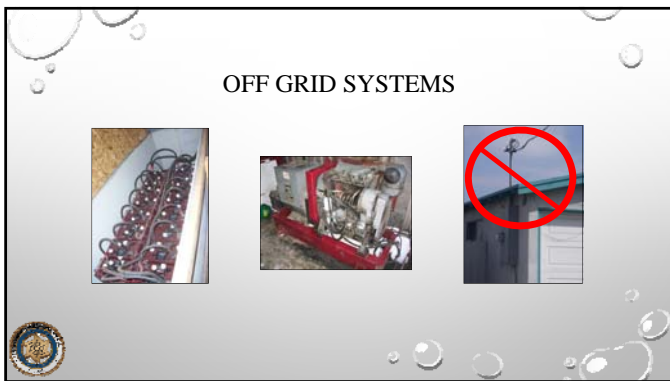
SYSTEM TYPES

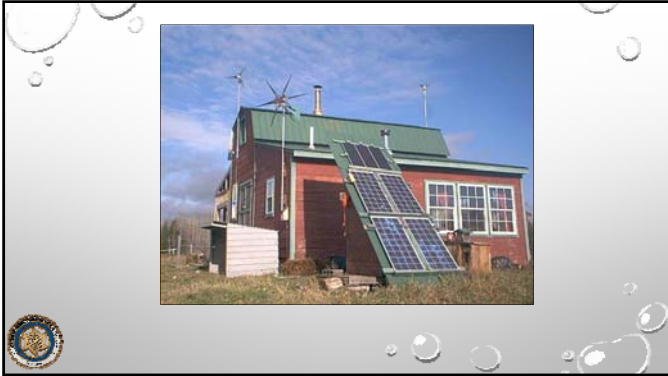
GRID VS. OFF GRID











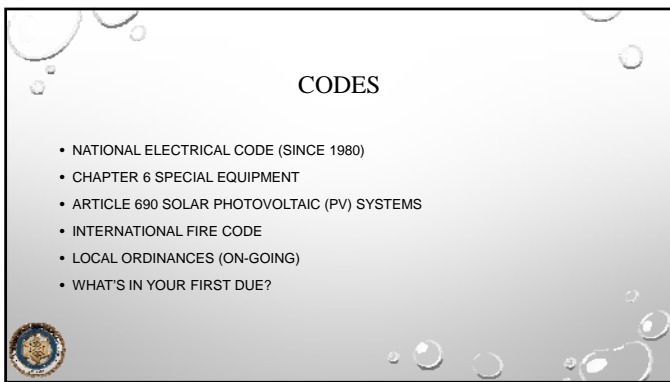
OFF GRID SYSTEMS

HardAccess SFI (Solar Plant 1) Simplified Wiring Diagram
Six 210watt Evergreen 60-210 PV Panels

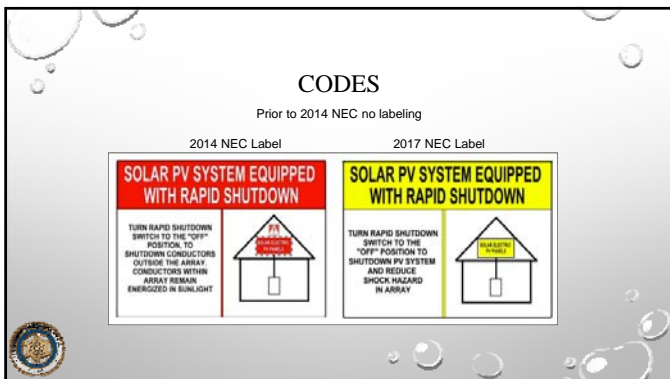
OFF GRID SYSTEMS



- REMEMBER, IF YOU ENCOUNTER AN "OFF-GRID" SYSTEM, IT WILL HAVE SOME SORT OF BACK-UP AS IT IS NOT TIED TO THE UTILITY GRID. THAT BACK-UP WILL EITHER BE A BATTERY BANK OR A GENERATOR.
- MANY TIMES "OFF-GRID" SYSTEMS WILL BE FED FROM MULTIPLE ENERGY SOURCES.



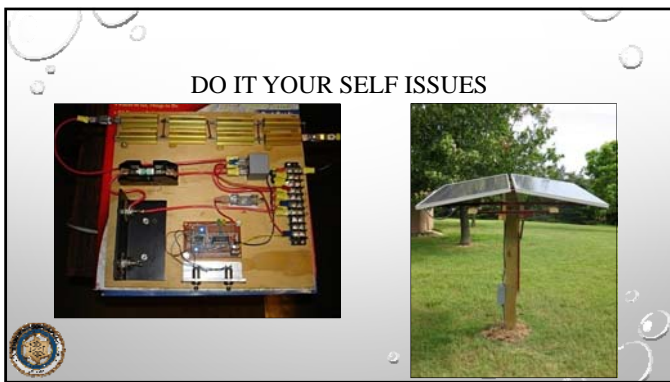


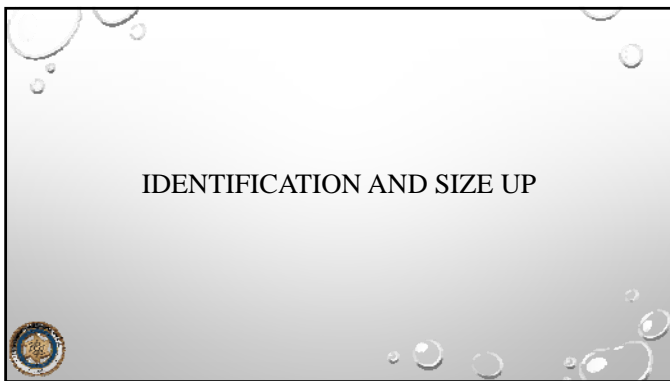
- NATIONAL ELECTRICAL CODE (SINCE 1980)
- CHAPTER 6 SPECIAL EQUIPMENT
- ARTICLE 690 SOLAR PHOTOVOLTAIC (PV) SYSTEMS
- INTERNATIONAL FIRE CODE
- LOCAL ORDINANCES (ON-GOING)
- WHAT'S IN YOUR FIRST DUE?



2014 NEC Label	2017 NEC Label
<p>SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN</p> <p>TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUTDOWN CONDUCTORS OUTSIDE THE ARRAY. CONDUCTORS WITHIN ARRAY REMAIN ENERGIZED IN SUNLIGHT</p> 	<p>SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN</p> <p>TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUTDOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY</p> 







IDENTIFICATION AND SIZE UP

- FOCUS ON SOUTH AND WEST FACES
- LOOK AT ALL LOCATIONS
- LOOK FOR COMPONENTS
- DOES THE BUILDING HAVE MORE THAN 1 ELECTRICAL METER



ROOF MOUNTED



ROOF MOUNTED



ROOF MOUNTED



ROOF MOUNTED



ROOF MOUNTED



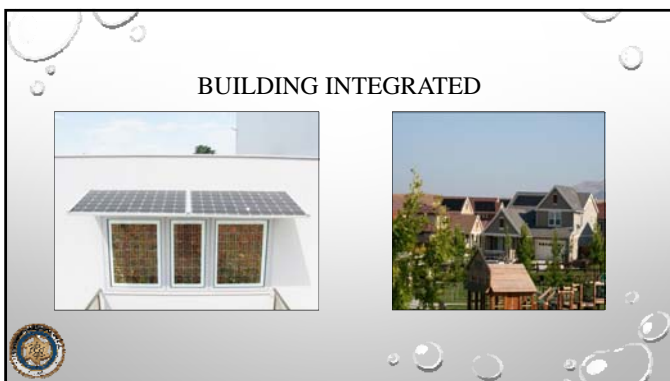





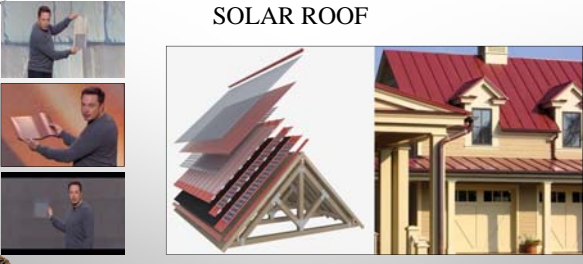










SOLAR ROOF



PARKING STRUCTURES



PARKING STRUCTURES



ACCESSORY STRUCTURES



GROUND MOUNTED



GROUND MOUNTED



GROUND MOUNTED



DISCONNECTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS

What is in the box???



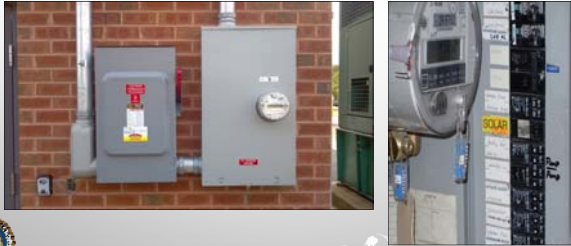
SUPPORTING ELEMENTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS



SUPPORTING ELEMENTS




LABELING





SIZE UP

- BUILDINGS EQUIPPED WITH PV ARE NO DIFFERENT THAN ANY OTHER SIZE UP.
- BASIC SIZE-UP INFORMATION
 - TIME OF DAY
 - TYPE OF BUILDING
 - LIFE SAFETY
 - PV SYSTEM PRESENT
 - FIRE ACTIVITY
 - STRUCTURE FIRE
 - CONTENT FIRE
 - SYSTEM INVOLVED
 - RESOURCE AVAILABLE



SIZE UP

- MUST DO A 360 SIZE UP
- LOOK UP
- LOOK DOWN
- LOOK INSIDE DOORS
- YOU MAY NEED TO ACCESS THE ROOF TO COMPLETE SIZE UP
- LOOK FOR COMPONENTS AND LABELS
- COMMUNICATE!!!!!!



HAZARDS

- SLIP, TRIP, AND FALL
- PV PANELS
- BIPV PANELS
- MOUNTING SYSTEM
- CONDUIT
- COMPOUNDED BY:
 - LIGHTING
 - WEATHER CONDITIONS



HAZARDS

Increased Snow and Live Loads



Increased Dead Roof Load



WHAT CAN BE GENERATING CURRENT



EQUIPMENT LIGHTING

- UL® CONDUCTED A SERIES OF EXPERIMENTS USING TYPICAL FIRE DEPARTMENT EQUIPMENT AVAILABLE TODAY. IN THE EXPERIMENTS, THE LIGHTING EQUIPMENT WAS AIMED DIRECTLY AT THE SOLAR ARRAYS, AND AT VARYING DISTANCES.
- EACH TRUCK'S LIGHTING SYSTEMS WAS ABLE TO PRODUCE ENOUGH ILLUMINATION TO CAUSE ELECTRICAL SHOCK HAZARD.
- EACH TRUCK BY ITSELF PRODUCED OVER 40 MILLIAMPS, THE THRESHOLD FOR "LOCK ON" EVEN AT DISTANCES AS FAR AWAY AS 38 FEET.
- TWO ILLUMINATED THE ARRAY TO OVER 40 MILLIAMPS AT A DISTANCE OF 75 FEET.



THE FIRE

- EXPERIMENTS WERE CONDUCTED ON A PV ARRAY FIRE TO SEE IF A FIRE IN CLOSE PROXIMITY SUCH AS FROM A PORTION OF THE ARRAY ITSELF PRODUCED SUFFICIENT ILLUMINATION TO PRODUCE HAZARDOUS POWER LEVELS AT NIGHT
- 12 WOODEN PALLETS WERE SET ON FIRE AND PLACED AT VARYING DISTANCES FROM THE ARRAY. WITH ONLY THE FIRE FOR ILLUMINATION TO THE ARRAY, IT WAS FOUND THAT IT COULD PRODUCE HAZARDOUS POWER LEVELS.
- THE FIRE'S ILLUMINATION PRODUCED CURRENT LEVELS EXCEEDING 40 MILLIAMPS (THRESHOLD FOR LOCK ON) EVEN AT A 75' DISTANCE!



THE MOON

EXPERIMENTS WERE CONDUCTED OVER A 24 HOUR TIMEFRAME TO DISCOVER THE EFFECTS, IF ANY, OF THE FULL MOON ON A PV ARRAY. FROM A TIME OF 20 MINUTES AFTER SUNSET TO A TIME OF 20 MINUTES BEFORE SUNRISE THERE WERE NO ELECTRICAL HAZARD CONDITIONS PRODUCED BY THE ARRAY FROM ONLY THE FULL MOON.




ELECTRICAL ENERGY STORAGE




WHY STORE ELECTRICAL POWER

- LACK OF POWER
- CRITICAL INFRASTRUCTURE
- GRID RESILIENCY
- SUSTAINABILITY
- GREEN ENERGY
- PEAK SHAVING
- VOLTAGE CLEANUP
- DEMAND LOAD SHARING
- EMERGENCY POWER
- UNINTERRUPTED POWER SUPPLIES (UPS) (SOME SYSTEMS CANNOT BE SHUTDOWN) (GENERATOR STARTUP DELAY)




BATTERY TYPES

- LEAD ACID
- LITHIUM-ION
- FLOW BATTERY




LEAD ACID

- FIRST USED 1859
- WET CELL – SULFURIC ACID
- GENERATES HYDROGEN GAS WHEN CHARGED
- SEALED CELLS
 - SLA – SEALED LEAD ACID
 - VRLA – VALVE REGULATED LEAD ACID CAPTIVE ELECTROLYTE
 - AGM – ABSORBED GLASS MAT – GLASS MATRIX CONTAINS ELECTROLYTE
- CAR BATTERIES




LITHIUM-ION

- FAMILY OF CHEMISTRY TYPES
- CELL PHONES TO TOOLS OR LARGER
- 10 YEAR ANTICIPATED LIFE
- MOST ENERGY DENSE
- LONGER SHELF LIFE
- VOLATILE
- FLAMMABLE ELECTROLYTE
- STATE OF CHARGE FIRE INTENSITY




LITHIUM-ION

- FAILURE MODES
 - THERMAL ABUSE
 - ELECTRIC ABUSE (OVER/UNDER CHARGING)
 - HEAT
 - MECHANICAL ABUSE
 - FACTORY DEFECTS
- DELAYED RESPONSE



LITHIUM-ION


- EQUIPMENT MATCHUP IS CRITICAL
- POST FIRE RE-IGNITION IS PROBABLE
- NOT A CLASS D FIRE, THE BATTERY IS NOT LITHIUM METAL
- WATER IS THE RIGHT AGENT
- PROPER SEPARATION OF CELLS IS CRITICAL
- PROPER VENTILATION IS CRITICAL ONCE WATER IS APPLIED



LITHIUM-ION

UNDER FIRE CONDITIONS

- TOXIC GAS COCKTAIL
- FLAMMABLE GASSES
- DEEP SEATED FIRES
- SIGNIFICANTLY DELAYED IGNITION MAY EXIST
- RE-IGNITION IS LIKELY TO OCCUR
- TIC MAY NOT BE EFFECTIVE
- POST-BURN STORED ENERGY MAY BE SIGNIFICANT (STRANDED)




LITHIUM-ION



LITHIUM-ION

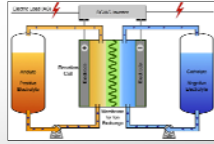
CLEAN WATER IS THE BEST AGENT

- COPIOUS AMOUNTS
- ELECTRICAL LEAKAGE
- ARCING (NOT ENOUGH WATER)
- NO ADDITIVES
- CLEAN AGENTS (INCIPIENT ONLY) (WILL NOT COOL)
- DRY CHEM FOR LEAD ACID ONLY NOT FOR LITHIUM-ION



BATTERY TYPES

- ACID THAT FLOWS BETWEEN TANKS
- 20 YEAR ANTICIPATED LIFE
- SECONDARY CONTAINMENT
- LOWER ENERGY DENSITY



BATTERY BANKS

- BATTERIES ARE WIRED IN SERIES AND PARALLEL TO PROVIDE THE VOLTAGE AND AMPERAGE NECESSARY FOR THE OPERATION OF THE ELECTRICAL SYSTEM



BATTERY BANKS

- HISTORICALLY MOST BATTERIES ARE LEAD ACID, NEWER SYSTEMS ARE UTILIZING LITHIUM-ION TECHNOLOGY DUE TO ENERGY DENSITY
- HYDROGEN GAS, PRODUCED WHILE CHARGING CAN IGNITE IN UNVENTED SPACES
- MAY HAVE EXPOSED TERMINALS



BATTERY BANKS

BATTERY BANKS MAY BE FOUND IN:

- GARAGES
- CLOSETS
- SHEDS
- RARE IN RESIDENTIAL GRID-TIED SYSTEMS



BATTERY BANKS




PROBLEMS FOR FIREFIGHTERS




PROBLEMS FOR FIREFIGHTERS

- THE PRESENCE OF PV SYSTEMS PRESENTS FIREFIGHTERS WITH ADDITIONAL CHALLENGES TO THE NORMAL "ROUTINE" OF FIRE SUPPRESSION ACTIVITIES.
- THEY PRESENT A PROBLEM IN JUST RECOGNIZING THEIR PRESENCE. THIS IS BECOMING MORE DIFFICULT EVEN AS WE SPEAK ...
- FURTHER, PV SYSTEMS PRESENT ADDITIONAL "INHERENT" DANGERS AND HAZARDS WITH SUCH TACTICAL CONSIDERATIONS AS:
 - UTILITY CONTROL
 - VENTILATION
 - SUPPRESSION
 - OVERHAUL
 - EFFECTS ON THE STRUCTURE



PROBLEMS FOR FIREFIGHTERS


A MAJOR DANGER POSED BY PV SYSTEMS IS SHOCK OR ELECTROCUTION. THIS IS DUE TO THE AMOUNT OF DC CURRENT THAT IS GENERATED BY THE ARRAYS AND TRAVELING THROUGH A CONDUIT TO AN INVERTER TO BE CONVERTED TO AC POWER. THESE SYSTEM COMPONENTS ARE A SHOCK HAZARDS TO FIREFIGHTERS PERFORMING VENTILATION OR OVERHAUL.



PROBLEMS FOR FIREFIGHTERS

WHEN THE PV SYSTEM IS INVOLVED IN FIRE, IT WILL PRODUCE ITS OWN UNIQUE TOXIC GASSES IN THE FIRE'S SMOKE.

Silicon	Tellurium
Boron	Arsenic
Phosphorus	Gallium
Cadmium	



PRE-PLANNING

A GOOD PROACTIVE SIZE UP (PRE-PLAN) BEGINS PRIOR TO THE INCIDENT

UTILIZE ALL AVAILABLE INFORMATION FROM:

- PRE FIRE SURVEYS
- COMPANY INSPECTIONS (DRILL NIGHT)
- BUILDING PERMITS



IC INITIAL PRIORITIES

- COMMUNICATE ALL ALTERNATIVE ENERGY LOCATIONS
- ASSIGN "UTILITIES GROUP" EARLY
- LOCATE AND DISABLE ALL ALTERNATIVE ENERGY COMPONENTS



TACTICAL CONSIDERATIONS



OPERATIONS

- TRADITIONAL TACTICS MAY BE DIFFICULT TO EMPLOY IN SITUATIONS WHERE ALTERNATIVE ENERGY SYSTEMS ARE PRESENT.
- THE TACTICS MOST IMPACTED BY ALTERNATIVE ENERGY SYSTEMS ARE UTILITY CONTROL.
- THE TACTICS MOST IMPACTED BY PHOTOVOLTAIC SYSTEMS ARE VENTILATION.
- THERE NEEDS TO BE GOOD COMMUNICATION BETWEEN THE IC, VENT AND UTILITY GROUPS.



UTILITY CONTROL

- MUST BE ASSIGNED EARLY BY THE IC
- DISCONNECT ALL POWER SOURCES
 - PHOTOVOLTAIC
 - COMMON UTILITY
 - AUXILIARY SUPPLY
 - GENERATORS
 - WIND
 - BATTERY BANKS
- DISCONNECT ALL LOCATIONS
- VERBALIZE WHAT HAS BEEN CONTROLLED AND WHEN IT WAS CONTROLLED
- LOCK-OUT-TAG-OUT PROCEDURES SHOULD BE FOLLOWED
 - LOCKS AND TAGS
 - IF NOT ELECTRICAL ZIP TIES (CHEEP)



UTILITY CONTROL

IF THE LIGHTS STAY ON OR COME BACK ON WHEN YOU DISCONNECT THE POWER.....



UTILITY CONTROL

- IN A PHOTOVOLTAIC SYSTEM, DISCONNECTING THE DC DISCONNECT WILL ISOLATE ONLY THE LOAD SIDE OF THE DISCONNECT SUCH AS THE WIRING TO THE CONVERTER.
- THE PHOTOVOLTAIC WIRING AND OTHER SYSTEM COMPONENTS BETWEEN THE MODULES AND THE DISCONNECT WILL REMAIN ENERGIZED IF THE MODULES ARE ILLUMINATED.



FIRE TYPE AND AGENTS

- IF THE SYSTEM IS ENERGIZED – CLASS C
- IF THE SYSTEM IS NOT ENERGIZED – CLASS A



INTERIOR OPERATIONS

CREWS MAY FIND AND SHOULD BE LOOKING FOR:

- BATTERY BANKS
- INVERTERS
- DISCONNECTS
- CONDUIT
- LABELING



VENTILATION/ROOF OPERATIONS



VENTILATION/ROOF OPERATIONS



Where are the wires/conduit???



VENTILATION/ROOF OPERATIONS



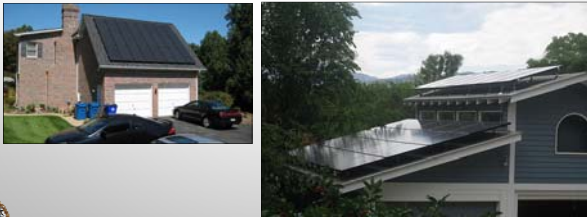
Roof Crews must evaluate for collapse potential and avoid photovoltaic components



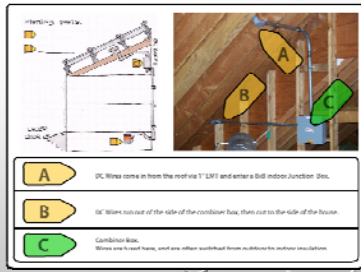
VENTILATION/ROOF OPERATIONS



VENTILATION/ROOF OPERATIONS





VENTILATION/ROOF OPERATIONS



COVERING THE PANELS


ALL STRINGS IN THE PHOTOVOLTAIC ARRAY MUST BE COVERED IN ORDER TO STOP THEM FROM GATHERING SOLAR ENERGY TO SEND TO THE INVERTER.

COVERING THE PANELS


USE OF TARPS TO BLOCK ILLUMINATION

CHART:	COST:	TARP:	COLOR:	LAYERS:	VOLTS:	AMPS:	HAZARD:
•	\$15	4.0 MIL. PLASTIC FILM	BLACK	1	33	0	SAFE
•	\$15	4.0 MIL. PLASTIC FILM	BLACK	2	0.5	0	SAFE
•	\$16	5.1 MIL. AP PLASTIC	BLUE	1	126	2.1	ELECTROCUTION
•	\$16	5.1 MIL. AP PLASTIC	BLUE	2	121	1	ELECTROCUTION
•	\$78	FIRE SALVAGE CANVAS	GREEN	1	3.2	1.8	SAFE
•	\$94	SALVAGE HEAVY VINYL	RED	1	124	1.8	ELECTROCUTION
•		FULL SUN		148	8.1		ELECTROCUTION



COVERING THE PANELS

THERE HAVE BEEN REPORTS OF DEPARTMENTS USING FOAM TO TRY AND COVER SOLAR PANEL ARRAYS. UL CONDUCTED EXPERIMENTS USING CLASS A COMPRESSED AIR FOAM OR CAFS. IT WAS FOUND THAT THE FOAM DID NOT ADHERE TO THE PANELS GLASS SURFACE AND THUS WAS INEFFECTIVE AT BLOCKING THE SUN'S ILLUMINATION.



WHAT'S ON FIRE?



WHAT'S ON FIRE?



WHAT'S ON FIRE?



WHAT'S ON FIRE?



WHAT'S ON FIRE?



WHAT'S ON FIRE?



FIRE ATTACK

SOMETIMES ITS IS THE PHOTOVOLTAIC SYSTEM THAT STARTS THE FIRE AND NOT THE STRUCTURE. AGAIN, THIS DIFFERENTIATION MUST BE MADE DURING SIZE-UP.

EITHER WAY, THE USE OF HOSE STREAMS ON A CHARGED SYSTEM CAN BE DEADLY. FIREFIGHTERS SHOULD MAKE EVERY ATTEMPT TO SHUTDOWN THE PHOTOVOLTAIC SYSTEM, WAIT FOR "BLEED DOWN" OF ENERGIZED COMPONENTS AND ONLY THEN ATTEMPT SUPPRESSION ACTIVITIES.



OVERHAUL

- SIZE-UP
- STRUCTURAL STABILITY
- RISK-BENEFIT ANALYSIS



SUMMARY

- THE GREATEST DANGER FOR EMERGENCY RESPONDERS IS THE LACK OF PV KNOWLEDGE NEEDED TO SAFELY OPERATE AROUND THIS EMERGING TECHNOLOGY.
- IDENTIFICATION OF THE PV ARRAY AND ALL THE RELATED COMPONENTS IS CRITICAL IN AN EMERGENCY RESPONSE