CAPTURING THE SUN

SOLAR PANELS, SOLAR THERMAL AND THE FIRE SERVICE

“Si vis pacem, para bellum.”

(In time of peace, prepare for battle.)

–Apius Claudius the Blind,
281 BC

LEGAL MUMBO JUMBO

- I have no commercial interest in any product you may or may not see, hear, read, infer or telepathically receive during this presentation.

- Although I offer ideas for tactics, ever situation involving solar energy is unique. Good judgement always trumps "some guy once said".

- I'm a jack of all trades, master of none. Learning about PVS is one of my passions.

- Comments are always welcome, as is fire house humor.

OBJECTIVES

- Explain the basics of solar power
- Types of solar power out there
- Implications for the fire service
- The "now what"
- The Future of Solar and the fire service
- Dealing with fires involving solar panels

TYPES OF SOLAR

- Most common is Photovoltaic Systems (PVS)
- Solar Thermal
- Passive Solar

SOLAR POWER FACTS & FIGURES

- Solar power is about money... Making it & saving it. A lot of it.
- Politicians (aka: the governor of NYS) is using solar power for political gain (creating jobs, going green, etc)
- In 2014 alone, NYS had 147 megawatts of solar panels installed, or roughly $451 million worth...
- At present, there's over 520 megawatts of solar energy installed and operating in NYS. That's more than a single nuclear power plant produces. (520 MW vs 479 MW)
- When a PVS burns, it creates a "hazmat soup" that's airborne...

SOLAR POWER FACTS & FIGURES

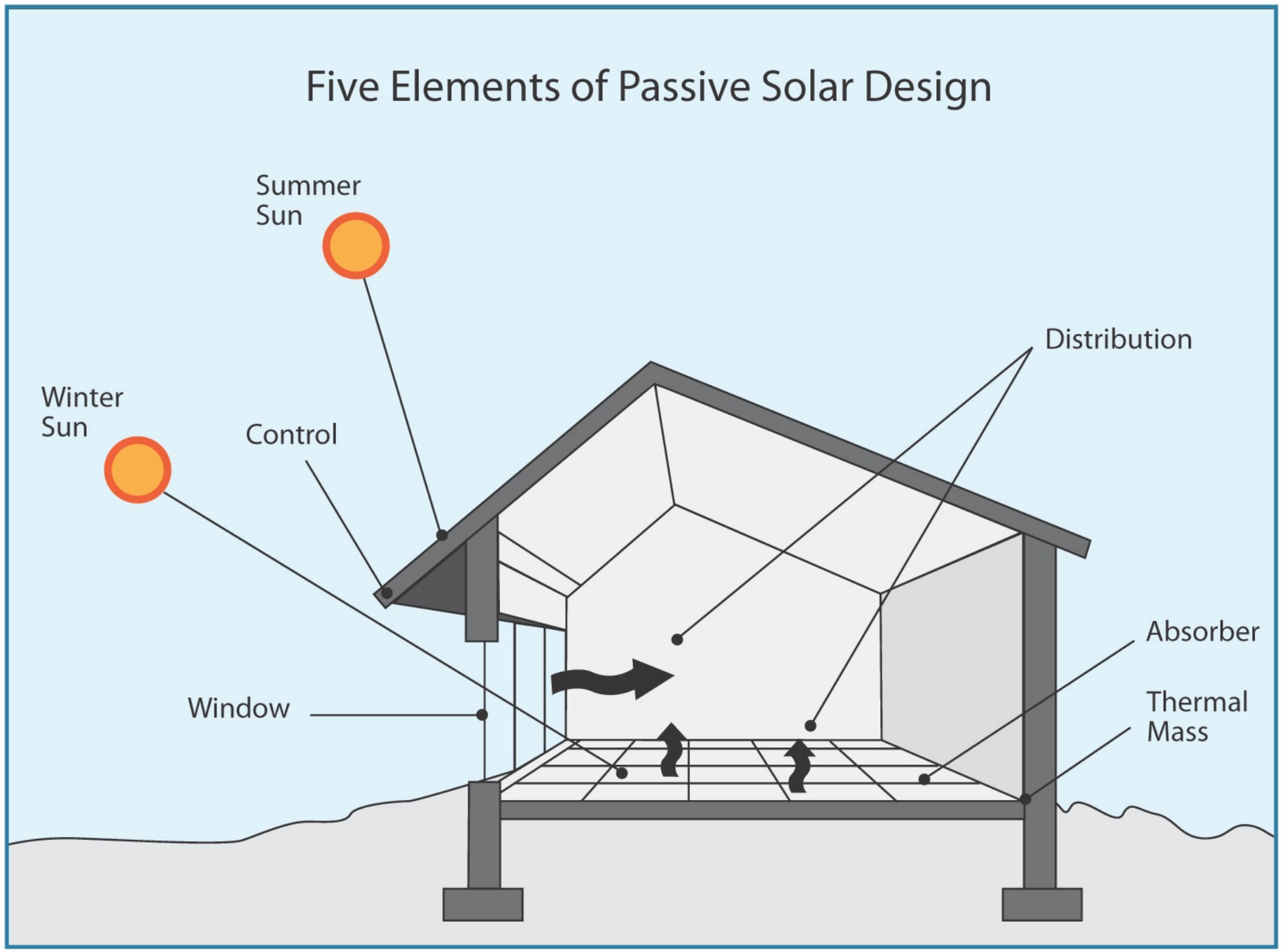
- Of the solar power installed in 2014:
- 89 MW were residential
- 49 MW were commercial
- 9 MW were utility-scale (solar farms, etc)
- Approximately 88,000 homes can presently be powered by solar power in NYS.
- Solar power hardware is getting cheaper (law of supply & demand)

PASSIVE SOLAR

PASSIVE SOLAR SYSTEMS

- Uses building features to utilize solar heating.
- Essentially, it's a greenhouse concept.
- Uses insulation, windows, internal air currents and "stored" solar heat.
- Doesn't typically use chemicals, etc. A very "green" concept for heating and cooling.
- Been around for a long time... Centuries.

PASSIVE SOLAR SYSTEMS



PASSIVE SOLAR OVER TIME

- The Anasazi Indians built their dwellings in the sides of cliffs hundreds of years before modern technology.

- They understood the concept and application of passive solar.

SOLAR THERMAL SYSTEMS

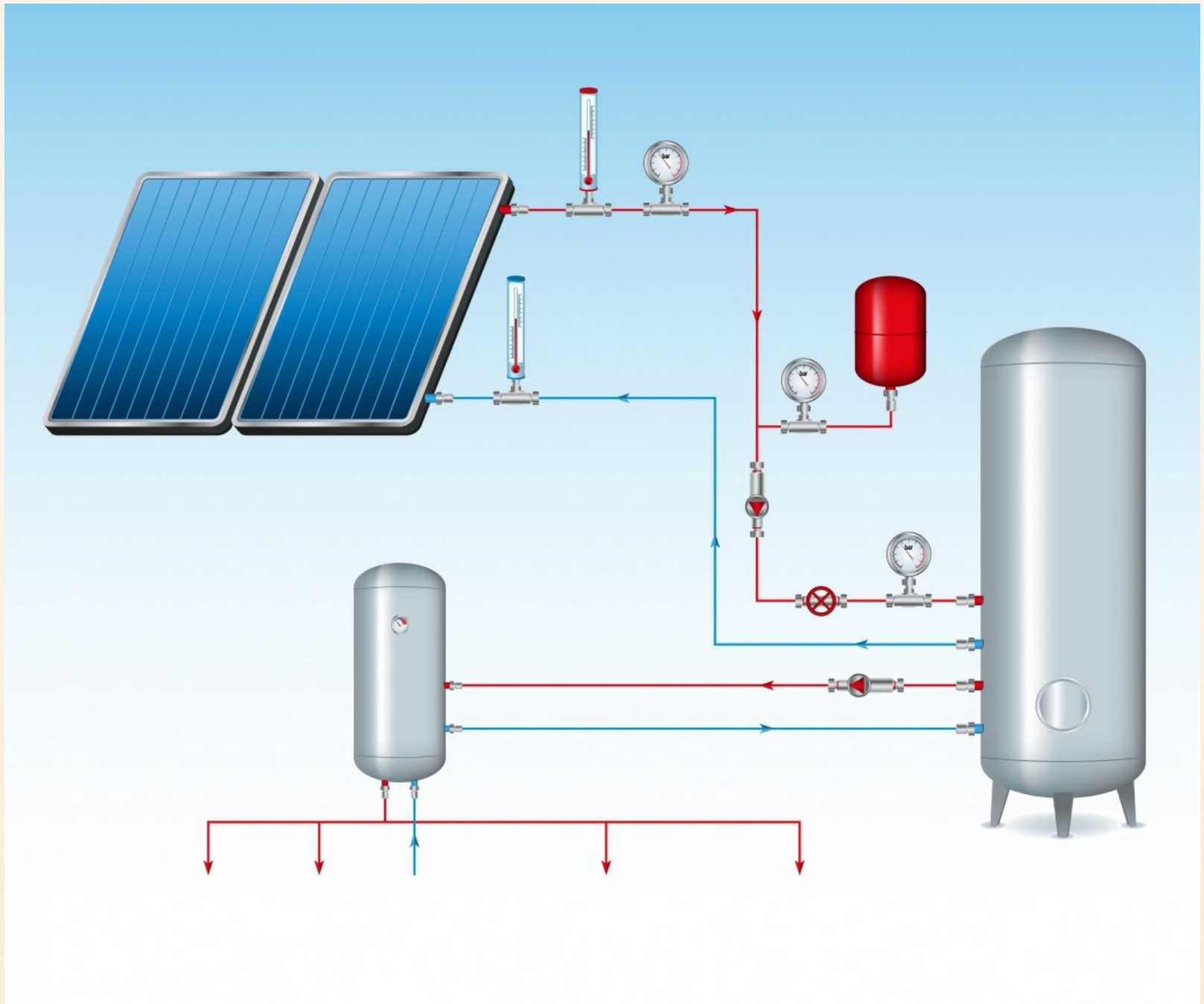
SOLAR THERMAL SYSTEMS

- Less popular due to maintenance
- Does not create energy, parse
- Creates heat, not electricity
- Heat transfer through a medium
- Heat transfer medium include: water, glycol/water mixture, hydrocarbon oils, air, refrigerants/phase change fluids.

IMPLICATIONS OF SOLAR THERMAL SYSTEMS

- Residential system is typically roof mounted.
- Weight
- Hazmat
- Flammable considerations of mediums; burning mediums can turn into a 3 dimensional fire.
- Not very popular in the Northeast
- Usually used as a swimming pool heater.

SOLAR THERMAL SYSTEMS



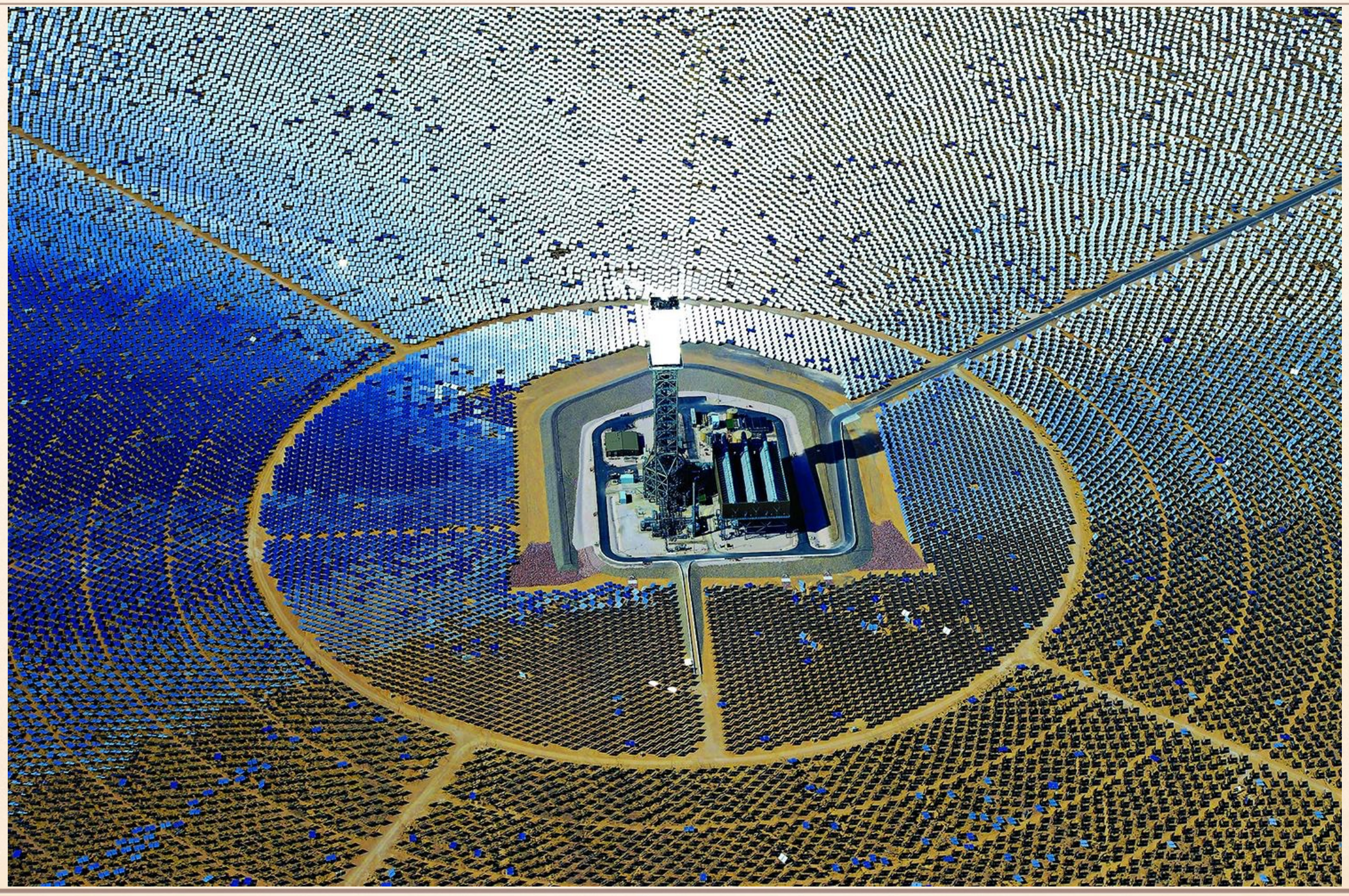
SOLAR THERMAL SYSTEMS

REDNECK SOLAR THERMAL

SOLAR THERMAL SYSTEMS

How would you ventilate this structure?

SOLAR THERMAL SYSTEMS
SOLAR FARM



SOLAR THERMAL SYSTEMS

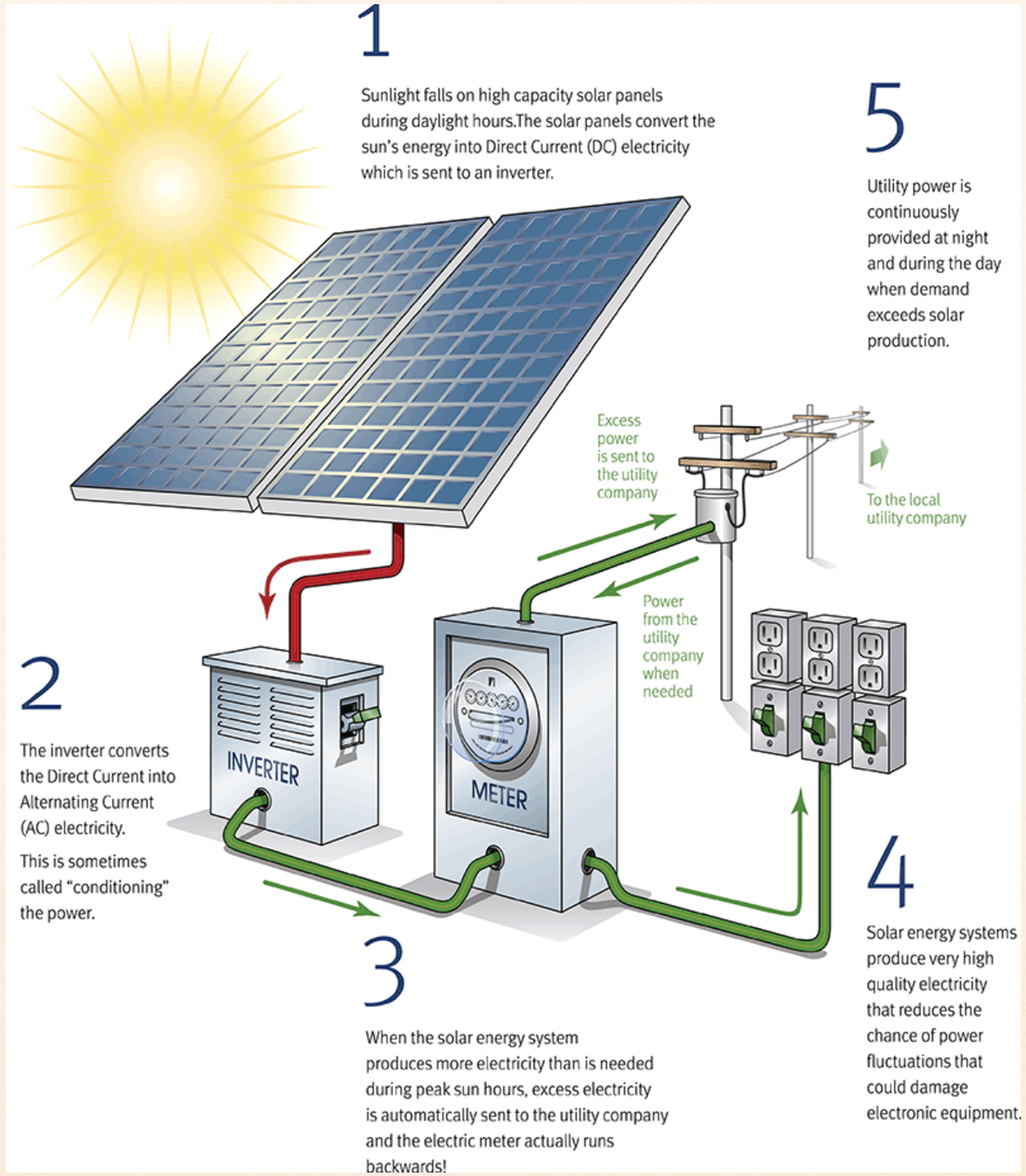
Say this system holds 400 gallons of water... Additional weight is?

3,320 pounds

REDNECK POOL HEATER

PHOTOVOLTAIC SYSTEMS (PVS)

PHOTOVOLTAIC SYSTEMS



SOME DEFINITIONS

- PVS (photovoltaic system): an electrical system intended on creating usable power from the sun.

- PVS array: all hardware that converts light to electricity.

- PV panel: a set of photovoltaic cells that create electricity

- PV cell: individual semiconductor that uses sunlight to create electricity.

SOME DEFINITIONS

- Solar inverter: converts DC electricity to usable AC electricity. (aka: converter; PV inverter)

- DC electricity (direct current): flow of electricity is unidirectional.

- AC electricity (alternating current): flow of electricity is bidirectional.

- Islanding: PVS that utilizes batteries to store and supply electricity without the need for commercial hookup. (aka: end-of-grid)

SOLAR PANEL BASICS

- Photons, or particles of light, knock electrons free from atoms, generating a flow of electricity.
- Basically, it's scientific "magic".
- Power produced by PVS is DC.
- DC must be converted to AC current via an inverter.
- Islanding systems use lead acid batteries.

SOLAR PANEL INVERTER

TYPES OF PVS SYSTEMS

- The most common PVS we see are "grid connected" or "on grid".
- Meaning, the PVS feeds electricity into the public power grid.
- The least common, but gaining popularity is "edge-of-grid" or "islanding" systems.
- Islanding is not very practical in NYS due to winter, but...
- These systems use batteries to store electricity generated from PVS panels.

SOLAR PANEL BASICS

- The solar cells are made from different elements, chemicals and compounds.

- When a solar cell burns, it creates a "hazmat soup"... Adding more carcinogens to an already dangerous mixture.

- Boron & silicone (relatively safe)

- Cadmium Telluride (known carcinogen)

- Gallium Arsenide (highly toxic and carcinogen)

- Phosphorus (highly toxic)

- PVC high density plastics (toxic and carcinogen)

- Acrylic (toxic)

THE TYPES OF PVS ARRAYS WE WILL SEE

- Roof mounted photovoltaic arrays
- Ground mounted photovoltaic arrays
- Photovoltaic tiles and shingles
- Low voltage/low amperage systems (personal use)

GROUND MOUNTED PVS

4
arrays

224
panels

12,096
cells

64 kW
system

RESIDENTIAL ROOF MOUNTED PVS

1 array

48 panels

1,152 cells

6 kW system

RESIDENTIAL INTEGRATED PV ROOF TILES

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* Photo courtesy of Kyle O'Connor, Schenectady Fire

RESIDENTIAL INTEGRATED PV ROOF TILES

* Photo courtesy of Kyle O'Connor, Schenectady Fire

COMMERCIAL ROOF MOUNTED SOLAR ARRAYS

UTILITY SCALE PVS

Nellis Airforce Base

Las Vegas, NV

PERSONAL PVS

BUILDING CODES & LAWS

- As of present, there are no specific statewide building codes addressing PV systems other than electrical. (NFPA 70). That changes on 10/3/16...

- NYS is putting most of the regulation of systems onto local municipalities.

- This frees up the state from muddying the waters with a "one size fits all" mentality towards PV installation.

- This allows local municipalities to have a greater input for their needs on regulation.

SO WHAT DOES THAT MEAN?

- It means that we, the fire service in NY, can directly affect the very buildings we respond to.

- It means we, the fire service, can petition to have our local building codes meet OUR needs.

- If your municipality doesn't have a local law pertaining to PV systems, it's time you do.

- And, as usual for the fire service, things will change, regulations will change.

FOOD FOR THOUGHT

- Since NYS has given the local municipalities the "Authority Having Jurisdiction", we should petition to have...

1. Fire department notification of panel installation at time of going live.

2. All structures with solar panels register them with the FD.

3. Have the presence of PVS made known to all responding units.

IMPLICATIONS TO THE FIRE SERVICE

IMPLICATIONS FOR THE FIRE SERVICE

- Building codes and construction
- Tactical considerations
- Preplanning for the event
- Respiratory protection of all, including nearby civilians

BUILDING CODES AND CONSTRUCTION

- Building codes can help standardize systems state wide.
- But, the only state wide code pertaining to PVS is the electrical code...
- Passive systems must meet building codes and construction. All of them.
- Solar thermal systems are not truly addressed in the building code beyond plumbing and mechanical codes.

BUILDING CODES AND CONSTRUCTION

- 2015 and 2016 brought some huge changes for PVS. Some good, some...

- Specifically addresses areas of concern for firefighters (pathways on roofs, quick shutoff's, etc).

- The "quick shutoff" is a misnomer. All it does is offer a "button" that must be depressed & shut down the feed within 10 seconds.

BUILDING CODES AND CONSTRUCTION

- Roof systems under the current building codes can handle the weight, for the most part.

- Prevalence of truss construction with gusset plates IS the problem.

- Flame impingement on truss construction is normally dangerous, now add a few thousand extra pounds of dead load.

ROOFING STUFF

- Newer constructed homes can withstand 25-50 pounds per square foot (ppf). But this is dependent on the pitch of the roof.

- Each panel weighs about 30-50 pounds each, including mounting material.

- A residential solar array weighs the equivalent of 10-15 firefighters…

- This equates to approximately 3-5 pounds per square foot additional (12.5% increase) in dead load weight.

- Then add snow. Or ice. Or both.

- A foot of light/fluffy snow weights about 7-10 ppf.

- A foot of dense/wet snow weighs in excess of 20 ppf.

- A cubic foot of ice weighs 57 pounds

ROOFING STUFF

- So, let's do some math to prove what we already know.
- A typical residential roof can handle 25-50 ppf dead weight.
- 18 inches of dense snow weighs about 30 ppf.
- 1" ice from melting/freezing weighs about 5 ppf.
- Typical PVS array adds 4 ppf.

ROOFING STUFF

- So, a typical winter in Upstate NY has a dead load roof weight of about 35 ppf. Add the solar array and we have…

- …39 ppf so far. Which is about the 3/4 the dead weight capacity of a 50 ppf roofing system.

- Then add flame impingement on the roofing system.

- But… The failure rate and time is dependent on BUILDING CONSTRUCTION.

ROOF BASICS

- This is where our initial size up and preplanning is key.

- Roof system failures vary on building type, construction materials, type of roofing system, roof pitch, percentage of fire involvement…

- Do we need to change our tactics when a PVS system is present?

TACTICAL CONSIDERATIONS

- Obviously, electrical current exposure & isolating the electrical system.
- Additional weight on roofing structures on top of roof mounted air conditioners, air handles, etc.
- Respiratory protection for nearby public (consider a "shelter in place" order for downwind residents).
- Burning PVS and cells
- Ventilation (vertical vs horizontal/cross ventilation)
- Batteries in "islanding" systems
- Equipment use and placement

TACTICAL CONSIDERATIONS

* Photo courtesy of Kyle O'Connor, Schenectady Fire

TACTICAL CONSIDERATIONS ELECTRICAL

- Electrical current exposure (a nice way of saying electrocuted)
- Don't cut conduit. Ever. For any reason.
- Look at the labeling of the PVS...
- Do deactivate the connection at the inverter (if safe). Just like throwing a main at a breaker panel.
- But solar panels and attached conduit are still electrified, even when the disconnect switch is thrown.
- Non-sunlight sources are still able to produce enough current to create a "lock-on" hazard. (Lock-on is referring to 40-240 milliamperes).
- In example: emergency lights, flash lights, light from the fire itself, full moon...

TACTICAL CONSIDERATIONS
ELECTRICAL

TACTICAL CONSIDERATIONS
ROOF

- Additional weight of PVS is about 5 ppf (pounds per foot)
- How much time do we have until a roof system will fail?
- Is vertical ventilation worth the risk?
- Easily put... Risk-benefit analysis needs to be done every 10 minutes.
- Should we be operating under a compromised roofing system with a PVS?
- Tarping a solar array has been the "industry recommendation". Unrealistic, unreliable, time consuming and manpower intensive.
- IF you tarp a non-burning PVS, only use green tarps or flat black plastic. Non-porous, canvas only.

TACTICAL CONSIDERATIONS
ROOF

Do we really have the time and manpower for this during the first 10 minutes of a fire?

TACTICAL CONSIDERATIONS
RESPIRATORY PROTECTION

- Air monitoring isn't just for hazmat & confined space anymore...
- Treat any fire where PVS/solar systems as a hazmat...
- Stage resources upwind/uphill if possible.
- SCBA use
- Consider a protect in place/shelter in place order for residents downwind. How far is incident specific. 100-150 yards is a safe start.
- Annual physicals looking for toxins is a good start.
- Report exposures & document them.

TACTICAL CONSIDERATIONS
BURNING PV CELLS

- When a PV cell burns, it is a airborne hazmat soup.
- Use water on burning PVS as a LAST resort.
- CO_2 and/or ABC dry chem is appropriate.
- If you have to flow water onto a burning PVS array, remote monitors and fog patterns from a distance is safest.
- Remember, as long as a PV cell has a light source, it will continue to produce electricity. Even flashlights…

TACTICAL CONSIDERATIONS
BURNING PV CELLS

- Another pneumonic to forget...
- I
- C
- E

- **Isolate** the panels electrically
- **Contain** the spread
- **Extinguish** the fire
- I know...it's stupid

TACTICAL CONSIDERATIONS VENTILATION

- The standard vertical ventilation is tricky with installed PVS.

- Never cut through an array, conduit or mounting systems for PVS.

- Use caution with roof ladders…

- You may have to consider a trench cut towards the roof peak as opposed to cutting directly over the fire.

- Consider horizontal ventilation in cases where a PVS is present.

- Consider roof ventilation on the north side of the roof.

- Consider a gable vent vs a roof vent.

TACTICAL CONSIDERATIONS
VENTILATION

Trench cut above a PVS

TACTICAL CONSIDERATIONS
VENTILATION

Gable ventilation

(c) Fire Engineering 4/16/15
Structure fires: beware of the dangers above your head
Bill Gustin

TACTICAL CONSIDERATIONS
ISLANDING BATTERIES

- Islanding is rare, but gaining popularity.
- Batteries are deep cycle, lead-acid based.
- Batteries are used in banks (several batteries stored in series).
- Although difficult to get burning, batteries offer other areas of danger...

ISLANDING

TACTICAL CONSIDERATIONS
ISLANDING BATTERIES

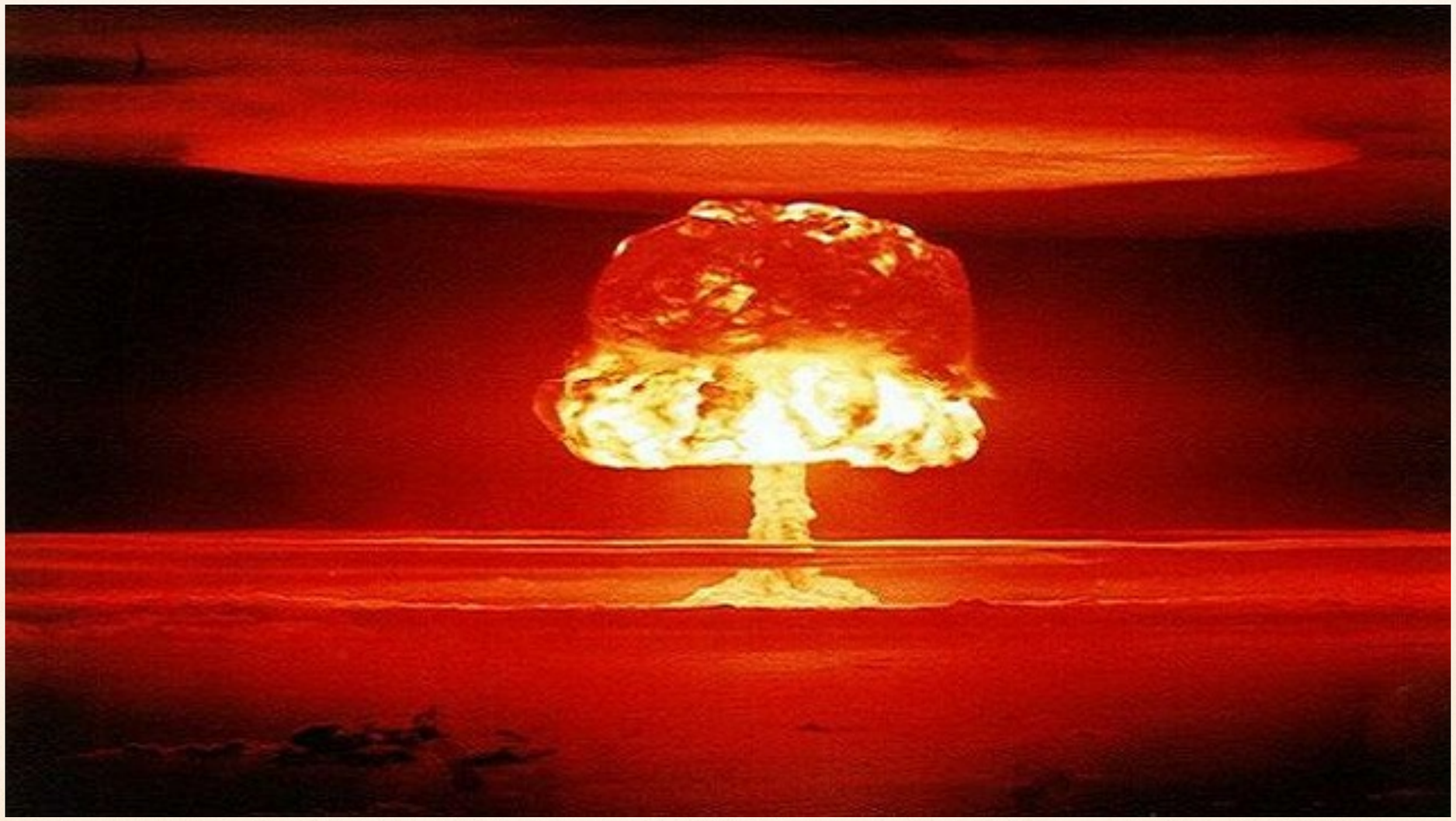
- If it ain't broke, don't fix it. Leave the batteries alone.
- When a lead acid battery charges, it produces hydrogen gas. Think the Hindenburg.
- Batteries exposed to excessive heat (like in a fire), produce other fumes and gasses (like chlorine, oxygen, etc).
- So, we have a corrosive gas, an oxidizer and a very unstable element. Produced in a fire...
- And we're putting several of these batteries in/near our homes.

FOOD FOR THOUGHT

What does a WWII sub and solar panel islanding have in common?

&

TACTICAL CONSIDERATIONS ISLANDING BATTERIES



This is what I think of when I hear "lead acid battery" and fire

SO, NOW WHAT?

"If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle."

~Sun Tzu, The Art of War

NOW WHAT

- We've covered a lot thus far.

- So, now what do we do?

- This is a multi pronged attack, covered in several areas.

NOW WHAT?

- Preplanning
- Input & influence local laws
- On scene operations
- Fringe thinking

NOW WHAT
PREPLANNING

- **Identify** structures where PVS & solar thermal systems are present. Record these locations in a central clearinghouse.

- Know your enemy, know yourself.

- Develop a plan prior to dealing with PVS & solar thermal systems.

- Do walk through tours of buildings as they're being built. Ask questions of the construction foreman.

NOW WHAT?
INPUT & INFLUENCE LOCAL LAW

- Since NYS has decided to empower local municipalities, we're given the opportunity to suggest facets of local law pertaining to PVS.

- Develop a positive working relationship with building department. Suggest ideas for local laws that affect firefighting operations.

- Get involved with building permit issuances.

- Get policy makers in your municipalities to see a building and subsequent PVS from the perspective of firefighters.

NOW WHAT?
INPUT & INFLUENCE LOCAL LAW

- The update for the International Building Code goes into effect October 3, 2016.
- Notable changes pertaining to PVS:
  - There's a "grey area" when dealing with total roof coverage & ventilation: uses term "...alternative ventilation method has been provided."
  - Arrays can NOT exceed 150 feet in length.
  - Single ridge roofs MUST have 36" walkways on all 4 sides of an array; 18" from any valley.
- The IBC has allowed some latitude to local municipalities; but they've also given the same latitude to PVS installers.

SOLAR PANEL NEWS FROM THE HEADLINES

- San Francisco will start requiring all new buildings under 10-stories to add solar panels. (*cnnmoney.com* 4/21/16)

- NY weighs rules that may limit rooftop solar panels (*poughkeepsiejournal.com* 1/10/16)

- Palo Alto set to make all new homes 'solar ready' (*paloaltoonline.com* 4/13/15)

- Long Island solar power installers object to proposed building codes (*newsday.com* 1/28/16)

- Onondaga County to get 10 percent of power from 31,000 solar panels (*syracuse.com* 11/16/15)

- College Launches Solar Power Panels (*cortland.edu* 5/9/14)

NOW WHAT?
ON SCENE OPERATIONS

- Size up, size up, size up!
- What's burning?
- Talk to the owner/ occupant/manager. Get intel!
- What's the building construction?
- Are their trusses?
- What's your preplan?
- How far advanced is the incident?
- What resources do we need?

NOW WHAT?
ON SCENE OPERATIONS

- An effective 360° will find a PVS, or signs indicating the presence of a PVS.

- Immediate notification to all members of the presence of a PVS; communications is key.

- Isolate the PVS from the junction box ASAP.

- Reiterate to members that the solar panels and conduits are still electrically charged.

NOW WHAT?
ON SCENE OPERATIONS

- If the solar panels or any part of the PVS is on fire, we need the change our tactics; no longer exclusively a type A fire.

- Are their batteries in the system?

- Consider calling for additional resources & specialized resources (i.e.: hazmat, extra command staff, etc).

NOW WHAT?
ON SCENE OPERATIONS

- When PVS cells, panels and arrays are involved, electricity can go anywhere it's not supposed to, due to new pathways from degradation of cells.

- Use of water on burning arrays can lead to electrocution.

- Public utility will NOT do anything with solar panels & arrays, unless they own it.

- Limit members time & numbers on and under roofs. Essential operations only.

- Rule of thumb: members off the roof after the first 10 minutes.

NOW WHAT?
ON SCENE OPERATIONS

Is this array safe to work under?

Not really

Is this array still producing electricity?

Yes

NOW WHAT?
ON SCENE OPERATIONS

- Do NOT spray water directly onto solar arrays with straight stream; use a moderate cone (10°) or fog pattern from a distance.

- Limit lighting up arrays during nighttime operations; consider turning off non-essential emergency lights.

- Even light from a handheld flash light can produce enough of an electrical current to be dangerous.

- AFFF does NOT prevent light from charging panels. CAFS foam reduces electricity production. Don't waste the money.

NOW WHAT?
ON SCENE OPERATIONS

- Don't place ground ladders in contact with solar arrays. Rule of thumb: 3 feet linear distance.

- Use of aerial ladders & PVS: same as ground ladders.

- Don't cut anything attached to a solar array (conduit, panel, etc)

- Be mindful of where you place your tools; keep them away from arrays and panels.

NOW WHAT?
ON SCENE OPERATIONS

Are hand lines safe for this situations?

From a distance

A smarter tactical decision is an aerial platform or elevated master stream onto the PVS.

NOW WHAT?
ON SCENE OPERATIONS

Overhaul poses the greatest risk for firefighters

- Exposed wires that are energized.

- Damaged cells and panels can & will produce electricity; in some cases, full power.

- Boots and gloves do offer some limited protection from electrical current. Keyword: limited.

- Damaging panels & cells with tools during overhaul can lead to electrocution, even in damaged cells.

NOW WHAT?
FRINGE THINKING

- Fringe thinking is your spur of the moment "plan B"

- Specific to the particular incident

- It's the "outside the box" stuff that legends are made of...

- ...or firehouse banter.

NOW WHAT?
FRINGE THINKING

Some examples of fringe thinking

- Taking 2 pike poles, wrapping a green tarp over the edges and covering an array.

- Use ladder pipes/portable monitors for ground mounted arrays on fire versus the use of hand lines.

- Befriend a trust worthy solar array installer; have him on speed dial.

THE FUTURE OF SOLAR ENERGY AND THE FIRE SERVICE

THE FUTURE

Technology is outgrowing our capacity to adequately plan for the future.

50 years ago, who would have thought that our country would be dependent upon technology for every day survival.

15 years ago, who would have thought that 98% of American's would be carrying their home computer on their hip.

10 years ago, who would have thought that PVS would be the next "oil rush".

5 years ago, who would have thought that I'd be teaching here.

Me neither.

THE FUTURE

- Municipalities REQUIRING roof space in future building designs that can accommodate for PVS and solar systems.

- High rise buildings that incorporate PVS technology into windows. Yes, windows.

- Municipalities requiring buildings to have a certain percentage of electricity from solar.

- Solar power assist on electrical vehicles.

SOLAR POWERED WINDOWS ARE A REAL THING

THE REALITY OF SOLAR CARS

REDNECK SOLAR CAR

SOMETHING OUT OF "THE WALKING DEAD"

FIRES INVOLVING SOLAR ARRAYS

DEALING WITH A SOLAR ARRAY FIRE

- Any solar array that is actively burning is a Class A & C fire.

- For single panel or a few cells of a PVS, use CO_2 and/or ABC dry chemical extinguishers.

- For solar thermal systems, water is ok to use. But be wary of runoff.

- Don't try and disconnect a panel or cell; it's still capable of producing electricity & electrocution hazard.

DEALING WITH A SOLAR ARRAY FIRE

- For solar panels that are actively burning, use narrow fog pattern (10°) from at least 20 feet away.

- Do NOT use a straight stream or smooth bore, if possible. This conducts more electricity due to a lack of air in the stream.

- Don't cut wires attached to a solar panel for any reason with any tool. No saws, no bolt cutters, no axes.

- Foam may help extinguish, but electricity will still be produced.

* UL Firefighter Safety and Photovoltaic Installations Research Project - 11/29/2011

SOLAR ARRAY FIRES FROM THE HEADLINES

DEALING WITH A SOLAR ARRAY FIRE

So this is why Apple products are so expensive...
Apple Data Storage Facility
Mesa, AZ 5/26/15

DEALING WITH A SOLAR ARRAY FIRE

New method of smoking meat.
Dietz & Watson Distribution Warehouse
Delanco, NJ 9/1/13

DEALING WITH A SOLAR ARRAY FIRE

The popping and cracking noises were not coming from the chiropractors office

Dentist & chiropractor office.

Latham, NY
5/8/15
Do all these guys belong on the roof?

DEALING WITH A SOLAR ARRAY FIRE

What's going on in Latham? Another solar panel fire.
11/27/15

DANGER

HIGH VOLTAGE

DANGER

Arc flash hazard!
Follow requirements in NFPA 70 E for safe work practices and appropriate PPE. Failure to comply can result in death or injury!

DANGER

NOT ONLY WILL
THIS KILL YOU
IT WILL HURT
THE WHOLE TIME
YOU'RE DYING

IN CONCLUSION

- Treat every PVS as if electrified.
- If you're not willing to put the weight of 10 firefighters on a roof, don't put anyone on the roof.
- 10 minutes, then get off the roof.
- ICE solar panels.
- Head on a swivel. Know your enemy. Know yourself.
- Change your tactics to fit the situation with PVS.
- Think outside the box.
- Isolate the arrays, but don't mess with them.
- 10 x 10: 10 minutes and weight of 10 firefighters. Is it worth it?

ACKNOWLEDGEMENTS

- Underwriters Laboratory Firefighter Safety and Photovoltaic Installations Research Project - 11/29/2011
- duke-energy.com/safety
- firerescue1.com
- solarenergy.net
- ncdoi.com
- wnyt.com
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- The Times Union
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- NFPA
- fireengineering.com
- OFPC
- Kyle O'Connor, Schenectady Fire Department