SOLAR SAFETY

Grid-scale Solar Development Requires Specialized Emergency Response

The economic landscape for grid-scale solar development in Pennsylvania is expanding and changing, bringing more smaller facilities of 15 to 20 acres. This means that more municipal officials need to understand the basics of emergency response at these facilities so they can advocate for optimal safe design with developers and understand the information and training their responders need to be safe.

BY **TOM MURPHY** / PSATS SOLAR PROGRAM EDUCATOR
AND **JOY DROHAN** / WRITER, ECO-WRITE, LLC

Solar energy is proving quite safe, according to studies. Fires tend to occur separate from the panels, and a grass wildfire in California never ignited the panels mounted above the grass.

Editor's note: *This is the eighth article in a series designed to inform municipal officials and employees about grid-scale solar projects. PSATS has partnered with the state Department of Environmental Protection (DEP) to provide these educational opportunities.*

More grid-scale solar developments (GSSDs) are being built with battery storage systems to provide electricity when the sun isn't shining. In a large-scale solar facility, a battery energy storage system (BESS) charges from the solar facility and then discharges, or sends its power out to the grid, later when it's needed.

The U.S. Energy Information Administration said in early 2024 that the capacity of energy storage systems could increase by 89% in 2024.

Solar energy "is becoming a truly safe medium," says Philip Oakes, chief of operations and training for the National Association of State Fire Marshals, an organization that focuses more on fire prevention than firefighting. He teaches other firefighters about safety of solar facilities and BESS.

However, leading firefighters in Pennsylvania still have safety concerns about large solar installations.

How dangerous are solar facility fires?

There is insufficient data in the U.S., but a United Kingdom (UK) government study reviewed all records of photovoltaic system fires it could find in the country for all sizes of systems between July 2015 and February 2018. The study analyzed 80 fire incidents and attributed the cause to the photovoltaic system or something else based on evidence. The report stated that these 80 incidents represented about 0.01% of the number of solar installations at that time in the UK.

Of all 80 fires analyzed, only six involved "solar farms," although the report authors "strongly suspect a degree of under-reporting," as issues are handled by the installer or maintenance engineer. About 36% of the solar-attributed fires were associated with installation errors.

The UK study found that fires in solar energy systems tend to happen most often in direct current isolators, connectors, cables, and inverters, plus energy storage systems. These are separate from the solar panels themselves.

In fact, heat from a small outside flame will probably not ignite a solar panel. For example, a grass wildfire beneath a three-acre array in California in 2015 did not ignite the panels mounted on racks just above the grass.

The greatest danger for firefighters responding to an incident at a large solar development is electrocution. However, as with all firefighting, they can also be burned or exposed to toxic substances. Solar panels run on and generate direct current (DC), which is more difficult to detect than the alternating current (AC) that powers our appliances and lights. In solar farms, on-site inverters transform DC into AC for transmission to the electric grid.

According to **fireengineering.com**, even when the power is shut down, solar panels can continue to generate electricity if exposed to light, even from a flashlight. Oakes says that panel fires don't tend to spread very far, and threatened panels can be covered with a heavy dark tarp or blanket to completely shut down generating power in the event of an incident.

An added challenge of firefighting at GSSDs is that they are often located in rural areas away from fire stations,

Battery energy storage systems (BESS) store and send power to the grid as it is needed.

which could result in longer response times.

Batteries pose additional hazards

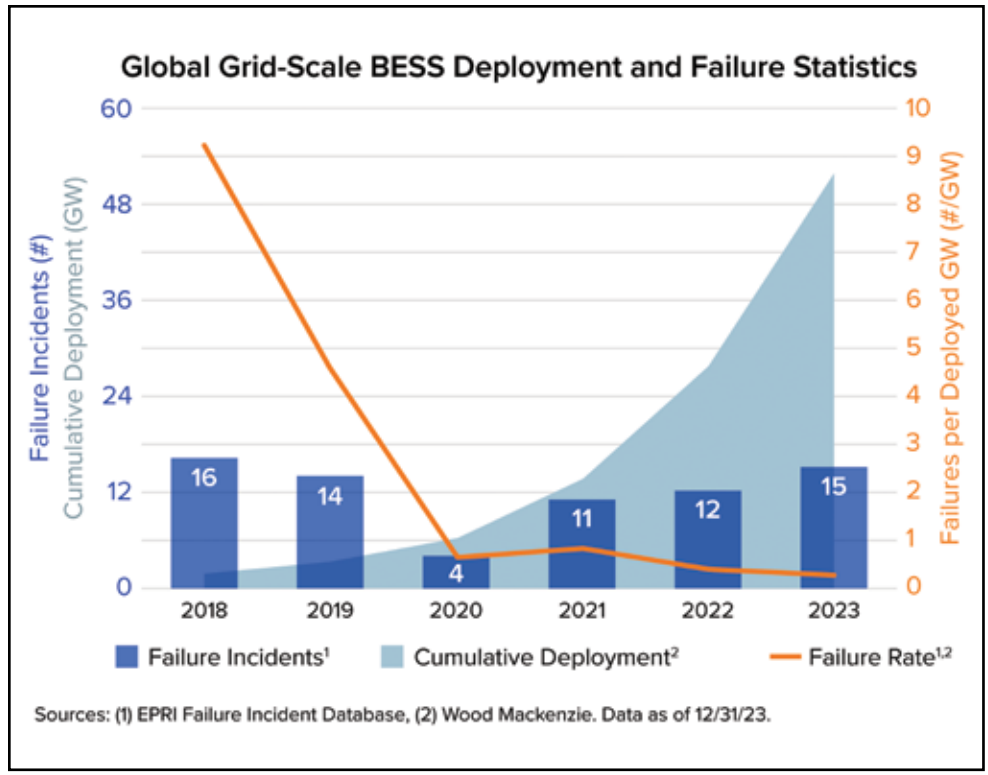
Most batteries used in GSSD are lithium-ion batteries. The chemical reaction that powers lithium-ion batteries can experience "runaway" if the battery temperature goes above 300°F or the battery is damaged. This means that a cell short-circuits or disintegrates, triggering a self-perpetuating chemical reaction that can spread to other cells. The reaction releases heat along with flammable and toxic gases that can burn or explode. Initially, a liquid electrolyte is what burns in a lithium-ion battery fire.

The safety of battery energy storage systems has advanced substantially since their introduction, and firefighters have learned a lot about how to combat fires in these facilities. The diagram pictured shows that despite skyrocketing installations of BESS globally since 2018, the failure rate has plummeted.

BESS are often placed in large metal shipping containers. Faced with a large-scale battery fire, firefighters will stand back and concentrate on keeping the fire from spreading away from the batteries.

The first line of defense is still water, Oakes explains, since it is immediately available. Large amounts of cool, flowing water can slowly cool the battery and help stop the problematic self-perpetuating reaction. This buys time to bring in other chemical firefighting options. Oakes notes that fire researchers are developing new ways to combat BESS fires.

Once the fire is out, the site can still pose dangers. Panels and batteries can remain energized during the cleanup, and hotspots from battery fires can continue for days.



Though installations of BESS have soared, failure rates have fallen. ***[Global Grid-Scale BESS Deployment and Failure Statistics. Sources: 1) EPRI Failure Incident Database, 2) Wood Mackenzie Data as of 12/31/23. From BESS Failure Incident Database, https://storagewiki.epri.com/index.php/BESS_Failure_Incident_Database, used with permission.]***

There are measures developers can take to minimize the dangers of battery system fires. Some best practices for large-scale BESS installations include:

- housing battery systems near the center of a solar development for the safety of surrounding properties;
- providing enough space between battery units to allow adequate airflow;
- placing firewalls within the battery storage container and fire breaks among groups of panels; and
- installing an appropriate fire detection system on site. By containing the fire, it will burn for less time and therefore, limit damage.

Communication and planning are critical

Oakes emphasizes that communication should be a two-way street between the fire department and the solar company. Each must inform the other of its needs and concerns. For example, the solar developer needs to know the hose length of local fire departments before it designs the site so it can place panels and roads to ensure water access throughout the site.

Oakes explains that it is typical for a fire department to have specific response plans for the five biggest threats in its service area, and it should have a plan for fighting a BESS fire.

"Proper planning leads to proper response," he says. Together, the local fire departments and the solar compa-

Together, the **local fire departments and the solar company should develop emergency response plans** for various scenarios.

ny should develop emergency response plans for various scenarios.

Firefighters do not need special equipment to fight fire at a large solar development, but they do need specialized training. The fire department must be informed about solar and BESS facilities. Firefighters must know how to identify energy storage devices, shut down their power, and determine whether the system is energized.

Oakes stresses that in addition to the fire chief and the manager of the solar facility touring the site, firefighters should talk with installation planners and solar maintenance staff. If firefighters on the ground don't know what to expect of the system, they will lose valuable time in figuring out the best response to a fire.

Safety codes apply to solar facilities

The National Electrical Code (NEC) includes requirements that make it easier and safer for first responders to operate at a solar energy system fire. All relevant provisions of the NEC must be followed in design, installation, and maintenance. These include:

- Code 690 – Solar Photovoltaic Systems
- Code 691 – Large-Scale Photovoltaic Electric Power Production Facility
- Code 705 – Interconnected Electric Power Production Sources

Additionally, the National Fire Protection Association Code 855 provides standards for installation of non-residential stationary energy storage systems, and NFPA is beginning to develop other relevant standards.

Philip Oakes, chief of operations and training for the National Association of State Fire Marshals, emphasizes that these codes lay out the minimum standards for building these sites, and ideally, developers should invest more for safety. He also notes that BESS technology is changing rapidly, and codes may be somewhat outdated.

Solar ordinances can address emergency response

Many draft solar ordinances fail to adequately address emergency services needs. Solar ordinances or leases should address best practices for design with emergency response in mind. These best practices can include:

• **Hazards —** Ordinances and leases should consider different types of hazards, including panel fire, battery fire, wildfire, and flooding in siting and system design.

• **Fencing —** A GSSD is essentially a power plant with electrical connections above and below ground, so people and animals should be kept out. Fencing of the site perimeter is typically required, and fence height and type are often specified. Many facilities use 7- or 8-foot-high chain link fence, sometimes topped with barbed wire.

• **Setbacks —** Many zoning ordinances adopt the same general setback

EMERGENCY RESPONSE

rules for GSSD, no matter the size, as for similar uses. Other times, special conditions created by GSSD are considered and new setback requirements are proposed.

The required setback of the panels from the fence and the fence from the road and property line should be indicated. The space should allow operation and maintenance workers to perform their tasks and emergency responders to access the site and turn around at the fence line as needed.

• **Placement of gates and roads —** The facility should have more than one way in and out. Consider the condition of the roads the local fire departments will travel to reach the site. Do they have weight restrictions or other impediments to travel?

The road bed around and through the site must withstand a full water tanker weighing about 80,000 pounds, even in very wet weather.

• **Climate-appropriate vegetation —** Regular maintenance of vegetation below the panels will reduce the chance of wildfire.

• **Warning signs —** Appropriate hazard signs as required by the National Electrical Code should be posted outside the fence and on sensitive equipment inside.

• **Emergency responder training —** The solar developer should pay for any specialized first responder training required. Trainings from the Interstate Renewable Energy Council and the National Fire Protection Association are often recommended.

• **Fire risk assessment —** This should be done before operation begins and at regular intervals. Monitoring with thermal imaging by a drone can identify problem hotspots, although Oakes says this technology may not yet be widely available.

Different companies have different risk tolerances. Some will want to install top-of-the-line equipment to protect their investment, while others will want to do the minimum required.

• **Regular maintenance —** The extent and frequency of site inspections and monitoring vary by jurisdiction and the applicable code, but should be decided on before the system is built.

* * *

Fire departments and solar developers are giving the whole issue of solar and BESS safety more attention these days, which Oakes welcomes.

"The best fire is the one that never starts," he says. "Build it right, and the problems diminish a lot down the road." ✦

Here's where to find more information

To learn more about grid-scale solar and related ordinance review and development, email Tom Murphy, PSATS' solar program educator, at tmurphy@psats.org, or call the PSATS office at (717) 763-0930. Additional resources on grid-scale solar development can be found in the *Municipal Officials' Guide to Grid-Scale Solar Development in Pennsylvania* at **www.marcellus.psu.edu/solar.**