Observations on Fire Safety in Past and Future Battery Energy Storage Systems

Prepared by the Saugerties Conservation Advisory Commission

Summary: Safety and environment impacts of utility-scale battery energy storage systems (BESS) are of utmost concern. Accounts of certain "failure incidents" (usually fires) are disturbing. We offer a detailed overview here to lend perspective.

A review of reported BESS "failure incidents" in the USA finds that BESS fires are infrequent. From year 2025 United States data, the most recent available, the probability of a BESS fire per installation per year can be estimated as 0.6% (95% confidence interval 0.2% to 1%). When they do occur, they don't pose nearly as great a threat to communities, first responders or the local environment as people might infer from accounts of the most extreme occurrences.

This document reviews thirty-eight BESS "failure incidents" in the USA between 2012 and May 2026. Thirty-three are tabulated in the most authoritative database, maintained by the Electric Power Research Institute. The other five were brought to our attention by concerned activists. It looks at the nature and outcomes of the different occurrences (not all of which were actual fires). It focuses on environmental impacts of fires, particularly on the threat of health effects to nearby biota due to toxic gases and metal particulates. It highlights the fact that standards in design and construction have tightened over the last three years; no future installations will resemble the Moss Landing 300 building, site of a fire in 2025 that was far and away the most destructive in US history It recounts how experiential advances in managing BESS fires and training first responders have improved tactics.

We conclude that the probability that a BESS facility built in NYS after 2026 will have a fire that puts a first responder in as much danger as does the average house fire is less than 1% per year. The likelihood that such an event will cause hazardous levels of air, water or soil pollutants outside the fenceline is far lower than that.

Introduction From 2012, when the first utility-scale BESS opened in the USA, through 21 March 2026, America has logged thirty-eight "failures" in which component cells and supporting structures were damaged in a "thermal incident." Concerns voiced by people who live or work where a BESS is proposed often center accordingly on the risk of a fire that would expose nearby residents to toxic gases and smoke and put firefighters in harm's way.

These concerns spring from two facts. Fire in lithium-ion batteries (1) is notoriously hard to extinguish with water, and even with agents specific to chemical fires. Also, in smoke from lithium-ion battery fires (2) some particulates can be metallic (e.g. Li, Ni, Mn, Co). Among the gases, carbon dioxide predominates; gases of intrinsic toxicity include carbon monoxide (CO), hydrogen fluoride (HF), hydrogen chloride (HCl), hydrogen cyanide (HCN), formaldehyde

(CH2O) and volatile organic compounds. Two other gases released in LIB (lithium ion battery fires) the toxicity of which has not been documented are POF3, for which there are many names e.g. phosphoryl trifluoride; and phosphorus pentafluoride (PF5)

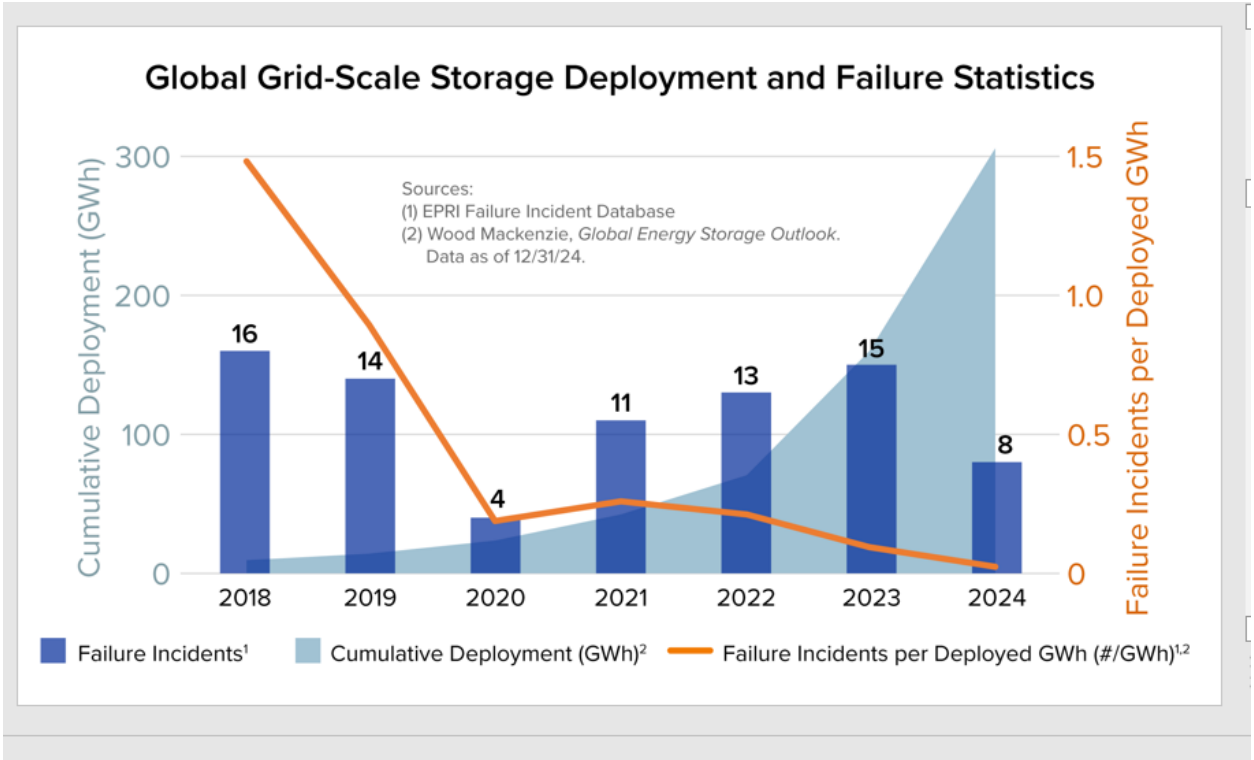
Notwithstanding the above facts, review of reported BESS fires in the USA finds that

- they are infrequent
- toxic gases from a BESS fire have never been documented in dangerous levels beyond the facility boundary and have never harmed a first responder by inhalation
- in only one case has metallic ash been detected outside the facility boundary

The case study of BESS calamities in most articles is by far the worst one in USA history, at the 300 Building, Moss Landing CA, in January 2025. Making it the poster child for opposition to BESS disregards the very low annualized probability of fire in a BESS and leaves a biased picture of the outcome of a BESS fire. Based on data from 2025, the chance of a BESS fire per installation per year (0.6%) is well below the annual incidence of fire on the property of gas stations (2.9%).

Probability of a BESS fire per installation per year In 2025 in the USA there were six BESS fires among the 956 BESS tabulated at cleanview.co . The latter tally does not include installations directly linked to solar, wind or thermal projects; thus 956 is a conservative value for the denominator. The incidence of fires in 2025, then, was 6/956 = 0.6/100 (95% CI 0.2%, 1%). This equates to 1 per 160 BESS per year. In the first four months of 2026, the Electric Power Research Institute file (5) of "failure incidents" has recorded only one, minor, fire. This was at an EV charging station in southern California, not a utility-scale installation. Note well: a brief fire occurred on March 16, 2026 at the Valley Center BESS in California. It was not as of May 3 recorded in the EPRI data set, which does not claim to be comprehensive.

Contrary to intuition, fires are not more likely the larger is the installation. Worldwide (there are no country-specific data for all years), the annual rate of BESS fire per GWh of energy capacity installed has trended down by more than 95% over the years. In 2024 it was 8/300 GWh = .027/GWh. In 2025, using data from EPRI and from Wood McKenzie, (6) it was 12/630 = .02/GWh



Annual incidence of "failure" in BESS per deployed GWh, by year 2018-2024
GWh = gigawatt hr = 1000 megawatt hr

Severity of BESS fires in USA One of the thirty-three "failures" on the EPRI listing was so much worse than any other in mass of battery cells combusted, superstructure damage, turmoil and misery to the neighborhood and monetary costs to remediate that it has retained the spotlight. This was the January 2025 fire in the 300 building at Moss Landing CA, operated by Vistra Energy. Smoke billowed, flames flared high. This is the only BESS fire in the USA after which toxic ash was documented offsite. No one can doubt that this fire had a psychological impact on neighbors. The facility has never returned to operation, never will.

Observations from Larsson et al suggest that with 75% of the battery cells in this plant of 1200 MWh energy capacity totally combusted, the release of HF would have been between 18 and 180 metric tons; yet HF concentration at the fenceline never reached 3 ppm, the lowest level detectable with the instrument. Air monitoring by EPA (7) for many days after did not once register levels of hydrogen fluoride (HF) above the OSHA Recommended Exposure Limit of 3 parts per million outside the fence. Results for consecutive days after the fire began are on-line; click here for Jan 17, the day after the fire began.

There is no doubt that HF is toxic in the high concentrations reached in a confined space. Once outdoors, however, the gases from HF in a battery fire rise and disperse very quickly,

posing no danger to the surroundings. Note that HF gas released under pressure from a tank behaves differently; it may drift in an invisible high-concentration front close to the ground. This is a completely different circumstance from a lithium battery fire.

Much less disruptive to the local community was the distant runner-up for worst American BESS fire, at Gateway Energy, San Diego County CA in 2024. The fire went seventeen days before it was declared finally out. At the Gateway, too, air monitoring never showed hazardous levels. HF was not reported.

ML300 and Gateway, the two leaders in material destruction, have much in common. When first on line, each had been considered the world's largest BESS. The affected cell systems at both facilities were closely packed and indoors. These design flaws made their fires propagate as in no other USA BESS fire regardless of power capacity. Both BESS had been built before National Fire Protection Association standard 855 became the norm for the industry. Large BESS are now in outdoor layouts where sub-units are self-contained and separate, typically in weatherproof structures that look like cargo containers. They are specially engineered to prevent fire spread. The BESS in ML300 was inside the old turbine building of a disused power plant, the roof of which caught fire.

Review of thermal incidents This paper scans the outcomes of all 33 BESS fires in the EPRI database for USA through May 2026 and five others not in that listing. Thirty-seven of 38 were not nearly as bad as the 2025 fire at Moss Landing 300.

The Electric Power Research Institute (EPRI) attempts to keep a running worldwide record of every "failure incident" in a *stationary* battery energy storage system that is at utility scale or "commercial and industrial." Their main case-finding tool is reports in public media. As mentioned above, from 2012 to early May 2026, thirty-three have been logged for the USA. These are re-listed below so that each can be referred to the original EPRI file. For some entries, data on power capacity or battery type or location have been added to the parent file. With each entry a link to a local news story is inserted to allow some assessment of the damage and the extent of threat to public or firefighter safety.

	year				MW	MWhr	type	notes
1	2026	San Marcos	CA					EV charge station
2	2025	Warwick	NY	Church St	4	17.9	LFP	deflagration
3	2025	Peoria	AZ		25	100		1 Tesla Megapack
4	2025	Boulder City	NV		90	360		2 Tesla Megapacks
5	2025	Parkfield	CA		60	240		4/84 Tesla Megapacks
6	2025	Hillsboro	OR					One "room" fire
7	2025	Moss Landing	CA	Vistra	300	1200	NMC	See links in text
8	2024	Escondido	CA		30	120		1 container/24

9	2024	Santa Ana	CA					One container
10	2024	San Diego	CA	Gateway	250	250	NMC	two weeks to put out
11	2024	Kearney Mesa	CA		20	80	LFP	"failure event"
12	2024	Melba	ID		2	8		Burned two days
13	2023	Valley Center	CA	Terra-Gen	140	560	NMC	inside one container
14	2023	Chaumont	NY		5	15		Burned four days
15	2023	Warwick	NY	Church St	4	17.4		alarm 6/26 no fire
16	2023	Warwick	NY	CR-1	8	36		alarm 6/26 fire 6/27
17	2023	East Hampton	NY		5	40		sprinkler doused
18	2023	Millvale	PA				LFP	in a basement
19	2022	Moss Landing	CA	PG&E	182.5	730		1 megapack/256
20	2022	Yellowstone	WY					smoke
21	2022	Rio Dell	CA				Pb A	RV park explosion
22	2022	Chandler	AZ		10	40		smoldered 3 days
23	2022	Valley Center	CA	Terra-Gen	140	560		easily contained
24	2022	Moss Landing	CA	Vistra	100	400		10 racks melted
25	2022	Moss Landing	CA	Vistra	300	1200	NMC	no flames seen
26	2021	Lasalle	IL		36	36	LFP	Did not spread
27	2021	Standish	MI					one container
28	2019	Surprise	AZ		2	2		explosion, 4 hurt
29	2019	Tualatin	OR					one rack, in test
30	2016	Franklin	WI					being assembled
31	2013	Port Angeles	CA					in a mall basement
32	2012	Flagstaff	AZ		.5	1.5		early model
33	2012	Kahuku	HI		10	15	PbA	third fire there

Table 1a. "Failure Incidents" at stationary BESS of "commercial" or "industrial" or "utility" size USA 2012-March 2026 source: modified slightly from table by EPRI cell types LFP Lithium iron phosphate LNMC lithium nickel manganese cobalt PbA lead acid

34	2024	Edwards Sanborn	CA	Terra-Gen	1100		fire suppressed
35	2024	Edwards Sanborn	CA	Terra-Gen	1100		inverter box
36	2024	Edwards Sanborn	CA	Terra-Gen	1100		smoke lessened
37	2024	Edwards Sanborn	CA	Terra-Gen	1100		total loss one
38	2026	Valley Center	CA	Terra-Gen	140		smoke

Table 1b. Thermal incidents at stationary BESS of "commercial" or "industrial" or "utility" size USA 2012-March 2026 that are not in the EPRI listing. Reports on the first four were sent to us by

Jillian Fried, who had obtained NFIRS reports from California under a FOIL request. Ms. Fried also informed us of the incident numbered here 38.

In nine occurrences no exterior flames were reported (nos. 11,13,15,17,20, 21, 22, 25, 34). Inbuilt fire suppression either prevented flames or kept them inside the walls. A September 2021 overheating event at the Vistra BESS in the Moss Landing 300 Building (site of the fire in 2025) caused melted wires and "scorched" racks, but no actual fire. In two (18, 31), the BESS was in the basement of a commercial establishment. In all but the biggest two BESS fires, *both in configurations built before more recent stricter standards*, flames had stopped gaining much ground within 24 hours, though in several burning persisted, needing surveillance. The mass of batteries destroyed in any of the other 31 was *far less* than at Moss Landing 2025 or Gateway Energy. All of the three BESS thermal events at Edwards Sanborn in CA resolved themselves as firefighters watched from a distance, leaving in four hours. The contents of each container were a total loss. The fourth event was fire in an inverter box, not technically the battery itself.

Two explosions occurred in the 38 events. That in 2019 in Surprise AZ (no. 28) sent nine first responders to the ER, of whom four were hospitalized. All four subsequently returned to duty. The technical report on the fire and explosion identified many flaws in design and highlighted that the firefighters had not been properly trained in advance. Lessons learned in design and in training fire-fighters have been incorporated nationwide. A small lead acid BESS at an RV park in California (no. 21) blew its roof off the day after it had been inspected. No one was hurt.

New Yorkers take note: Four "failure events" in New York State (nos. 17, 16, 15, 14) in 2023 impelled Gov Hochul to convene an inter-agency working group. The group reviewed three of the events, probably nos. 17, 16 and 14. (There was no actual fire at no. 15, though that BESS on Church Street was the site of the December 2025 fire in Warwick (no. 2)). The report in 2024 called for many improvements in the NYS fire code for BESS that were included in the 2025 edition. According to a news report, air around the 2025 fire in Warwick did not pose any hazard to the community.

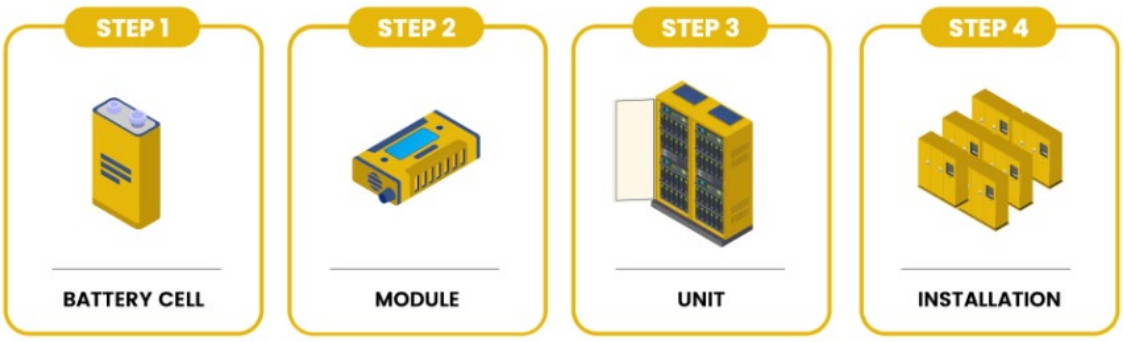
Some of the other failure incidents around the country led to brief cautionary measures like evacuation, shelter in place, highway closure. In none of them, however, did fire rage as it did at Moss Landing Jan 2025 (no. 7) The California Energy Storage Alliance, an industry group, compiled a report on environmental impacts from incidents 7, 8, 10, 14, 16 17 and 19 in the list above. The conclusion was "no public health impact."

Takeaways from review of the 38 BESS "failure incidents" 2012-May 2026

- In none of the several fires at which air monitoring was reported were any toxic gases like HF detected at dangerous levels outside the fence.
- No BESS fire caused documented physical trauma to members of the public or site workers. Investigation continues.
- Heavy-metal ash was deposited outside the fenceline after *the worst* fire (no. 7), but in no other BESS fire.
- One BESS fire (no. 28) seriously injured four fire-fighters. We found no other reports of injury to first responders.
- Fourteen years of experience with BESS fires in the USA have shown firefighters that spraying water into flames is not helpful to extinguish them and can make fire worse. Hose water can be useful for cooling nearby battery containers or cabinets; best practice is to stand down and let the fire die under observation, consuming all its materials. Water running off uninvolved structures cooled in this way is no more contaminated than rain.
- A BESS is unmanned; at newer ones the containers or cabinets have no space to enter; it is therefore most unlikely that a firefighter will have to brave flames, smoke or vapors to rescue anyone as is sometimes needed in a building fire.

Improvements in technology and methodology for BESS safety

- Study of past fire incidents has brought improvements in design and materials at every level of structure from cell to module to unit to container and more rigorous testing protocols for all levels. It has also given insights into training and equipping first responders for safe management of battery fires. New York State Fire Code 2025 requires adherence to UL 9540 UL9540A and NFPA 855



Organization of a BESS. Assembly of cells makes a module. Modules are stacked into units (racks). Racks are arranged in a cabinet or larger enclosure, one or more of which comprise an installation https://bess-sdk.com/resources/bess-101/ul-9540a-explained

- ❖ UL 9540 sets the standards for safety. The latest edition is 2025.
- ❖ Certification to UL 9540 requires UL 9540a testing if indicated by the codes the Authority Having Jurisdiction (AHJ) follows.
- ❖ UL9540a is key to limiting thermal runaway. This rigorous testing protocol was not available in readying the two BESS that have had the worst fires in US history (nos. 7 and 10). Planning for BESS to be built in future in NYS requires 9540a testing.

Sidebar on designs for BESS built in NYS after 2025: These will use materials and designs (e.g. backup cooling systems, sensitive alarms, weathertight containers) that minimize the chance for even a single cell of the thousands to progress from overheating to ignition. UL 9540a leads the way here.

9540a begins with a test of how well a cell of a given size and type can withstand heat directly applied. Can the cell be forced into thermal runaway? If yes, a further test is required to see whether the initiated fire will propagate into the tray of interconnected batteries ("module") where it started and possibly trigger thermal runaway at that level.

If runaway is induced in the module, a test of the next level of organization is required. This is the stack of modules called the "unit" or "rack." The aim now is to see if a fire in one unit will spread to another unit or open a wall. If severe challenges can't make fire in the incited unit jump to a nearby unit, no further testing is needed.

Some large BESS house a cluster of units, e.g. eight, in one metal "container" with its own cooling system. The containers used there undergo installation-level testing required by 2026 NFPA 855 to ensure that fire will not jump from the container of origin to another non-contiguous container even in the absence of external fire suppression measures.

- ❖ An additional safeguard in NYS is the Peer Review Program, which requires a second opinion by an outside expert on the quality of every phase in planning, building and operating a BESS of over 600 KW capacity.

Sidebar on Peer Review Program, quoting from the NYSERDA Guidebook

> "Critical battery energy storage system (BESS) permitting deliverables, particularly the Hazard Mitigation Analysis (HMA), Failure Modes and Effects Analysis (FMEA), and UL 9540A test reports containing product-level test data, collectively contain information on which to base important siting decisions and requirements. Misinterpretation or misunderstanding of these deliverables can lead to design and installation of energy storage systems for which the requirements of Fire Code of New York State (FCNYS) 1206 are not sufficiently met. Peer reviews by experts in the field can assist local authorities having jurisdiction (AHJs) in their review and understanding of BESS permit applications and their compliance with existing fire code requirements. The 2020 FCNYS Section 1206.8 Peer Review1 gives local AHJs the authority to require that BESS developers pay for an independent peer review of the developer's permit application."

- ❖ A third element of safety, continuing from commissioning to decommissioning, is periodic inspection.

Sidebar on periodic inspection,

According to NYSERDA, the Authority Having Jurisdiction (e.g. municipal governing body) is responsible for ongoing checks on maintenance of all equipment and modifications of hazard management plan. Paul Williamson of KCE responded to an inquiry from the Saugerties Conservation Advisory Commission chairperson that if KCE operated a BESS in Saugerties, the company would "conduct periodic operation and maintenance tests through the life of the project, which includes tests of the safety systems. These are important for us because we want to protect our investment, but they are also required by our insurance and financiers. And again, the Town Planning Board can stipulate that these be made available to the Town Inspector and/or Fire Marshall or Fire Chief so the Town is involved and informed of the safety of the project through the life of its operations."

NYSERDA also has its own every three years inspection.

Conclusion We conclude that the probability that a BESS facility built in NYS after 2026 will have a fire that puts a first responder in as much danger as does the average house fire is less than 1% per year. The likelihood that such an event will cause hazardous levels of air, water or soil pollutants outside the fenceline is far lower than that.

Afterword on injury statistics. The 3.3 million miles of gas and oil pipelines in the USA make them much more important to date in America's energy economy than BESS. Such a vast network also exposes far more people to risk of accident than do the country's 1500-or-so commercial or utility-scale BESS behind their fences.
In that sense, the comparison of injury statistics below is unbalanced. Still, the two columns of zeros under BESS have meaning.

	PMHSA pipeline			BESS	
year	incidents	deaths	injuries	deaths	injuries
2021	25	9	32	0	0
2022	13	1	16	0	0
2023	23	16	38	0	0
2024	22	12	34	0	0
2025	27	11	34	0	0

Table A. Deaths and injuries in serious incidents tracked by Pipeline and Hazardous Materials Safety Administration compared to those in the EPRI data base on failure incidents in BESS, by year. Notes: (1) serious incidents by definition involve death or injury (2) pipeline incidents exclude all "fire first," in which an external fire preceded the pipeline incident.

Addendum 1: On April 28 we were notified of a report published August 2025 https://cleanpower.org/resources/assessment-of-potential-impacts-of-fires-at-bess-facilities/ At more than 50 pages of text, it must be the most thorough and technical analysis of thermal events in lithium ion battery aggregations available now in the USA. It includes thirty-five events from 2011 through 2024.

The report, prepared for American Clean Power, an industry group, caught our eyes now for these two reasons: First, it may offer insight into how well the EPRI database on large stationary BESS captures all relevant events. Second, it incorporates findings on air, water and soil testing after two events for which our review had not covered such testing.

Regarding the first reason, the EPRI database for 2012 through 2024 has twenty-six failure incidents, two of which (Rio Dell CA and Kahuku HI) are not in the ACP paper as they involved lead acid batteries. The ACP list has nine events not in the EPRI database for sizable stationary BESS. These include four non-BESS episodes that involved large aggregations of Li batteries. Three of these were in transportation (Baker CA 2024, Columbus OH 2024, San Pedro CA 2024) and one in a battery recycling plant (Fredericktown MO 2024). A fifth occurrence not in the EPRI stationary BESS list was a fire in a mobile trailer-mounted BESS used to charge EV charging stations (Baker CA Jan 2023). Significantly, these five are in the companion EPRI file kept for "other energy storage failure incidents."

That four of nine incidents in the ACP lithium battery fire file are not in either of the EPRI databases raises the possibility that the thirty-eight cases we reviewed do not make up the national total. Missing items, however, would be so small or so remote from population that they would have triggered no news coverage.

We ourselves found a news report of a battery storage fire in a basement in August 2025 in Los Angeles, also not in the EPRI data set. The installation must have been relatively small not of commercial or industrial size. The lead acid batteries did not fail primarily. They were ignited by a nearby trash fire.

The review done for CPA also spotlights a subset of BESS fires where environmental sampling or monitoring was done. Our review identifies a slightly different set on which results were presented in technical reports, industry publications or news media.

Saugerties CAC review	*FRA review for CPA*
East Hampton NY	East Hampton NY
	Surprise AZ
Escondido CA	Escondido CA
Warwick NY CR-1 2023	Warwick NY CR1 2023
Chaumont NY	Chaumont NY

Melba ID

Gateway, San Diego CA
Moss Landing Elkhorn 2022
Moss Landing Vistra 2025
Warwick Church St 2025

The table below is from the literature review done for the CPA.

Table 1: Summary of Environmental Sampling Performed at Case Study BESS Fires

Event #	Location	Date	Air	Soil	Water
1	Valley Center, CA	5-Apr-22	N/A	N/A	N/A
2	East Hampton, NY	31-May-23	X	X	X
3	Surprise, AZ	19-Apr-19	X	X	X
4	Escondido, CA	5-Sep-24	X		X
5	Lyme (Chaumont), NY	27-Jul-23	X	X	X
6	Melba, ID	2-Oct-23	X		
7	Warwick, NY	26-Jun-23	X	X	X

In addition to the case studies summarized above, a large indoor BESS fire occurred on January 16, 2025, involving a 1,200 MWh system at Moss Landing, CA. This facility, uniquely designed to operate within a historic, retrofitted former natural gas plant, is anomalous in several ways and would not be allowed under today's codes and standards. Accordingly, this incident is described separately in Appendix B and is not reflected in the conclusions of this report.

That review did not include the fire at Moss Landing in January 2025. A fact sheet assembled by CESA presents data from the Monterey County Vistra fire dashboard that show no injurious levels of air, water or soil pollutants outside the perimeter of the facility.

The Executive Summary part 1 of the CPA paper concludes thus:

"In none of the reviewed cases of environmental sampling related to the BESS fire events were contaminant concentrations found that would pose a public health concern or necessitate further remediation. This finding includes airborne contamination sampling conducted on-site, off-site, and within nearby communities, as well as relevant sampling of water from firefighting activities, automatic suppression system run-off, and groundwater testing in specific instances."

Addendum 2 2 June 2026 as a post-script to the conclusions of the review done for CPA–Ms Elizabeth Reece alerted us on June 2 2026 to *Newsday*'s having reported that the Suffolk County Water Authority has brought suit in federal court alleging that a type of PFAS recently found in wells near the East Hampton site of a BESS fire in 2023 is due to contamination by water applied in fighting the fire. If this premise is upheld, it contradicts the statement in the CPA review NB: water used as it was in that case is no longer a recommended practice for BESS fires.

Corresponding author of this review is Stephen Shafer MD MA MPH, Saugerties. Tel. 917 453 7371 Members of the Saugerties Conservation Advisory Commission have commented extensively on this and previous versions. 14 June 2026

Realizing that hyperlinks are no use if one is reading a print copy, we started to list urls on this page, then decided not to continue. A piece of this length is much more likely to be read on line than from a printed copy.

(1) Larsson, F., Andersson, P., Blomqvist, P. *et al.* Toxic fluoride gas emissions from lithium-ion battery fires. *Sci Rep* **7**, 10018 (2017). https://doi.org/10.1038/s41598-017-09784-z
(2) https://www.usfa.fema.gov/a-z/lithium-ion-batteries/risks-and-response-strategies/
(3) LITHIUM-ION BATTERY FIRES AND EMISSIONS CHARACTERIZATION REPORT Texas A&M Engineering Extension Service 2024
(4) https://industrialfiretx.com/gas-station-fire-statistics/
(5) https://storagewiki.epri.com/index.php/BESS_Failure_Incident_Database
(6) https://www.woodmac.com/news/opinion/global-energy-storage-market-surpasses-100-gw-annual-installation-milestone-in-2025/
(7) https://www.readymontereycounty.org/emergency/2025-moss-landing-vistra-power-plant-fire/us-environmental-protection-agency-epa-the-monterey-bay-air-resources-district-mbard-and-vistra-air-quality-monitoring-updates