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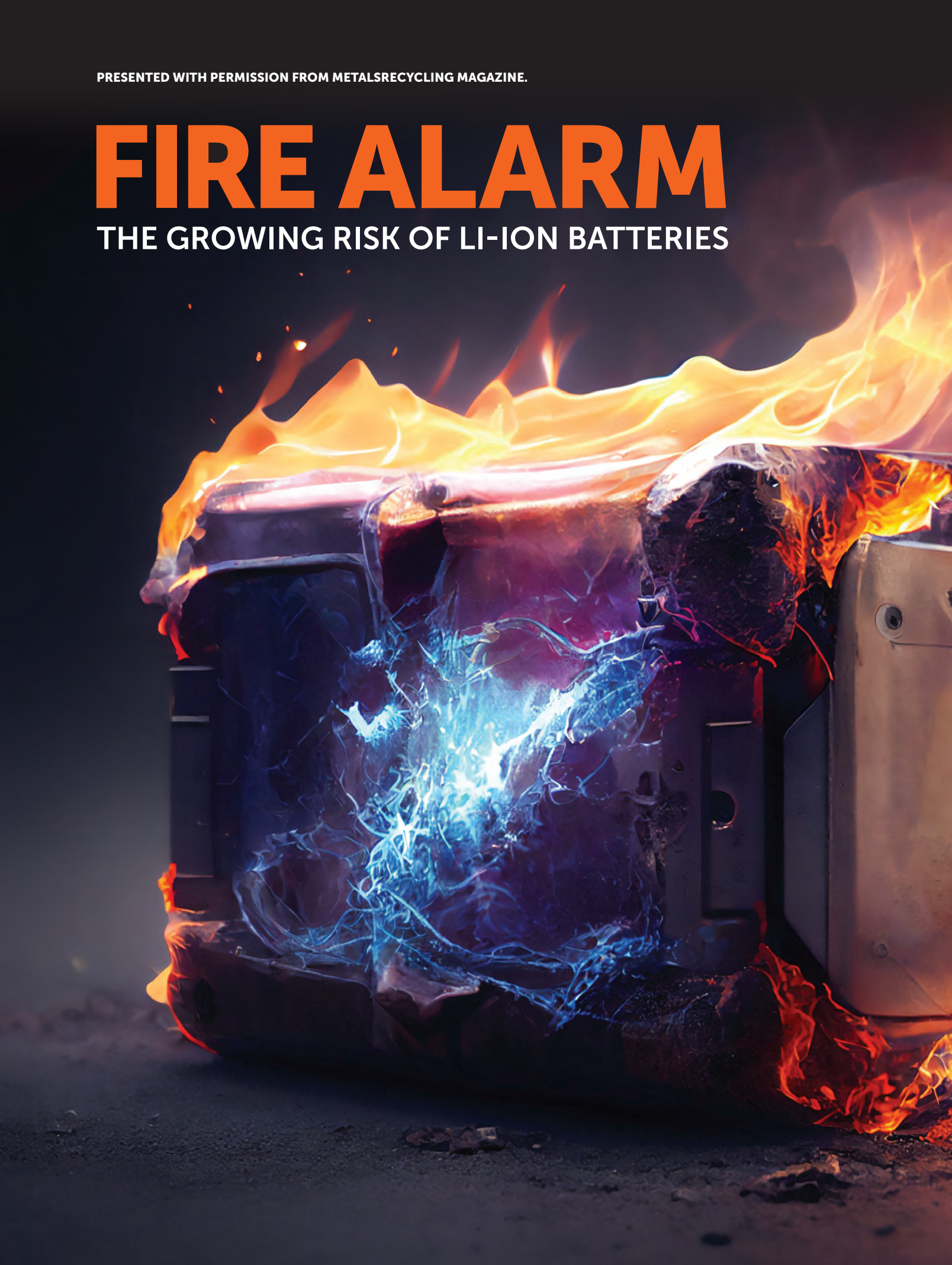
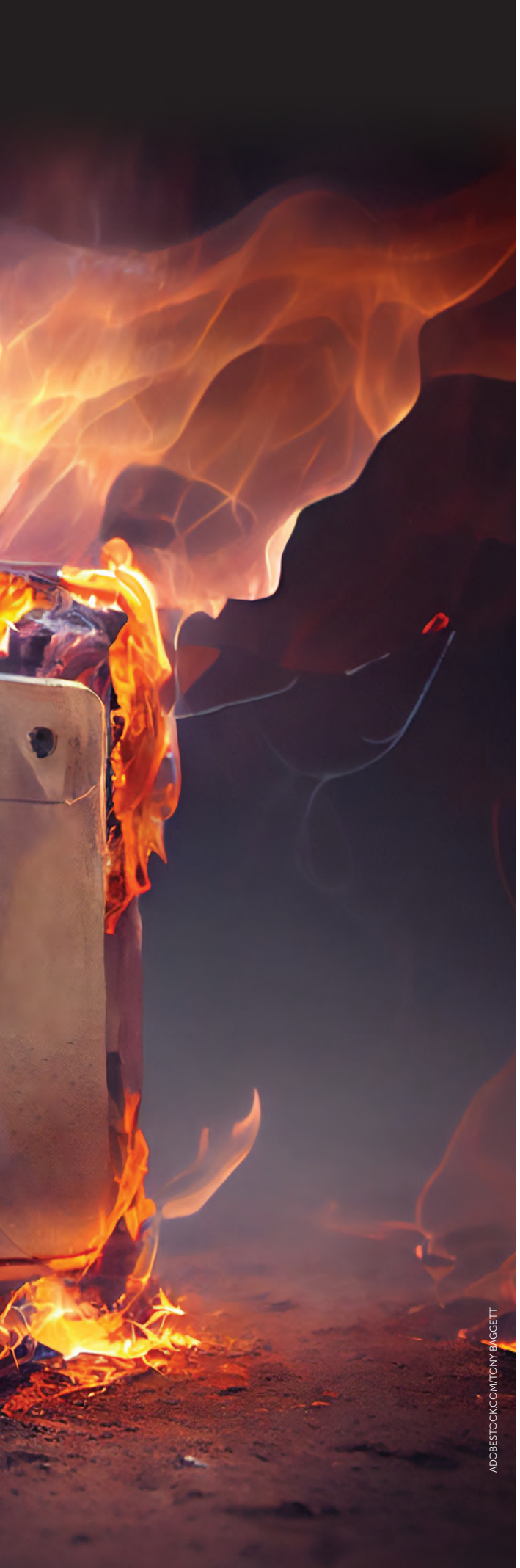
FIRE ALARM

THE GROWING RISK OF LI-ION BATTERIES

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Lithium-ion batteries are causing fires at an alarming rate in recycling and waste management operations, spurring stakeholders to explore educational, operational, technological and governmental solutions to this growing problem. BY KENT KISER

The news headlines tell the story:

- "Lithium Battery Fires Are Threatening Recycling as We Know It" (Vice)
- "Lithium-ion Battery Fires Continue to be a Growing Threat to the Industry" (Waste360)
- "Recycling plants are catching on fire, and lithium-ion batteries are to blame" (The Verge)

In short, lithium-ion batteries (LIBs) are causing fires at every stage and in every sector of recycling and waste management, including scrap processing yards, electronics and battery recyclers, materials recovery facilities, transfer stations, collection trucks and landfills.

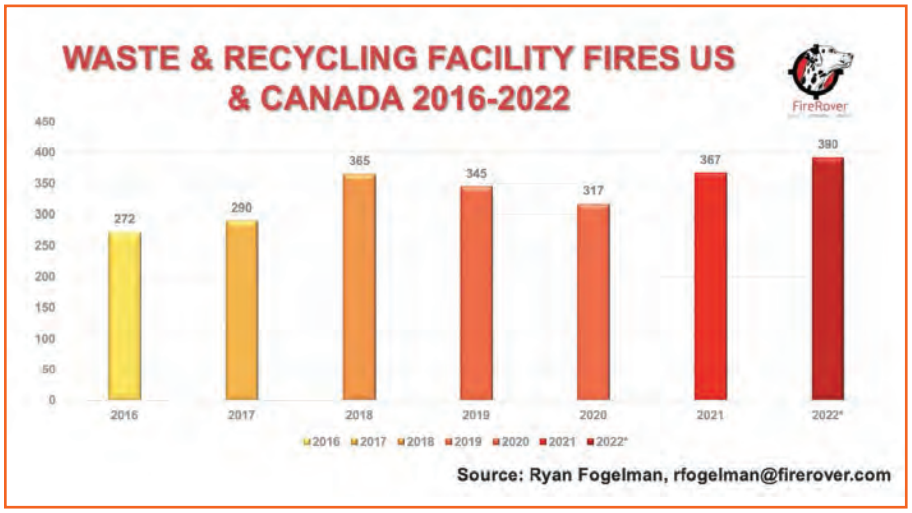
How bad is the problem? In 2022, waste and recycling facilities in the U.S. and Canada experienced 390 publicly reported fires, according to data from Ryan Fogelman of Fire Rover, Farmington Hills, Michigan, a provider of fire detection and suppression technology. The estimated number of nonreported LIB fires at such facilities boosts that number to more than 2,400—which is "extremely conservative," he said—and 2023 is on track to surpass last year's record total.

The risks and ripple effects of LIB fires are extensive. First and foremost, such fires threaten the health and safety of recycling/waste workers and firefighters. LIB fires also can cause significant property damage, ruin the marketability of recyclables, lead to employee furloughs or layoffs, disrupt recycling/waste service schedules, increase business costs and pose hazards to nearby communities and the environment through air pollution, toxic water runoff and collateral property damage.

Currently, the costs of LIB fires fall on recycling/waste operators, their insurers, municipalities and local fire departments, though some states have passed laws to make manufacturers help with the management and costs of end-of-life batteries. As the stakeholders debate who should pay and which strategies will best mitigate the problem, everyone agrees on one point: LIB fires will remain a threat to the recycling/waste industry for the foreseeable future.

LIB BASICS

LIBs are used in an array of consumer electronic products, including smartphones, tablets, laptops, e-cigarettes, drones, hearing aids, greeting cards, e-bikes, e-scooters and electric vehicles. LIBs are popular due to their high energy density, which means they store a large amount of energy relative to their size and weight. And the demand for LIBs in consumer devices is expected to continue rising at a near-exponential rate. Plus, "the batteries are getting bigger, which means



The number of reported LIB fires dipped during the pandemic, but the past two years exceeded the previous record—and the 2023 total is on track to hit a new high.

the consequence of fires from them is getting bigger," said Eric Frederickson of Call2Recycle, an Atlanta-based consumer battery recycling and stewardship program. "The bigger the battery you have, the more capability it has to light other things on fire."

In general, LIBs are safe products with an extremely low failure rate.

"Contrary to what the media coverage implies," Fogelman said, "lithium-ion batteries do not typically explode for no reason. The issue is that batteries that are treated improperly, incorrectly charged or made with substandard parts or materials are the ones that burn."

When LIBs get into the recycling/waste stream, for example, they can get crushed in a collection truck, run over by a front-end loader in a recycling facility, punctured in a baler or shredder, jostled on a conveyor belt or overheated in a scrap pile.

When a LIB is damaged, it can undergo a process called thermal runaway in which the heat from one cell in the battery ignites the other cells in succession like matchsticks. As the temperature and pressure rise in LIB battery cells, they can release toxic and flammable gases that can ignite or explode. And due to their multicell design, LIBs can reignite hours or even days after their initial flames are doused.

FACTORS BEHIND THE FIRES

LIBs have been in commercial use for decades, so why the recent rise in LIB fires in the recycling/waste industry?

The main factor is the growing number of devices that include LIBs, which has increased the number of LIBs and LIBs-containing devices in the recycling/waste stream. That proliferation boosts the odds that more of those batteries and devices will get damaged and start fires.

Another big-picture factor, Fogelman said, is greater stress on the recycling/waste infrastructure due to the global "green" trend, which is increasing the volume of LIBs in the recycling system.

As Frederickson noted, "we've got a population with an increasing eye toward sustainability who want to do the right thing with their electronic products at end-of-life. Sometimes people are misguided and try to recycle those products the wrong way."

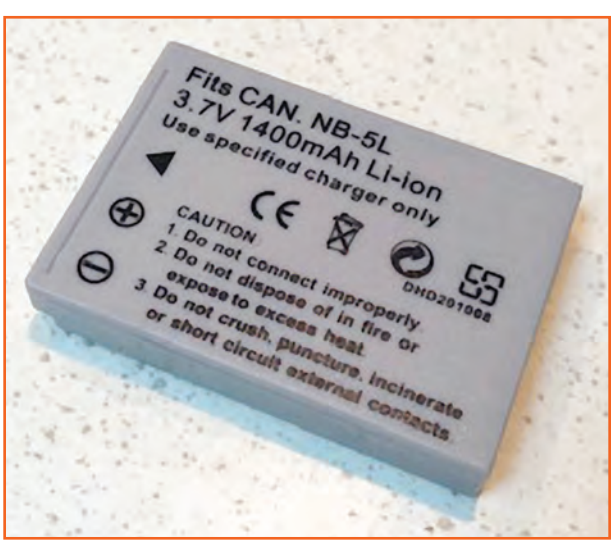
Then there's the ongoing staff shortage in recycling/waste operations, which allows more LIBs to slip through the operational cracks and cause fires, Fogelman said. The escalating heat and dryness around much of the U.S. also creates potential overheating conditions that could lead to more LIB fires. In the pandemic era, Fogelman added, the growing presence of alcohol-based sanitizer products in the recycling/waste steam added an accelerant risk to the LIB fire potential. And—last but not least—there are not enough firefighters properly trained or equipped to fight LIB fires, which can cause a manageable LIB fire to quickly become a runaway one, he said.

ADDRESSING THE PROBLEM

So, what can be done to address the growing LIB fire threat in the recycling/waste stream?

Educate the public. Since much of the problem stems from consumers tossing LIBs and LIB-containing devices into their recycling and waste bins, a key solution is educating them on the potential dangers of LIBs and

The labeling on LIBs—such as this battery from a digital camera—can confuse consumers, who can interpret the chasing-arrows symbol as a green light to throw such batteries in their curbside bin. In reality, the symbol may only be included for international compliance and/or to suggest that the batteries are recyclable only through proper channels.



KENT KISER

One key to reducing LIB fires is educating consumers to recycle their LIBs and LIB-containing devices properly and not toss them in their recycling or waste bins. Toward that end, Call2Recycle offers educational resources through its "Avoid the Spark—Be Battery Safety Smart" campaign, which includes a video, poster, logo and other collateral for general use.

persuading them to stop putting such items in their bins.

Ideally, consumers should—whenever possible—remove LIBs from their devices, tape the terminal ends and drop them at their local household hazardous waste facility, a Call2Recycle bin at a participating retail store or a large retailer like Lowe's or The Home Depot. Consumers can potentially find other recycling outlets through Earth911.com or contact private battery recycling companies. As for devices with non-removable LIBs, consumers could direct the devices to an electronics recycler, call their local solid waste authority or contact the manufacturer.

According to Frederickson, Call2Recycle collected more than 3 million pounds of consumer LIBs in 2022, and its collection volume continues to grow by double digits each year. The group also recently launched an e-bike battery recycling program, currently with more than 1,900 drop-off locations. Despite the success of those programs, there is room for improvement—especially considering that more than 2 billion pounds of new LIBs will enter the U.S. market this year. But Frederickson pointed to previous successful public education campaigns on matters such as seat belts and smoking as cause for optimism regarding the public's LIB recycling efforts.

"There is still a very large opportunity to educate the public to do the right thing with their end-of-life batteries," he said. "It is possible to make behavior changes in the long run that will help the world out."

Fogelman is less optimistic. The reality, he said, is that consumer education "is confusing, expensive and largely ineffective in the short term—and the jury is still out for the long-term benefits. We have been spending these dollars for a few years and are still having major incidents and catastrophic losses."

Consumer education also only affects the curbside recycling and waste sectors, he said, with "no effect on the fires at scrap metal, construction/demolition and e-scrap operations, which still deal with LIBs as part of a power source in appliances, cars, burned down buildings and more."

In addition to understanding the fire risks of LIBs, consumers should know that LIBs are valuable, so recycling them can reclaim raw materials such as lithium, cobalt, manganese, nickel and graphite, reducing the need to mine virgin resources. When LIBs are discarded rather than recycled, those intrinsic materials—some of which are considered critical minerals—are lost.

In truth, consumers have good reason to be confused about how best to handle LIBs.

"As there are no standardized labels in the United States for LIBs, and the products are often labeled for international compliance," the U.S. Environmental Protection Agency (EPA) says. "LIBs are also sometimes labeled with the 'chasing arrows' recycling symbol and/or that of a trash can with an 'X' over it, which can confuse customers and lead to LIBs being tossed in regular recycling bins rather than being sent to specialty recyclers."

Implement operational best practices. Since recycling/waste operators can't count on consumers or suppliers to keep all LIBs out of their inbound material, they are implementing operational best practices to safeguard their employees and facilities.

Such practices can include a comprehensive fire prevention and management plan as well as emergency response training. Specific operational strategies can include:

- diligent housekeeping to limit dust and material buildup that could serve as fuel;
- limiting the size of material piles and keeping piles clearly separated to prevent fire spread;
- inspecting inbound material for LIBs and LIB-containing devices;
- safely managing any LIBs removed from incoming material;
- having the appropriate fire protection equipment/system on-site; and
- working with local firefighters so they know your facility layout, the materials you recycle and how best to combat LIB fires.

"Firefighters are best at what they do a lot, so they're most effective at house fires," said Kenn Kunze, a former fire department battalion chief and principal of IC Fire Prevention, Columbia City, Indiana, since 2015. "When they get into an industrial fire situation, they need to be aware of the processes and materials that exist there. You know more than your fire department about those factors, so teach each other. Find out what they know that you don't—and what you know that they don't—to become the most effective response team together."

Jerry Sjogren, senior director of safety at the Institute of Scrap Recycling Industries (ISRI), Washington, D.C., agreed.

"We preach to all of our members that you should have a good relationship with emergency services and not

be afraid to bring them into your facilities," he said.

ISRI offers resources to assist recyclers with LIB- and fire-related best practices, including a *Guide to Creating a Fire Prevention and Management Plan*, videos on fire-related topics and a free, four-hour course on Hazard Recognition: Fire Safety & Prevention in Recycling, funded by a grant from the Occupational Safety and Health Administration.

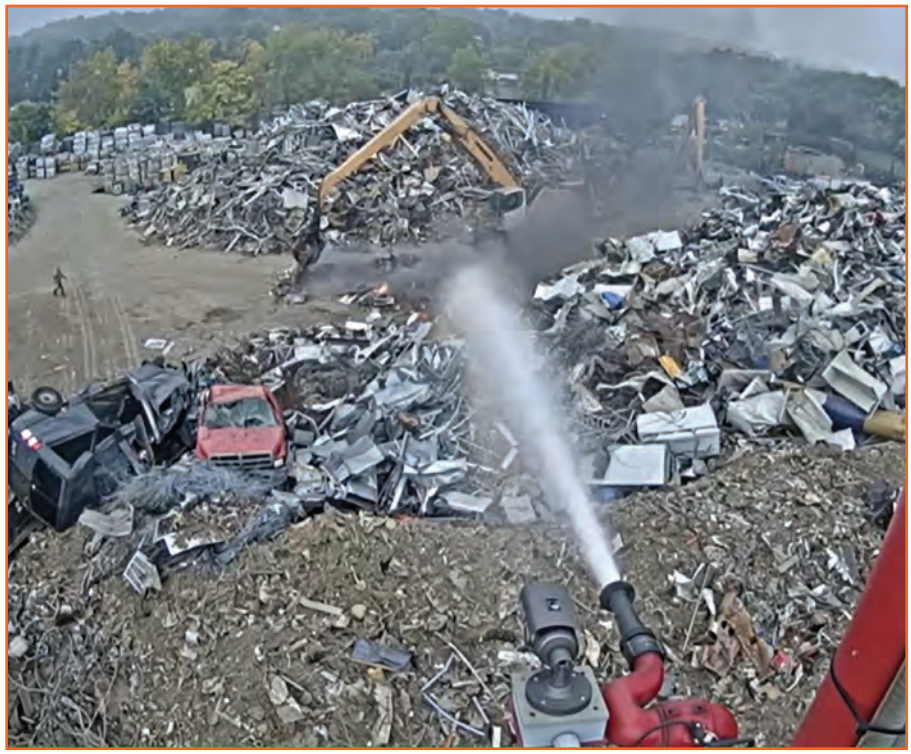
"We've probably trained about 1,000 people in that program so far," he said. "We've got all this great information, and we want to share it."

ISRI and partners also recently launched a new training program—High Voltage Electric Vehicle Technology Training for Recycling Professionals—on the safe handling of electric-vehicle (EV) batteries. In addition to an online, on-demand module, this program will offer an in-person, technical classroom course and hands-on training on how to safely handle electric vehicles in collaboration with Call2Recycle, Energy Security Agency, Piqua, Ohio, and other industry experts. A third component will be targeted to management professionals responsible for on-site management of batteries in their operations.

For auto dismantling operations—which increasingly are receiving battery-containing EVs—the Automotive Recyclers Association, Manassas, Virginia, also offers safety resources on safely handling and managing such batteries. And Suppliers Partnership for the Environment, a forum of global automotive manufacturers and their suppliers, just released a free guidance document on *EV Battery Safe Handling & Storage*.

Consider Fire Detection/Suppression Technology. No amount of training and best practices can prevent all LIB fires in recycling/waste operations.

"With all the measures that we could consider to try and stop fires, we're still going to have the likelihood of a fire," Kunze said. "So, with the goal of preventing large fires, being prepared to detect early and respond effectively is going to be the next step."



FIRE ROVER

High-tech fire detection and suppression systems—such as this one from Fire Rover—identify hotspots, smoke and fires early, notify local firefighters and then spray an environmentally friendly cooling agent around the problem area to slow down or prevent thermal runaway.

Or, as Fogelman put it, "even after doing everything right, there are still fires, so that's where technology comes in."

Kastle Systems, Falls Church, Virginia, for one, offers a detection system that uses advanced thermography cameras with built-in radiometers to monitor the surface temperature of covered areas/material in recycling/waste facilities. If the temperature exceeds a predefined level, the system notifies representatives in Kastle's 24/7, UL-listed central station in Virginia, who then contact the customer and notify the local fire department.

Fire Rover offers a system that uses military-grade thermal cameras as well as optical smoke and flame detectors to catch fire risks early. The system uses analytics to filter out false alarms and verifies legitimate threats using human agents who are on duty 24/7 in a Fire Rover office. When a threat is verified, the Fire Rover agent immediately notifies local fire authorities. Then, operating the customer's on-site Fire Rover system remotely via video camera, the agent sprays an environmentally friendly cooling agent on the material around the hotspot or fire to slow down or eliminate thermal runaway, breaking the fire chain and allowing the fire to burn itself out.

"We focus on the first 10 minutes between prevention efforts breaking down and when the fire department arrives on the scene to fight the fire," Fogelman said.

When it comes to such technology, Sjogren advises operators to take a candid look at their operations.

"There are solutions out that there that will help but you need to examine your processes, your materials and your facility to see if those particular solutions fit," he said.

Kunze agreed, adding, "Sometimes operators think they can buy a solution

when really the best solutions are in focusing on prevention."

If a LIB fire does occur, Kunze encourages recyclers to call the fire department right away, even if they begin to fight the fire on their own.

"Large fires are what get the headlines, and small fires can become large fires if you don't call the fire department quickly," he said.

When facing a LIB fire, Fogelman said, "the biggest issue is that you do not fight lithium-ion battery fires like typical ones. The key is ensuring that all material or collateral assets near the fire incident cannot burn by applying the proper suppression material as soon as possible."

Hazard Control Technologies (HCT), Fayetteville, Georgia, a provider of fire, vapor and contamination control solutions, recommends the use of its F-500 encapsulator agent, which can be included in handheld or wheeled extinguishers or mixed with the water in a recycler's sprinkler system or a fire department's hose system. Among its advantages, said HCT's Jeffrey Bonkoski, F-500 does not contain any fluorinated active ingredients and significantly reduces the amount of water required to extinguish a fire. The agent also can reduce the carcinogens and toxins in black smoke, encapsulate flammable liquids so they're no longer a flammable hazard and encapsulate flammable gases in the air so they can't find an ignition source downwind, Bonkoski said.

According to HCT, F-500 "is made to cool a fire and the surrounding structures, with the ability to absorb six to 10 times more heat energy than plain water, without the creation of superheated steam."

In tests, the agent has reduced the temperature of a fire from 1,000 degrees F to 100 degrees F in seconds.

"By dropping the temperature below the ignition level, you eliminate the source for reignition," said HCT's Ron Lowrey.

"When we talk with fire departments, they're all looking for a solution for the battery fires," but they often face budget constraints and view battery fires as the recycler's hazard responsibility, Lowrey added. "So we encourage recyclers to house F-500 on-site that the fire department could use, then train the firefighters why it's so effective on battery fires."

If the firefighters instead use a fluorinated foam or volumes of water to fight a battery fire, "it's going to lead to an environmental nightmare that the recycler will be on the hook to clean up," he said.

Hold manufacturers responsible. Up to now, recycling/waste operators, insurers, fire departments and municipalities have borne the costs of LIB fires—a situation that's prompting push-back, and action, from those stakeholders as well as industry associations and government agencies and officials.

"It is only fair that some of the costs of these fire hazards—which, in my estimation, cost more than $1.2 billion in the U.S. and Canada—should be borne by the battery manufacturers," Fogelman says. "We need to hold the entire lithium-ion battery supply chain accountable for the products it is manufacturing—not because the battery producers are evil corporations but simply because they should be good stewards in sharing the benefits and costs of the products they make."

Frederickson added, "We need to have end-of-life pathways for products, and the scrap recycling community can't be expected to just bear the cost of recycling those products. It's in everyone's best interest—including manufacturers, policymakers and nonprofits—to make sure we've got a healthy scrap and recycling community."

One option, Fogelman said, is to hold LIB manufacturers "responsible for providing the equipment, technology and training needed to combat the fire problem we currently face." Manufacturers also could subsidize operators' insurance costs, which have increased due to LIB fire risks and losses, he said. In some cases, operators can't even secure insurance now.

"So far, manufacturers have avoided paying for any of the real problems," he said. "We have to hold them more accountable. They're trying to get everyone *not* to look at them."

Some states *are* looking closely at them and passing extended producer responsibility (EPR) laws that require LIB battery manufacturers to provide money and/or other assistance to manage end-of-life LIBs. California, Washington, New York, Minnesota and Washington, D.C., have enacted LIB EPR-related laws, and at least six other states already had battery laws on the books, though those laws don't necessarily cover all battery chemistries. "Government really needs to step up and solve this problem," Fogelman said. "The government can decide what should happen."

Promote battery standards and recycling. Government officials also are introducing legislation to ensure that LIBs—especially those used in e-mobility products—meet recognized

safety standards. The New York City Council passed a LIB legislative package earlier this year in reaction to the growing number of LIB-related fires in the city, including several that caused fatalities. The legislation prohibits the sale of e-bikes, other powered mobility devices like e-scooters and batteries that don't meet a recognized safety certification such as UL.

Similarly, New York state representatives introduced legislation that would ban the manufacturing, sale and distribution of all LIBs and chargers for light e-powered vehicles and personal e-mobility devices that do not meet minimum safety standards. A second bill would prohibit the sale of used LIBs intended for use in e-bikes, e-scooters or limited-use motorcycles.

On the federal level, Rep. Ritchie Torres (D-New York) introduced in March the Setting Consumer Standards for Lithium-Ion Batteries Act (H.R. 1797), which would require the Consumer Product Safety Commission (CPSC) to establish a final safety standard for rechargeable LIBs in e-mobility devices. The bill focuses on ensuring that LIBs and chargers for e-mobility products are tested and certified to accepted safety standards.

"There are a lot of poorly made imported batteries on the market," Frederickson said. "The government has a responsibility to keep those batteries out of the hands of U.S. consumers."

Several federal government agencies also continue to conduct research projects and hold stakeholder meetings to find solutions to LIB fires. In February 2018, for instance, CPSC released a report on its High-Energy-Density Batteries Project, which focused on ways to improve the safety of high-energy-density batteries such as LIBs.

In October 2021, the EPA's Office of Resource Conservation and Recovery hosted a two-session, multi-stakeholder workshop to brainstorm solutions on preventing fires from end-of-life LIBs and how best to promote the recycling of small/consumer and large-format LIBs.

More recently, CPSC held a public meeting on LIB safety in July, seeking to "gather additional information from experts in battery safety, fire prevention and other aspects of consumer product safety to further its understanding of best practices for preventing lithium-ion battery fires in e-bikes and other micromobility products."

And the federal government is devoting significant funds to bolster the domestic LIB recycling market. In particular, the Infrastructure Investment and Jobs Act—which became law in 2021—includes $335 million for LIB recycling efforts. The law allocates $10 million and $15 million to the EPA to develop battery recycling best practices and battery labeling guidelines, respectively, by September 30, 2026. The goal is to develop best practices that can be technically and economically implemented in battery collection and recycling programs at the local, tribal and state government levels.

Some of the money also is earmarked for the U.S. Department of Energy to spend on initiatives such as battery collection, transportation, processing and recycling. This program will provide funding to support the recycling of consumer electronics batteries and battery-containing devices to help build a strong domestic critical material supply chain for EV batteries.

While the above efforts are encouraging, "we're not going to get rid of this problem for a long time," Fogelman said—especially considering the billions of LIBs already in use and the billions more that will enter the market in the coming years. All of those batteries will enter the recycling/waste stream at some point.

"There will be opportunity to make a positive impact on the world with battery recycling for decades to come," Frederickson said. "But it's going to take a lot of us working together." **/**

Kent Kiser is a freelance writer based in Charlottesville, Virginia. Previously, he was publisher of Scrap magazine for the Institute of Scrap Recycling Industries.