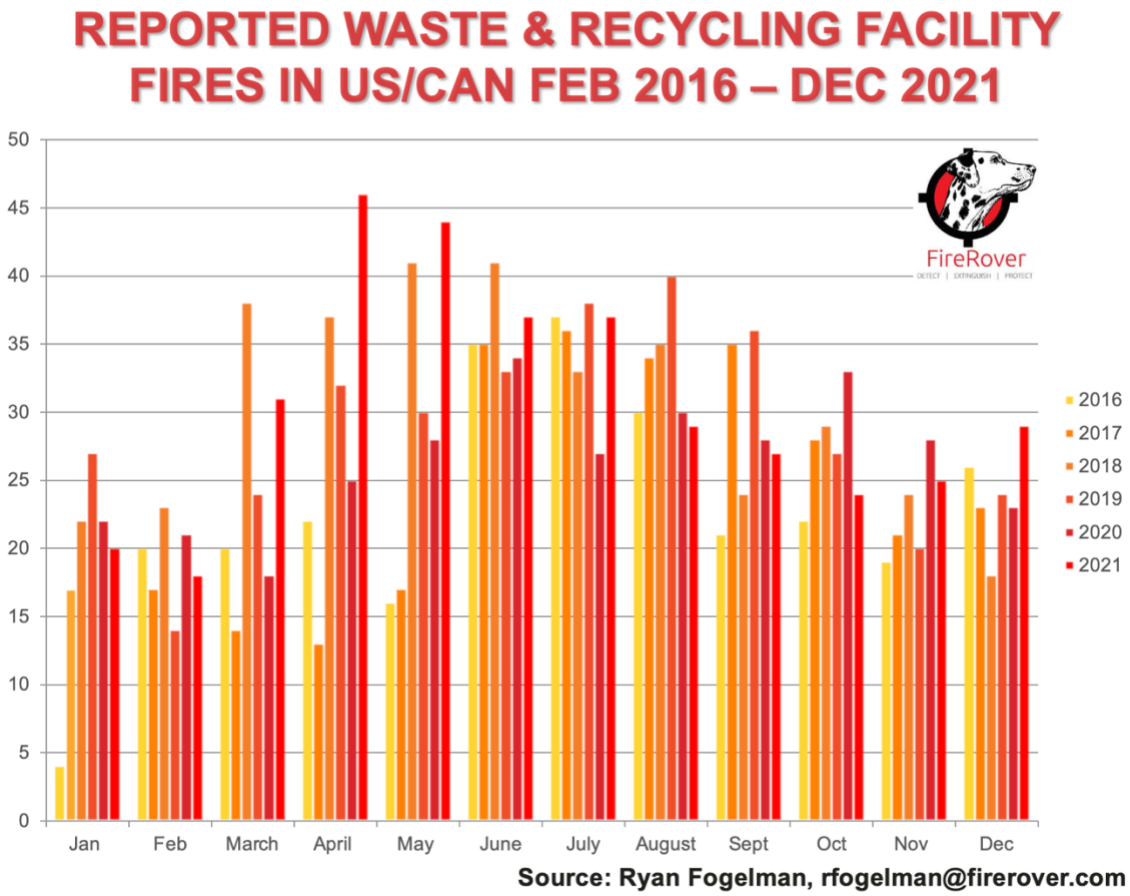
5th ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN



2021 REPORT

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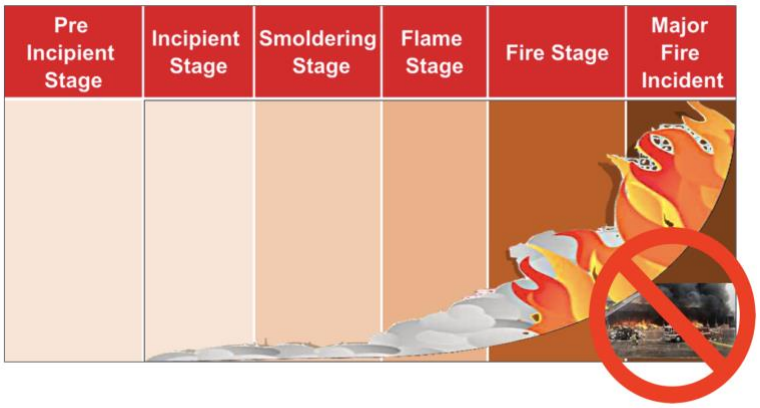
Executive Summary

The Bad News: **THERE IS AN INHERENT RISK OF FIRES IN THE WASTE AND RECYCLING INDUSTRY!** I do not make that statement lightly. The problem is not going away. In fact, all the data in my report point toward the problem getting worse. What is causing this to happen? In a nutshell, traditional hazards combined with the onslaught of batteries in our waste and recycling streams, worsening heat across the globe, and a myriad of other factors continue to make operating in this space more dangerous. Additionally, as the world seeks to become "greener," more stress is being placed on our waste and recycling infrastructure. Hazards that used to get thrown in a landfill or illegally dumped are not being handled properly but causing some negative effects on our infrastructure. So, in essence, the resulting increase in fires is a good problem to have for the globe, but dangerous, nonetheless.

The Good News: There are solutions to our fire problem. Many industries that have an inherent risk of fires in their operations have learned through education, operational best practices, and investment in technology to safely operate within the constraints of their issues.

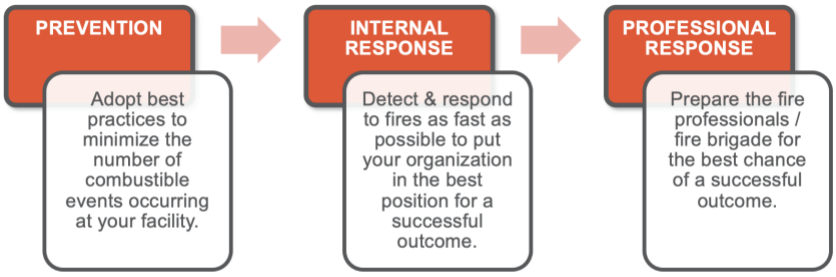
There are many great folks who work on educating the public about proper recycling, some of whom are highlighted in my report. I also believe that it is only fair that some of the costs of these fire hazards should be borne by the manufacturers of the batteries as opposed to the operators, insurance companies, and municipal fire departments. Due to the sheer number of facilities, we need to roll this out to almost 6,000 materials recovery facilities (MRFs) and transfer stations in the U.S. alone. Add to that the number of hazards that are increasing at a compounding scale, it's clear we need to fight this fight on several fronts.

What can the operators, technology providers, and fire professionals do? **NOT HAVE A MAJOR FIRE INCIDENT.**



The Goal: Do Not Have A Major Fire Incident!

Fire is not the problem until it becomes the problem. Early on in my industry tenure, I kept hearing the same thing, “Fire grows in size and scope every X seconds/minutes.” Put whatever compounding factor in you want, but the reality is the earlier you catch a fire, the better chance you have at mitigating the risk to employees, fire professionals, operations, and physical infrastructure.



After prevention, the real opportunity is improvement in internal response time!

So, what does that mean in reality?

Prevention: It’s the operator’s job to follow best practices to minimize a fire.

Internal Response: Outside of a fire brigade, the operators must train their employees on best practices such as when it is safe for them to respond and when they must evacuate. In addition, they should invest in solutions like the Fire Rover that detect the fire early with thermal cameras, optical flame/smoke detectors, eliminate the need for a response when the situation warrants, and can engage the fire professionals when warranted.

Professional Response: Arming and equipping our fire professionals with the proper tools, training, techniques, and education to successfully fight these types of fire hazards.

Successfully fighting fire problems on a long-term basis requires a combination of all parties working together in lockstep and ready to respond when and if the situation arises. Since no two fire incidences are the same, no two responses are the same, which is why we need a framework that allows for flexibility, quick thinking, and proper actions to ensure if an operator has a fire incident that it is not “major” or “catastrophic.”

Check out Appendix G, **The Combinational Approach™ to Fighting a Waste and Recycling Fire**, for best practices developed by Jim Emerson and me.

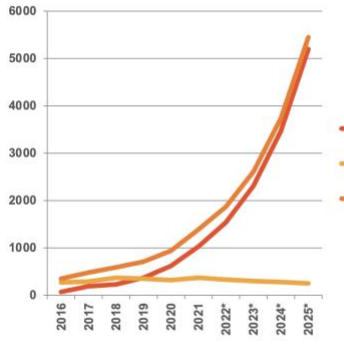
In 2021, my team at Fire Rover was responsible for more than 1,000 saves at our 300-plus client operations. We have never had a catastrophic incident that began in an area that we protect. Are we perfect? No, but we have successfully fought any major incident that we faced with minimal damage to any of our clients’ facilities.

Even with our performance, 2021 was the highest year for reported waste and recycling facilities fires that we have experienced since I began consolidating the data in 2016. We even beat 2018, which until this year, I incorrectly thought was our high-water line.

Why is this number significant? We know that the number of batteries we use in personal electronics and personal storage equipment is only growing. Now maybe 2021’s high number of reported incidents was due to 2020’s pullback we assigned blame to our COVID issues. The assumption is that the waste and recycling tonnage slowed down in 2020 and was pushed into 2021.

WASTE & RECYCLING FACILITY FIRES
US/CANADA ACTUAL & FUTURE TRENDS

FireRover



Year (*Est)	Fire Rover Client Saves	Publicly Reported Fires (Major Fires)	Total Known Fire Incidents
2016	75	272	347
2017	189	290	479
2018	228	365	593
2019	369	345	714
2020	621	317	938
2021	1028	367	1395
2022*	1542	325	1867
2023*	2313	300	2613
2024*	3470	275	3745
2025*	5204	250	5454

Source: Ryan Fogelman, rfogelman@firerover.com

Even With Increasing Lithium-ion Battery Contamination, Additional Fire Protection Solutions Will Result In Fewer Major Fire Incidents

I say this each year, but only time will tell. As we head into 2022, we are installing more of our systems each month, not only in the U.S. and Canada but through our distributors in Australia, the UK and soon to be France. Our solutions are helping to fight this global problem and changing the way we think about fighting fires.

The best practice of "water, water, water," which is a fire response approach used for hundreds if not thousands of years, is evolving into early detection and immediate response. Lowering the risk of catastrophic incidents through operational, technological, and professional best practices puts the waste and recycling industry in a good position to stem the tide over the next couple of years, even with the onslaught of hazards continuing to barrage our waste and recycling streams across the globe.

Getting the Numbers the Waste and Recycling Industry Needs

When I started working for Fire Rover in 2015, I noticed a massive void in the waste and recycling industry: fire incident data. I searched high and low for data on fire incidents at waste and recycling facilities across the U.S. and Canada. I browsed online sources and spoke with facility owners and operators, safety and insurance personnel, and investors—all without success.

I knew this data was much needed, and I became determined to uncover and share this data, not only to provide the industry with important information to determine the true scope of the problem but to prove that Fire Rover is a fire suppression system as well as a business continuity solution that is backed by a real return on investment for executives to justify the investment.

By 2016, I had gathered enough data to begin producing a report called "Reported Waste & Recycling Facility Fires In The US & CAN," which is now published monthly in *Waste360*. The report provides updated data each month for the U.S. and Canada; the 2,000-plus actual facility fire number that I use for this data is based on the assumptions from the data that the UK Environment Agency (EA) collected in the table below.

CFOA Reported Fires 2001-2014

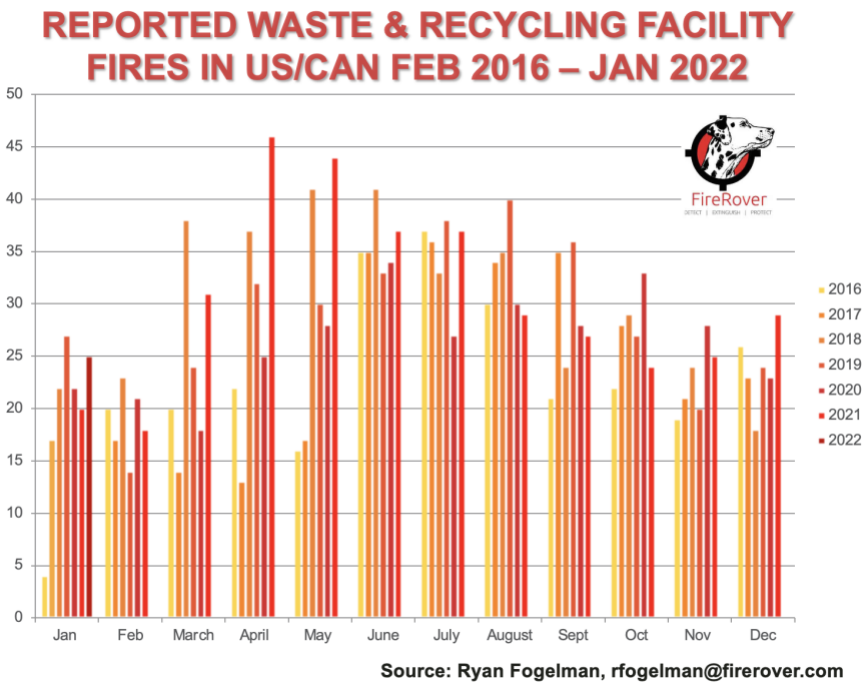
The latest statistics, from the Environment Agency, show the incidence of Waste Fires from 2001 to 2013.

Year	Regulated[1] Sites	Unregulated[2] Sites	Total fires
2001	154	92	246
2002	203	140	343
2003	288	110	398
2004	254	83	337
2005	239	107	346
2006	284	95	379
2007	236	54	290
2008	227	48	275
2009	282	55	337
2010	286	59	345
2011	348	77	425
2012	247	55	302
2013	248	50	298

Data is for all categories of incident recorded.

1. Regulated – where a permitting regime specific to the source has been identified, eg waste operations and waste installations.
2. Unregulated – where no permitting regime specific to the source had been identified.

The monthly reports help us identify trends and where we need to make improvements to operate more safely and efficiently. When I first started to collect the data, I knew it was going to take years to begin to see trends. Now that we are heading toward year seven, not only can we see trends but we can and have been able to respond to these trends. See the chart below that features the latest data from February 2016 to January 2022. I include January's number of 25 incidents, which is the second-highest January for incidents since 2016.



Tracking Reported Fires in the U.S. and Canada

Over the years, I've been able to collect important data on reported facility fires. I define "reported facility fires" as any fire that has been reported by the media that occurs at a waste or recycling facility in the U.S. and Canada. Typically, the fires that are reported by the media are larger fires that require fire professionals to arrive on scene and where there are effects that the public can witness.

Some industry professionals suggest that the majority of fires related to waste and recycling are not reported. Others disagree. One thing the industry can agree on, however, is that any fire is one too many.

According to my research, **in 2021, waste and recycling facilities in the U.S. and Canada experienced 367 fires, two deaths, and 37 direct and indirect injuries.** These fires ranged from small incidents to complete burnouts and occurred in all types of operations including those for metals, rubber, paper, construction and demolition (C&D) material, plastics, waste, compost, hazardous materials, chemicals, and fuels.

Based on my research, information made available in published news stories, and other published reports, I believe we can assume that the number of non-reported fires that occur at waste and recycling operations across the U.S. and Canada is significantly higher.

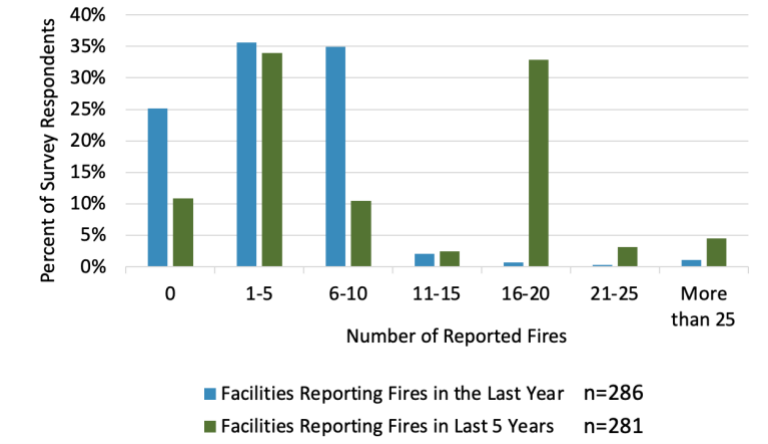
In a 2016 report entitled "Municipal Solid Waste Management in the U.S.: 2010 & 2013," for example, the Environmental Research & Education Foundation (EREF) suggested that in 2013, there were 3,913 recycling facilities and 81 waste-to-energy facilities. This means more than 40 percent of facilities across the country experienced a fire incident in the 12 months previous.

More recently, in 2018, the California Products Stewardship Council (CPSC) released survey results from 26 waste facilities located in California. According to the results, 83 percent of the surveyed facilities experienced a fire in the two years previous.

Based on reports such as these, I believe the number of waste and recycling facility fires that occurred in 2021 in the U.S. and Canada is more than 2,200. **That's almost six times the reported number of 367, which includes the Fire Rover reported client incidents I will highlight later in this report.**

To close the gap between estimating the number of reported fires and un-reported fires, EREF has partnered with the National Waste & Recycling Association (NWRA), the Institute of Scrap Recycling Industries (ISRI), and the Solid Waste Association of North America (SWANA) to develop a research study featuring data from MRFs, scrap yards, and transfer stations during 2019 and 2020.

To date, the preliminary results indicate that more than 35 percent of the respondents had between one and five facility fires during the year that they took the survey. Over a five-year period, 33 percent of respondents indicated that they had 16 to 20 facility fires.



The survey also included questions about the number of fires that required an external response. While not all fires that require an external response will inherently be serious, these are most likely fires that are large enough to be reported on by media outlets.

According to Dr. Suzi Boxman, who is managing the study for EREF, in the case of MRFs, 26 percent of respondents reported having one to five fires that required an external response. When this is extrapolated to the estimated number of MRFs in the U.S., there were 215 to 355 MRFs that experienced, at a minimum, one fire that required an external response. Assuming these fires are more likely to attract media attention and be captured in my annual reports, the survey data suggest there were 1.4

to 2.3 times more facility fires than the 156 average reported fires in the 4th Annual Waste & Recycling Facility Fire Report.

	Estimated US Facility Count	Number of Survey Responses	Number of Facilities with 1-5 External Response	Extrapolated Number of Facilities with 1-5 External Response	Margin of Error
MRF	799 - 1,316	111	29 (26%)	215-355	8.6% - 8.9%
Scrap Yard	2940	62	13 (20%)	588	12%
Transfer Station	4,565	129	10 (7%)	319	9%

Overall, these results suggest that there are more fires that are significant enough to require an external response, but they are not being reported on by the media, as I've said in my findings for the past six years. On another note, EREF is in the process of finalizing the estimated MRF, scrap, and transfer stations, which is data I will use going forward.

A Global Problem

While my research focuses on data from facilities within the U.S. and Canada, fires at waste and recycling facilities and in industry vehicles are a global problem.

In the UK, for example, the waste industry faces an estimated 201 waste fires caused by lithium-ion batteries (Li-ion) each year, according to a 2021 report entitled "Cutting Lithium-ion Battery Fires in the Waste Industry" published by Eunomia and the Environmental Services Association (ESA).

According to the report, of the 670 fires recorded by ESA waste management members across the UK in 2019-2020, 38 percent were either recorded as caused by Li-ion batteries or "suspected" to have been. This is higher than the percentages recorded in the previous three years by the body (21 percent in 2016-2017, 25 percent in 2017-2018, and 22 percent in 2018-2019).

It's not that surprising, however, since Veolia UK stated in 2020 that the average UK resident throws away around 24.5 kilograms of electronics annually, and only 43 percent of the public is aware that lithium-ion batteries can spark fires. Additionally, fires in waste vehicles have increased by 37.5 percent since 2017, which is a major concern because anyone who operates a waste and recycling fleet knows the high price tag that comes along with downtime, repairs, replacement vehicles, etc.

Noticing these trends, some countries like Australia are making an effort to help prevent and reduce fire incidents. The Victoria State Government, for example, established the

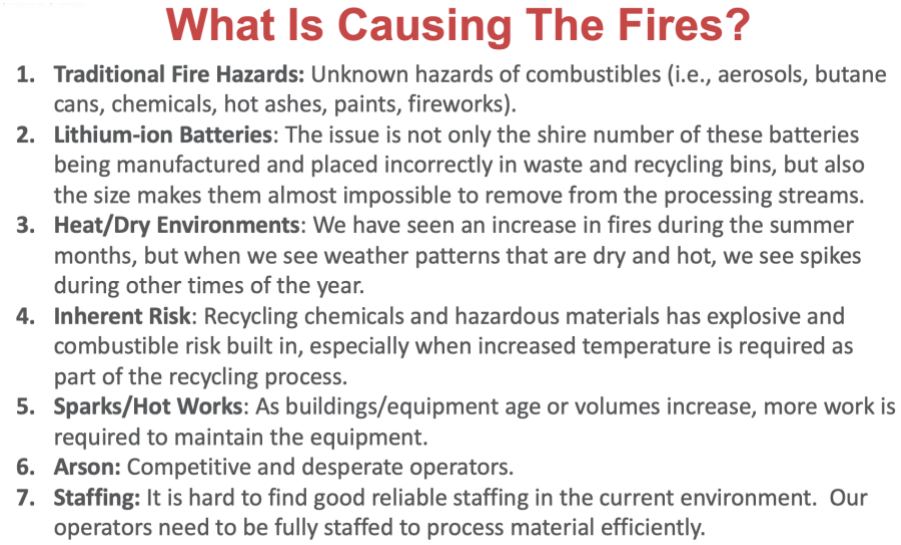
Resource Recovery Facilities Audit Taskforce chaired by the Australian Environmental Protection Agency (EPA) to inspect resource recovery facilities and tackle stockpiles that might pose a fire risk.

By 2017, according to that year's Australian Fire Preparedness Report, about 73 of the 500 recycling centers and tipping floors across Victoria had been inspected. Perhaps not surprisingly, most lacked the planning and resources to deal with a fire event.

"While some operators are considered to be at best practice, the audit program identified that the resource recovery sector is generally poorly prepared and ill-equipped when it comes to managing fire risks at their facilities,'' stated the Australian EPA on its website.

These are just some examples of what's happening around the globe, and to no surprise, we are all challenged with the dangers of fires and working toward fire prevention and reduction.

The Causes



Lithium-ion Batteries

Storing large amounts of energy, whether it's in larger rechargeable batteries or smaller disposable batteries, can be inherently dangerous. When the two electrodes come in contact with one another, the battery can short circuit, leading to a chemical chain reaction known as thermal runaway.

During thermal runaway, temperatures can climb to more than 1,000 degrees Fahrenheit, which creates intense pressure that causes the flammable liquid electrolyte

to combust. Contrary to what the media coverage implies, lithium-ion batteries do not typically just explode for no reason. The causes of lithium battery failure can include puncture, overcharge, overheating, short circuit, internal cell failure, and manufacturing deficiencies.

In a report developed by Consolidated Edison (Source: *Report No.: OAPUS301WIKO(PP151894), Rev. 4, February 9, 2017),* there was a great question that outlines the true risks dispelling the media's approach of overhype to these incidents:

> **Question: Are the commonly cited battery fires in the media due to spontaneous ignition events?** Finding: No. The Literature Review (an addendum to this report) covers several incidents in detail. In the context of fire risk and firefighting for batteries, it is helpful to summarize the abuse tests that are performed in United Nations (UN) 38.3, the required testing scope in order to ship and transport Li-ion batteries. The eight separate tests in UN 38.3 are a checklist of nearly all physically conceivable abuses that could cause a Li-ion battery to catch fire. **These abuse events are: 1. Low ambient pressure 2. Overheating 3. Vibration 4. Shock 5. External short circuit 6. Impact 7. Overcharge 8. Forced discharge**
>
> All of the safety incidents commonly reported in the general media can be traced to one of these abuse mechanisms. **In some cases, contaminants in the battery (as a result of manufacturing defects) weaken the ability of the battery to withstand instances of these eight abuse factors.** In general, it is good practice to avoid any scenario that may introduce the threat of any action on the above list.

In the waste and recycling industry, we are tough on our trash. Try telling those in our industry to "avoid any scenario that may introduce the threat of action in the above list." This is an impossible task. Yes, we can do all we can to educate the public on the proper disposal of lithium-ion batteries, but we would be naïve to assume that this is not a hazard we are going to continue to face for the foreseeable future. Specific risks that I have seen in our clients' fire incidents include loaders driving over batteries; shredders mincing batteries; batteries exploding on tip floors; and deep-seated fires that sparked from one of the traditional risks of charcoal, fireworks, fertilizers, and other materials that start the reaction near a battery.

Example pictures for damage classes of portable batteries:

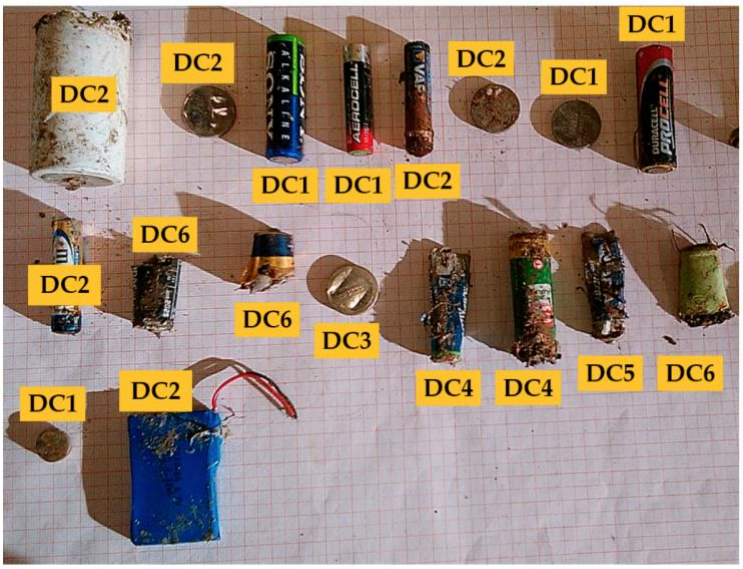


Figure S1. Damage classes of end-of-life portable batteries (after sampling campaign).

In an Austrian study called [“Lithium-Ion Batteries as Ignition Sources in Waste Treatment Processes—A Semi-Quantitate Risk Analysis and Assessment of Battery-Caused Waste Fires,”] the research team developed the following table that separated the process activity by the possible threats and subsequent risk assessment. It is clear that most lithium-ion fire incidents occur within collection vehicles, on tipping floors, during consolidating and processing, and once in finished product storage.

Table 5. Qualitative risk assessment of possible hazards and threats of portable batteries (waste stream: residual household waste).

Facility Area/Process	Possible Hazards and Threats	Risk Assessment
Collection bins	Damage due to external short-circuit	low
Loading activity	Damage due to external short-circuit	low
Collection vehicle	Mechanical damage due to compaction	medium
Unloading activity	Mechanical damage due to tip-off	low
Waste bunker/input storage	Damage due to external short-circuit Damage due to external heating (self-heating of waste)	medium–high
Waste transfer activity	Mechanical damage due to (wheel) loader or gripper	medium
Treatment facility	Mechanical damage due to pre-shredding process Mechanical damage due to post-shredding process Dangerous heat generation after damage Carry-over through the processing facility	high–very high
Output storage	Damage due to external short-circuit Damage due to external heating (self-heating of waste) Dangerous heat generation after damage	low–medium

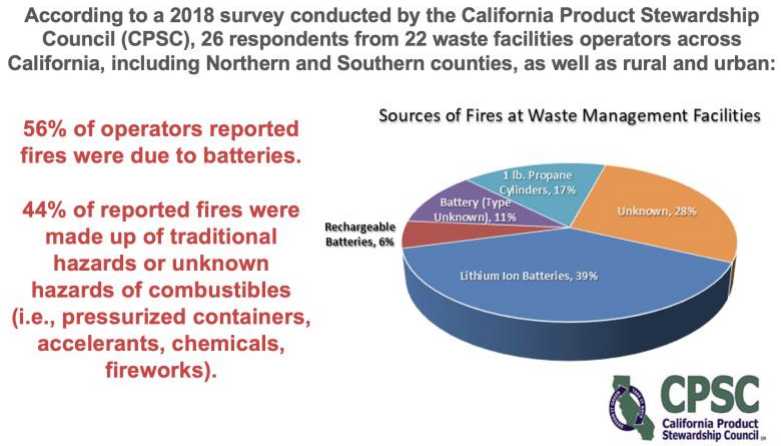
The same study concludes that:

> No other substance or material has ever comparably endangered the whole waste industry. Hence, besides research and development activities for investigating and understanding the hazards and risks of lithium-based portable

batteries, **increased technological development and innovation efforts** are indispensable for reducing the risk potential of end-of-life portable batteries.

In order to reduce risk, the waste sector has to aim to collect as many batteries as possible in separate collection systems and take-back schemes, as only this collection system guarantees a damage-free return system. That requires increased efforts in public relations and consumer awareness. However, a 100 percent separate collection rate for portable batteries is highly unrealistic without a comprehensive deposit system. Hence, operators of treatment facilities have to find ways to … protect critical infrastructure and treatment processes (e.g., including new detection and extinguishing methods) or … detecting and separating portable batteries in the course of their treatment processes.

For many years, I've forecasted fire danger will rise because of the increased volumes of lithium-ion batteries in our waste stream. And in 2018, my prediction was realized. That year, CPSC released a survey indicating that 65 percent of the reported fires in California were due to batteries.



Then, in 2019, there was an explosion at the APS McMicken Energy Storage facility in Surprise, Ariz., where several fire professionals responding to the scene sustained chemical and chemical-inhalation burns. The facility housed utility-sized batteries used in the storage and distribution of solar energy. Although this incident did not occur in a waste and recycling facility, the implications for first responders in facilities that store and house lithium-ion batteries have been far-reaching.

According to the same report by Consolidated Edison (Source: *Report No.: OAPUS301WIKO(PP151894), Rev. 4, February 9, 2017),* first responders had very similar training when it comes to fighting any fire, including battery fires.

9.7 Project Development Considerations for Interaction with First Responders and AHJs DNV GL surveyed several handbooks for fire departments in large cities across the country and found a universal theme in firefighter training concerning extinguishing. **Firefighters are trained to achieve the following objectives when arriving at the scene: Objective 1: Remove endangered person(s) and treat the injured. Objective 2: Stabilize the incident and provide for life safety. Objective 3: Provide for the safety, accountability, and welfare of personnel (this priority is ongoing throughout the incident). Objective 4: Protect the environment. Objective 5: Property conservation.** Note that Objective 5 is often the primary concern of the property owner. It is on the priority list of the first responder, but safety of life at the scene takes precedence.

This is a truly important point for those who deal with the lithium-ion battery risk. The first responders are not to come on scene to put their lives at risk to save the property. On the contrary, their role is to protect the lives of any employees who are inside the building. If there is no one in the building, the first responders will take a defensive approach to fight these fires.

With this in mind, at Fire Rover, we developed a solution that is currently protecting lithium-ion battery recycling facilities and has expanded to provide full fire sprinkler replacements to waste operations to help fire professionals and property owners get the best chance at not only protecting their employees but their property as well. Along with our early thermal detection and remotely operated fire suppression, we added a quick connect that allows fire professionals to safely add an additional water supply from outside of the building. This solution has received variances in some jurisdictions as a replacement solution for traditional fire sprinkler equipment.

This solution allows for continued remote-operated targeted suppression to the source of the material. Combined with our thermal monitoring, we can continue to apply water until the heat level is safe for professionals to enter the building. Depending on the risk factors, lithium-ion battery fires can reignite. “Upon extinguishing, great care must be taken to assure that all electrical, thermal, and mechanical abuse factors are neutralized. If any remain, it poses a hazard for continuing (not reigniting) the fire.” (Source: *Report No.: OAPUS301WIKO(PP151894), Rev. 4, February 9, 2017*)

As we look to the future, I believe the problem of batteries is poised to get worse. The fact that 2021 was our worst year for fire events only makes this case more telling. The fact is that lithium-ion batteries are being cemented as our main power source for portable electronics, cars, storage, and more. This is due to their small footprint, power capabilities, and relatively safe technology when handled properly. Public education is key to ensuring these batteries stay out of the waste and recycling stream, but the hazards do not stop there. The electronic recyclers, automotive companies, and processors of these types of batteries have inherent fire/explosive risks in their operations.

The biggest issue is that you don’t fight lithium-ion battery fires the same way you fight typical fires. You can do your best to get to the problem before thermal runaway, but the key to fighting these fires is by avoiding the “domino effect.” If not, you can end up with incidents like the one that occurred last year in Morris, Ill., that took over a week to put out and required the use of concrete to finish the job. (Source: *Everyone Thought the Warehouse Was Abandoned. Then It Caught Fire.*)

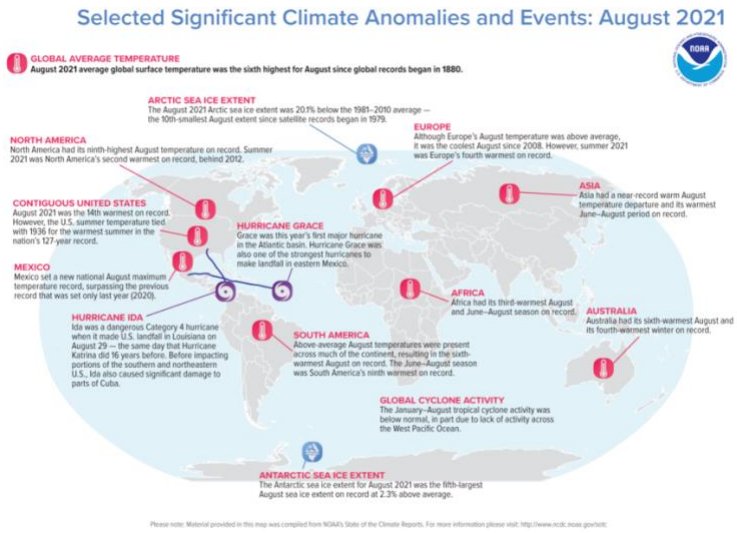
> Because firefighters didn’t know the hazardous materials were inside, it was impossible for them to respond to the fire appropriately. Spraying water on a lithium fire probably won’t help and likely only makes it worse—knowledge that’s only useful if firefighters are aware they are dealing with batteries to begin with. And because the Morris firefighters weren’t, they “used water for fire suppression” which, the lawsuit stated, “caused lithium batteries to explode.”

Our highly trained Fire Rover agents know not only to apply our environmental cooling agent directly to the heat source in the battery but to apply the agent to the collateral material and assets around the battery to lessen the chance of these incidents becoming major. This can only be done responsibly through proper separation, safe storage/protective storage, operational best practices, and properly trained and equipped fire professionals in combination with solutions like ours. Our expertise dealing with these hazards in MRFs, transfer stations, scrap metal yards, electronic recyclers, and lithium-ion batteries processors is getting better as we all continue to fight this growing risk across mission-critical operations across the globe. The truth is that

there is a ton of work to do as we are truly still in the early stages of hockey stick growth that is heading our way.

Heat and Dryness

Over the past six years, there has been an increase in fires during the hotter months. According to a climate report published by the National Centers for Environmental Information (NOAA), the 2021 Northern Hemisphere meteorological summer (June through August) was the Northern Hemisphere's second-hottest meteorological summer on record, tying with 2019.



The 2021 year-to-date (January through August) global temperature was 58.78 degrees Fahrenheit—1.48 degrees Fahrenheit above the 20th-century average. The globally combined land and ocean surface average temperature was 1.62 degrees Fahrenheit above average.

That being said, according to the National Centers for Environmental Information's Global Annual Temperature Rankings Outlook, it's likely that 2021 will rank among the 10 warmest years on record.

We are dealing with hotter summers and dryer winters across the globe. Even if just anecdotal, this cause is only going to get more important as we continue to face global warming.

Seasonal Spikes

In previous years, we experienced a seasonal spike of fire incidents during the summer months and the holiday season. This is in large part due to the hazards we see during those times. During the summer months, we have more propane tanks, fireworks, charcoal, and other hazards. During the holiday season, we see an increase in the

number of lithium-ion batteries in our toys, gadgets, and other electronics we receive as gifts. This trend, however, did not completely hold true in 2020 or 2021.

From a fire incident perspective, the first few months of 2021 were the worst on record since I began reporting waste and recycling facility fire incidents in the beginning of 2016. In March, we incurred 31 reported fire incidents. In April, we incurred 45 reported fire incidents, which was a historical record. Then, in May, we incurred 44 reported fire incidents. This spike occurred earlier in the year as opposed to during the summer months, but we did see another spike in December, which marked the worst month for fires in December since 2016. That spike's timing wasn't as much of a surprise, however, as it occurred during the holiday season.

Staffing

This is a new factor that made the list in 2021. Across the U.S., we have seen our workforce tighten. In November 2021, Alex Kamczyc, a reporter for *Waste Today Magazine*, wrote a great article highlighting the issue:

> Last year, it is estimated that the United States lost 10 million jobs during the height of the pandemic, according to the U.S. Department of Labor. However, as the economy began to rebound from the effects of social distancing and state and local stay-at-home orders that were enacted to avoid the spread of the coronavirus, "Help wanted" signs began decorating a spectrum of businesses across the country, including recyclers and waste haulers.
>
> While life seems to be returning to normal with the availability of the vaccines, a labor shortage is in full force in many places. Recyclers and waste haulers are now competing among themselves and other industries to hire candidates to fill open positions.
>
> "Hiring has grown and changed during the pandemic," says Patrick Hudson, vice president of customer experience for Phoenix-based Leadpoint Business Services, a provider of work teams and operations support services to the recycling industry. "Due to several reasons, we've seen a reduced interest in applying for these kinds of jobs for both passive and active applicants."
>
> This has disrupted the collection of waste and recyclables and scrap processing, creating cash flow issues, and slowing processing times.

I am certainly not a staffing expert, but I believe that an operator's biggest issue from a fire perspective seems to be properly staffing their sorting and pre-sorting activities along with the increased spacing requirements for sorting lines that were built pre-COVID. Removing hazards from the waste stream takes human eyes and/or robotics.

Every time a hazard such as a battery or propane tank gets through this process, there is another chance for something to go wrong.

Fire Causation Trends

When I started consolidating the reported waste and recycling facility fires in 2016, I was realistic that the first few years would drive the baseline data defining the scope of the problem, providing us with a basic understanding of the consequences and finding and evaluating the effectiveness of solutions available to address the problem. Now that we have six years of data, we can highlight the trends and identify where we need to take action.

According to the data, **2021 was the worst year for publicly reported fire incidents at waste and recycling facilities in the U.S. and Canada since 2016.** We experienced 367 reported fire incidents, which is higher than the average number of 318.

So, how do we make sense of that number from a historical perspective? During 2018, we had limited data and a minimal understanding of the problem. Now, with three more years of data, we have a better understanding of the problem and are in a much different place than we were in 2018. Today, it is well established that there is an inherent risk of fires in our waste and recycling streams. The scariest part of this data is not one of these fires occurred at any of the 300 facilities equipped with our Fire Rover system. That is not to say there were no fires at our clients' sites, but only one got to the point of being reported, and the fire did not start in an area that we protect. Additionally, publicly reported incidents are normally 2 alarm or more, which makes them newsworthy.

A potential hypothesis that we must look at as well is the "pandemic effect." We all know that 2020 was far from a normal year for most aspects of our lives. We were under stay-at-home orders; we were following social distancing requirements on our sorting lines; and we were experiencing a monumental shift in our waste and recycling streams from commercial to residential. Just as we experienced a decrease in fire incidents in 2020, that material tonnage could have shifted from 2020 into 2021. This would make sense as a significant number of fire incidences occurred in the first half of 2021.

REPORTED WASTE & RECYCLING FACILITY FIRES BY MATERIAL US/CANADA

Incidents By Type Of Material Processed	2016	2017	2018	2019	2020	2021	Total	% of Total Incidents 2016-2021	2021 % Change v. 2020	Average '16-'20	2021 % Change v. Average
Waste, Paper & Plastic	146	147	154	177	158	176	958	49%	11%	156	13%
Metals	72	89	145	100	108	136	650	33%	26%	103	32%
Organics	16	18	31	29	20	17	131	7%	-15%	23	-25%
Chemicals	12	13	15	10	4	8	62	3%	100%	11	-26%
C&D	11	8	11	10	8	19	67	3%	138%	10	98%
Rubber	11	10	6	10	7	6	50	3%	-14%	9	-32%
E-Scrap	4	5	3	7	12	5	36	2%	-58%	6	-19%
Total	272	290	365	343	317	367	1954	100%	16%	317	16%

Source: Ryan Fogelman, rfogelman@firerover.com

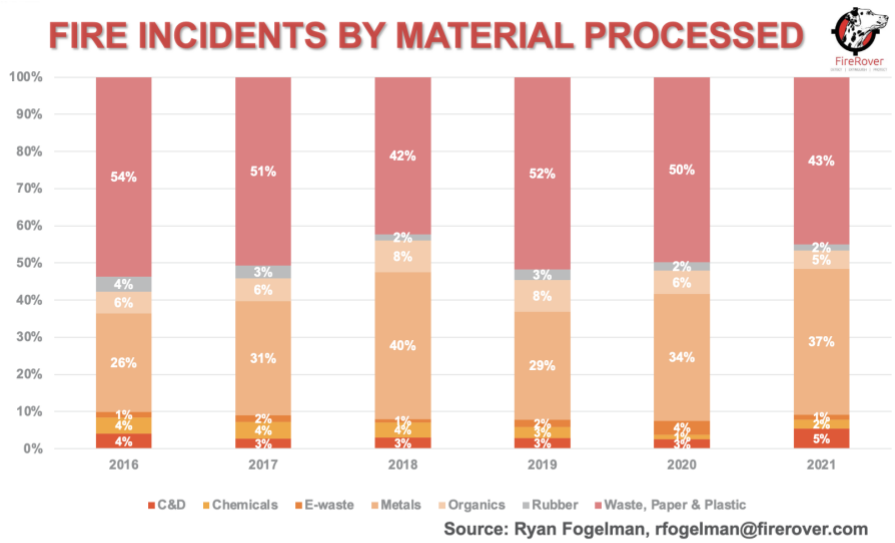
Now, let's dive into the data from 2021. To understand the numbers, I think it is best to look at percentages. As you can see from the graph, we saw more than a 10 percent increase in waste, paper, and plastic fires from 2020 as well as from the average number of fires from 2016 to 2020. Both metal and C&D operations also saw a significant increase from last year and historical norms in 2021, rising more than 30 percent and more than 100 percent, respectively.

REPORTED WASTE & RECYCLING FACILITY FIRES BY MATERIAL % OF TOTAL ANNUALLY

Incidents By Type Of Material Processed	2016	2017	2018	2019	2020	2021	Total	% of Total Incidents 2016-2021	2021 % Change v. 2020	Ave '16-'20	2021 % Change v. Average
Waste, Paper & Plastic	54%	51%	42%	52%	50%	48%	960	49%	11%	157	12%
Metals	26%	31%	40%	29%	34%	37%	652	33%	26%	103	32%
Organics	6%	6%	8%	8%	6%	5%	131	7%	-15%	23	-26%
Chemicals	4%	4%	4%	3%	1%	2%	62	3%	100%	11	-26%
C&D	4%	3%	3%	3%	3%	5%	67	3%	138%	10	97%
Rubber	4%	3%	2%	3%	2%	2%	50	3%	-14%	9	-32%
E-Scrap	1%	2%	1%	2%	4%	1%	36	2%	-58%	6	-20%
Total	100%	100%	100%	100%	100%	100%	1959	100%	16%	318	15%

Source: Ryan Fogelman, rfogelman@firerover.com

To show a different perspective, I have broken out the percentage change each year to take the number of incident bias out of the equation. Here, we see that the waste, paper, and plastic numbers are in line with historical norms with 11 percent over 2020 and 12 percent over the historical average. Metals fire incidents, on the other hand, are up 26 percent from 2020 and 32 percent from the historical average. Chemical fire (hazmat) incidents were double over 2020 but in line with the historical average, and C&D incidents were more than double over 2020 and almost double the historical average.



From a percentage basis, our two top years of 2018 and 2021 seem to be driven by an increase in Metals fires.

If you've been reading my annual reports each year, you'll know that I include all waste, paper, and plastic fire incidents in one bucket as it's not always clear in the media which materials actually caused a fire. This bucket makes up the MRF and transfer station operations across the U.S. and Canada. The major distinction in the material is that these are traditionally the channels where hazards like lithium-ion batteries, chemicals, and gasoline and propane tanks are improperly placed into the waste and recycling stream.

Other buckets include C&D incidents, scrap metal incidents, and e-scrap incidents. I keep these incidents separated as each occupancy has its unique aspects; however, they all share a similar pattern where their material has risks that can be alleviated on the front end where practical.

Let's take a further look at these buckets and the trends we saw in each one in 2021.

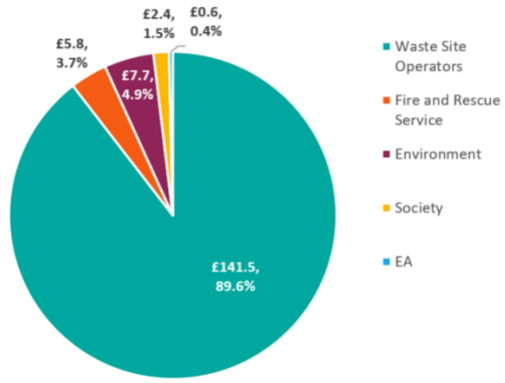
Increase in Waste, Paper, and Plastic Fires: Municipal solid waste (MSW), paper, and plastic recycling fires increased in 2021. The total number of fires was 176 compared to last year's total of 158. While we may not be able to pinpoint the material that caused each of these fires, a change in material tonnage and the continued improper disposal of lithium-ion batteries likely played a role in this more than 10 percent rise in fires.

This issue is a global issue and its cost to the industry was recently outlined in a report based on research conducted by Eunomia. According to the report, this problem is only set to get worse, with more and more Li-ion batteries placed onto the market each year.

The positive news is that those that have focused on safety, proper fire prevention planning, and investments in technology solutions have experienced fewer fires. The survey results by Eunomia outline its recommended best practices for risk reduction to the industry, such as getting lithium-ion batteries out of the waste stream through education, fines, deposit programs, and more, but it does not single out technology innovations like Fire Rover, which has proven to be key to mitigating these risks in the U.S.

The real problem in both the UK and the U.S. is that the cost for these fire incidents is unfairly borne by the operators and their insurers. Producers get off scot-free in this equation where they manufacture these batteries, distribute them across the board, and leave the operators, fire professionals, and society to deal with their problems.

Figure E1-1: UK Cost of Waste Fires Caused by LIBs by 'Cost Incurred By' (£mil, %)



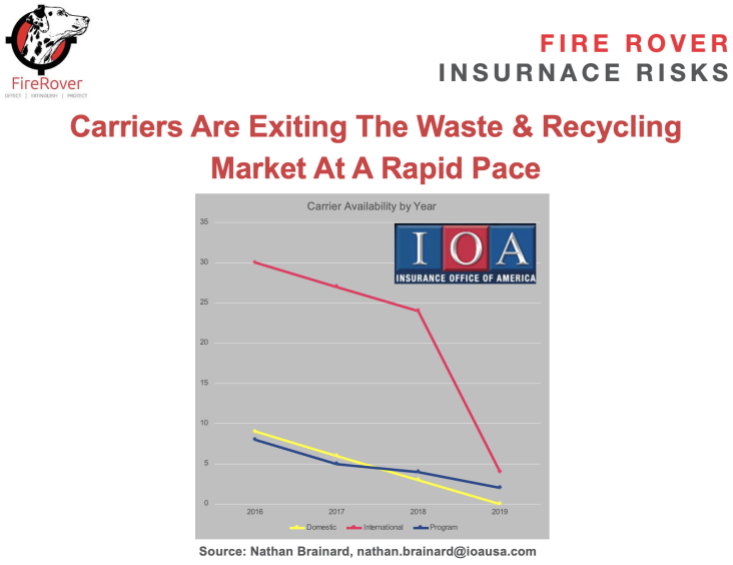
Eunomia has estimated the real cost of lithium-ion battery fires in the UK to be about £158 million. If we use the same assumptions I use in my reasonable assumption for unreported fire incidents and take into account the current exchange rate, **the cost to**

the U.S. and Canada due to lithium-ion battery fires is unfairly more than US$1.2 billion. Since Eunomia's study only blamed lithium-ion batteries for about 50 percent of fires, which is in line with past U.S. surveys I have shared, the real cost borne by our waste and recycling operators, and indirectly their insurance carriers, is realistically about US$2.5 billion annually.

Another report, released by the U.S. Environmental Protection Agency in 2021, also backed this point of view. The report, "An Analysis of Lithium-ion Battery Fires in Waste Management and Recycling," which includes information from various sources including my research, draws attention to the following facts:

1. There is an inherent risk of fire incidents in the waste and recycling industry.
2. Most of the costs of these incidents unfairly falls on our waste and recycling operators and the local fire professionals.
3. There is not a consensus solution to the problem, but there are effective solutions to the problem such as best practices and technology.

Our solution of best practices and investments in technology is working. How do we know this is the case? Insurance companies have noticed. According to Nathan Brainard from the Insurance Office of America's (IOA) data from 2018 and my experience, insurance companies couldn't leave our occupancy fast enough.

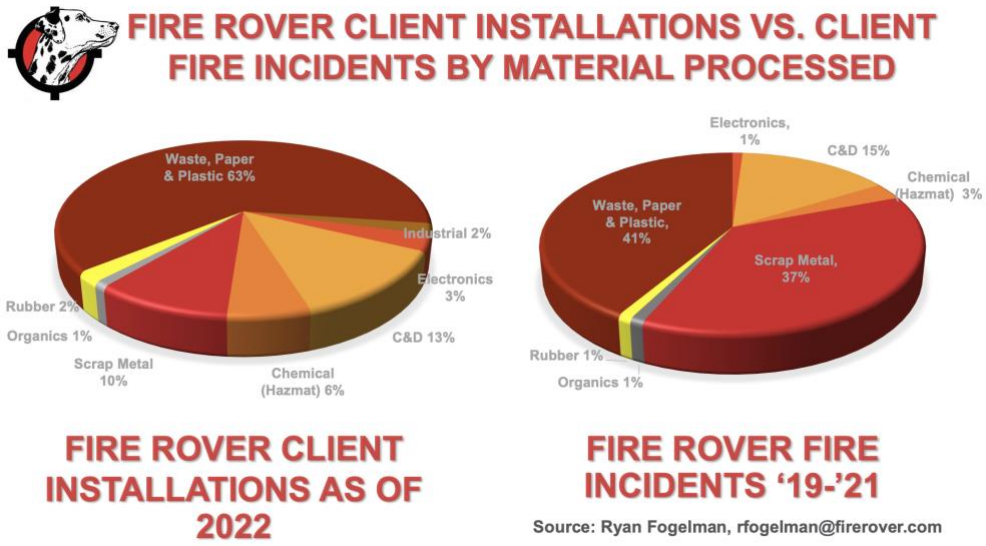


Since that time, we have been gradually gaining options for the best operators. I have personally fought and won favorable outcomes by proving that **our customers that have developed operational best practices, in combination with having our early thermal detection and fire elimination solution in place, have less fire risk than**

any point in history, which includes the time before the lithium-ion battery wave even began.

Increase in Scrap Metal Fires: In 2021, scrap metal fires continued to increase from their large drop in 2019 or, depending on your interpretation, their huge spike in 2018. My belief holds true that if you take out 2019, we are continuing on an upward trend, especially since we saw a 26 percent jump from last year.

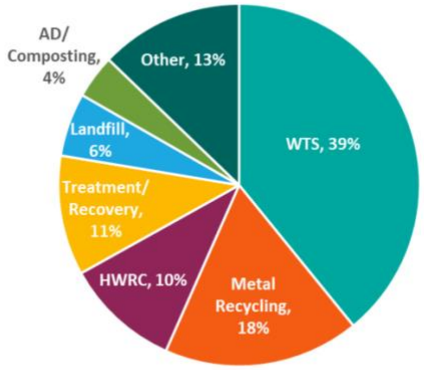
So, how is the scrap industry responding? It has spent a ton of time and effort on implementing “best practices” developed by traditional industry fire experts, but in my opinion, this occupancy could benefit the most from investment in new fire technology and evaluation and recommendations from fire experts outside of the industry.



Take a look at the latest numbers from fire incidents we have detected and eliminated at our clients’ operations in the past three years. As you can see, scrap metal fire incidents account for 37 percent of our total fire incidents even though they account for only 8 percent of our client installations. Don’t get me wrong, these are great operators that understand that they need to invest in proven technologies to help them mitigate their specific risks. Can the fire risk be mitigated in other ways? Of course, and many operators have done so successfully. There are several potential fire risks for the operators to deal with—from the automotive shredder residue piles to light tin piles, shredders, storage, and more.

The truth is that insurance companies are willing to provide policies to all types of high fire-prone industries. Insurance companies only leave when they feel that the risks are not able to be controlled or there is no end in sight.

Figure 1-4: Waste Fires in England by Facility Type (2014-2019)



Source: EA data, provided by the EA on 15.10.20 (2020) Waste fires reported for England 2014 - 2019

Looking at England's data provided in Eunomia's report, only 18 percent of its fires occur at metal recycling operations. This data looks at all waste fires, not just fires caused by lithium-ion batteries. According to my data, scrap metal fire incidents make up 32 percent of all reported fires in the U.S. and Canada; 34 percent if you include e-scrap fire incidents. In the same data, waste, paper, and plastic fires make up 49 percent of all fires. If you add HWRC (household waste recycling centers) and WTS (waste transfer stations) in England, the number accounts for 49 percent of all reported fires.

After seeing this data, the question we must ask is why are the scrap metal operators in the U.S. experiencing almost double the number of fires incidents than in England?

There is no easy answer to this question, but I can confidently state that any of the scrap operators that have added our technology to their operational best practices have not had a major or catastrophic fire incident while our solution has been in place. Only time will tell whether the fire prevention planning strategy that ISRI has developed and rolled out to its members is enough to stem the tide of these fires alone, or if the investment in technologies will be required in the future.

Increase in C&D Fires: C&D fire incidents were up significantly, with a total of 19 compared to eight in 2020. This is the highest number we've seen since I began tracking these fires in 2016. Additionally, since C&D operations are typically located further distances from the public, some fires may not have been reported by the media, possibly making this number even higher.

While it's unclear what caused this spike in incidents, C&D outfits are continuing to grow and hybrid MRFs are continuing to accept C&D materials. Personally, I have seen these operators taking the fire hazards extremely seriously across the industry. There has

been a ton of growth in this sector, and I have seen firsthand the kindness of most C&D operators to share best practices with their industry breatharian. Hopefully, 2021 was an abnormality and in future years we see these numbers back to their industry average or lower.

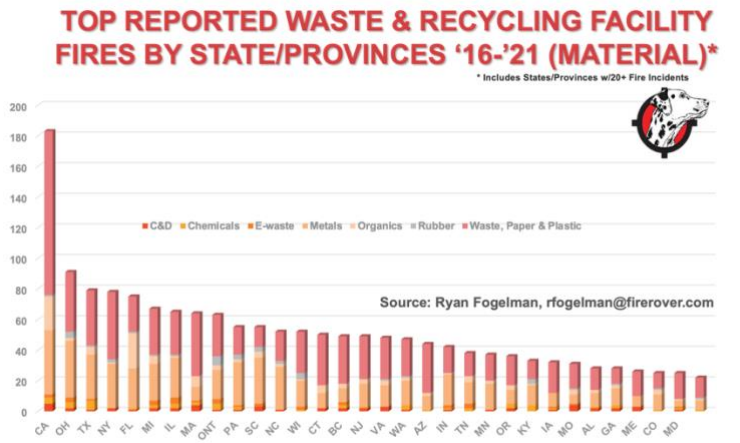
Decrease in E-scrap Fires: A new concern I have been tracking is fire hazard incidents with an e-scrap specialty. In 2021, we saw a 58 percent decrease in e-scrap fire incidents from 2020 and a 19 percent decrease from the average number of fires from 2016 to 2020.

Recycling personal electronics and personal storage is in its infancy from a historical perspective. Some folks say only 5 percent of all lithium-ion batteries in the world are not recycled, a number I feel is low but leaves a ton of opportunity for improvement. The public push to recycle these materials has two very positive effects: (1) less personal storage and/or electronics get into our waste and single stream recycling, and (2) we are able to better recycle and reuse all of the components including rare earth metals we so desperately need. The issue is that anyone with pliers and a garage can hang a shingle and claim to recycle electronics. There are some great operators out there, but the process is custom and different than RMA (return merchandise authorization) programs, which have been in existence for years and allow a specific manufacturer to control how they disassemble and reuse or dispose of their products' components, specifically batteries.

Recycling general electronics comes with many different processes, such as for disassembly and removal of lithium-ion batteries in products, and unfortunately, operators performing this very necessary function for society are often left to hold the bag with most of the risk and cost of fire dangers.

State and Province Breakdown

Here are the waste and recycling facility fires by U.S. state and Canadian provinces from 2016 to 2021:



Some States Like SC, NC, PA, IN & KY Have More Metal Fires Historically Than The Typical Top Driver Of Facility Fires At Waste, Paper & Plastic Facilities; FL & CA Have Some More Organic Fires Than Most Other States.

As expected, the top states and provinces for reported waste and recycling facility fires for the past six years are those with higher populations: California; Ohio; Texas; New York; Florida; Michigan; Illinois; Massachusetts; South Carolina; Pennsylvania; and Ontario, Canada. Additionally, data has revealed that some states such as South Carolina, North Carolina, Pennsylvania, Indiana, and Kentucky have more fires historically than the typical top driver of facility fires at waste, paper, and plastic facilities. Also, Florida and California have notably had more organic fires than most other states.

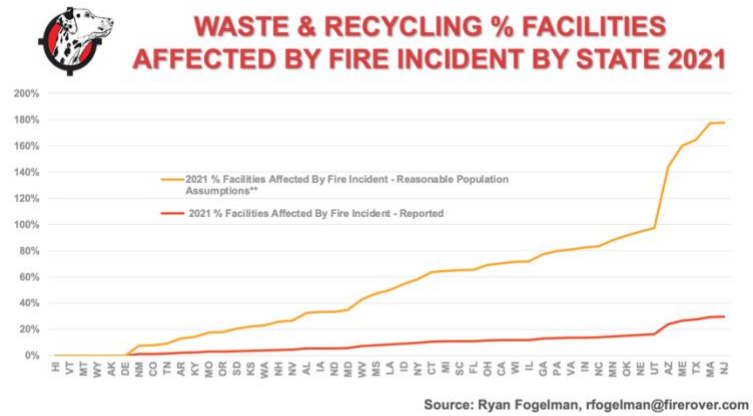
Year-Over-Year Comparison

Reported waste and recycling facility fires in the U.S. in 2021 compared to previous years' average:

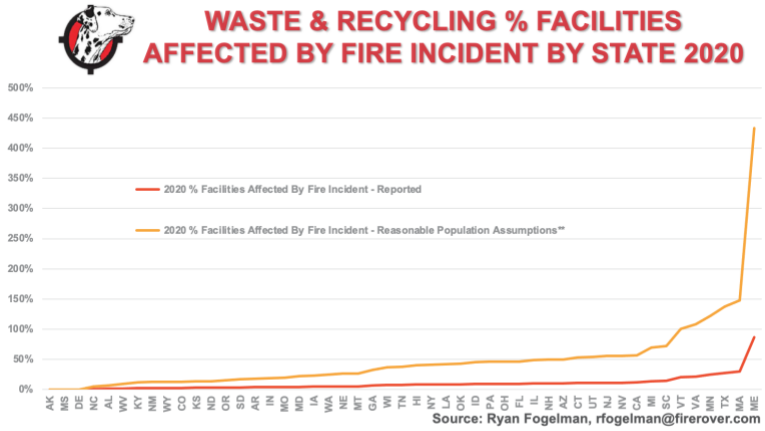
In 2021, 23 States Experienced An Increase In Reported Facility Fires Over Their Prior 3-Year Averages. NJ, IN, NC, MA, PA, WI, AZ, OK, GA, AL, UT, NE had the Highest Increases.

With the overall increase in fire incidents in 2021, I decided to compare the year with previous years' average incidents incurred by each state. Based on the data, 23 states experienced an increase in reported facility fires over their prior three-year averages.

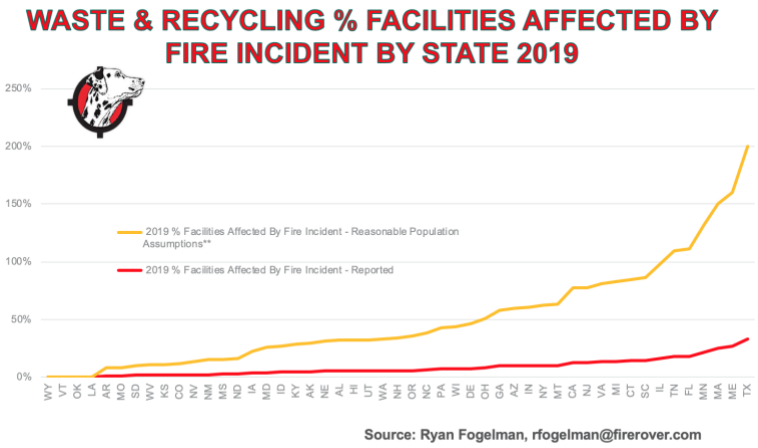
In the following graphs, I provide the percentage of each state's waste and recycling facilities that have likely been affected by a fire incident, utilizing both the reported number of fire incidents and reasonable assumptions outlined earlier:



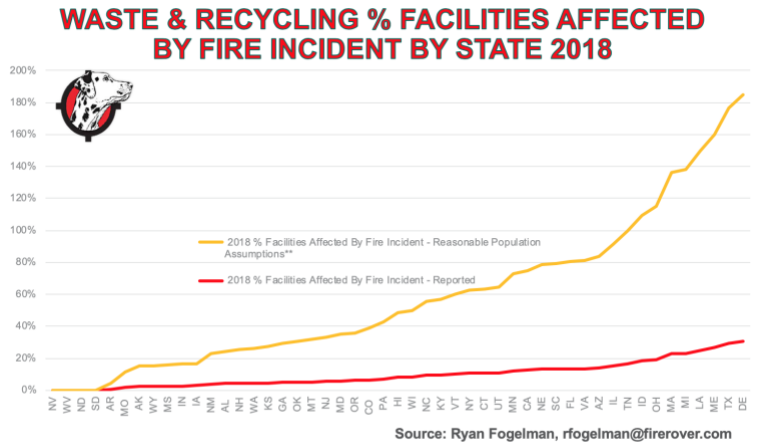
States w/Highest % Affected Per Fire Incident: New Jersey, Massachusetts, Texas, Maine & Arizona



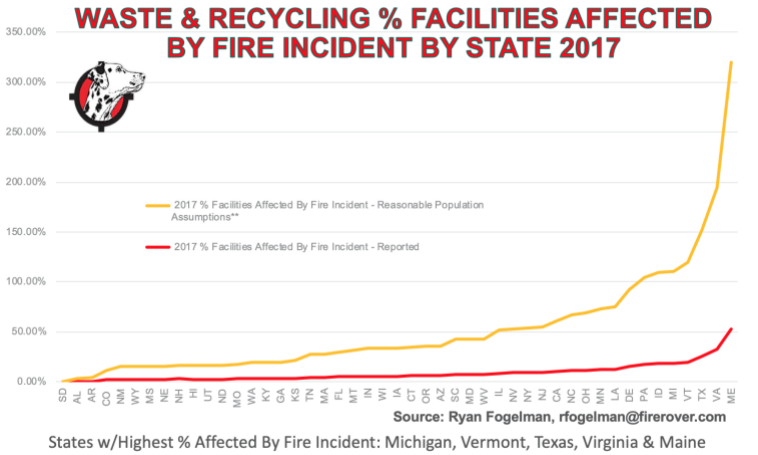
States w/Highest % Affected Per Fire Incident: Maine, Massachusetts, Texas, Minnesota & Virginia



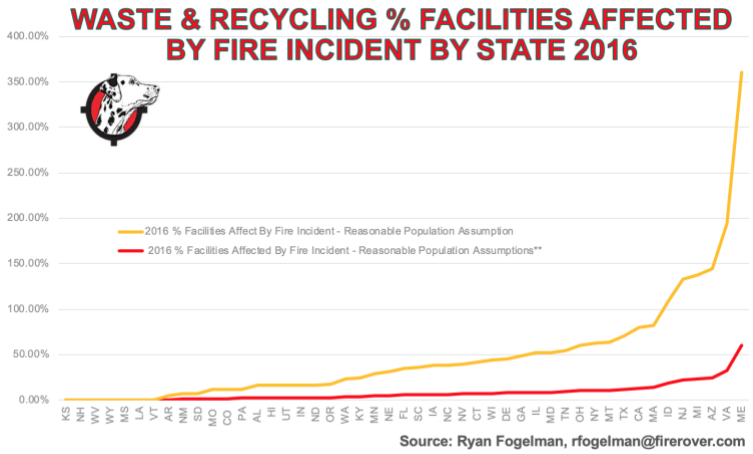
States w/Highest % Affected Per Fire Incident: Texas, Maine, Massachusetts, Minnesota & Florida



States w/Highest % Affected By Fire Incident: Delaware, Texas, Maine, Louisiana & Michigan

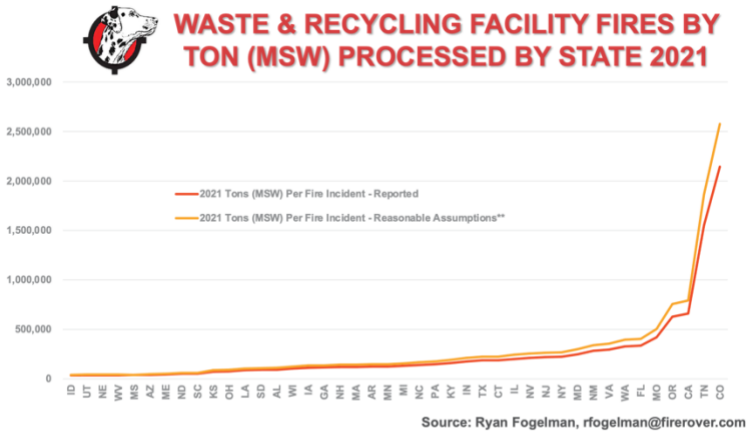


States w/Highest % Affected By Fire Incident: Michigan, Vermont, Texas, Virginia & Maine

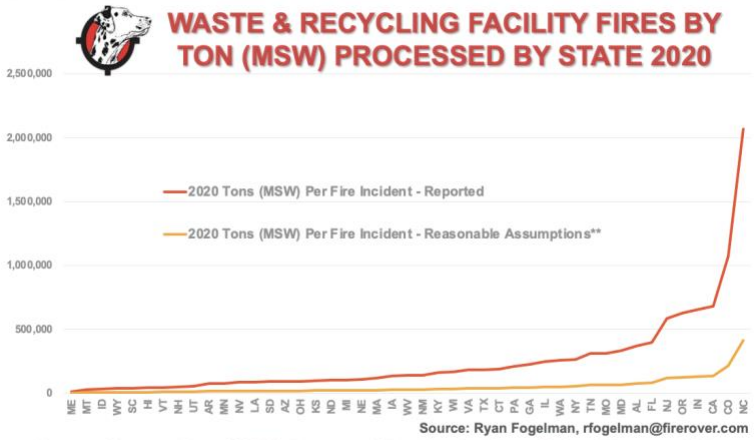


States w/Highest % Affected By Fire Incident: Maine, Virginia, Arizona, Michigan & New Jersey

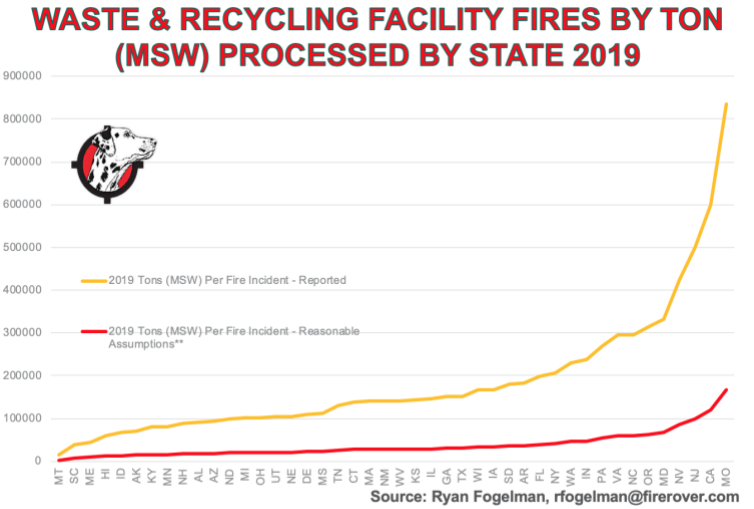
In the graphs below, I outline the estimated number of fire incidents using an estimated number of tons processed, the reported number of fire incidents, and reasonable assumptions outlined earlier:



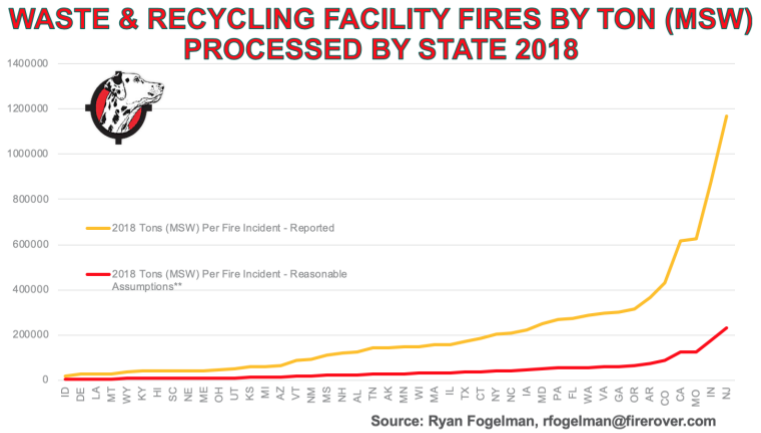
States w/Lowest Tons (MSW) Processed Per Fire Incident: Idaho, Utah, Nebraska, Wyoming & Mississippi



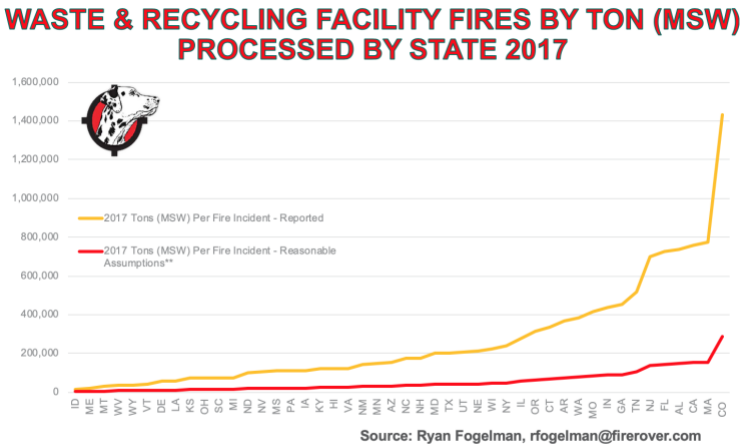
States w/Lowest Tons (MSW) Processed Per Fire Incident: Maine, Montana, Idaho, Wyoming & South Carolina



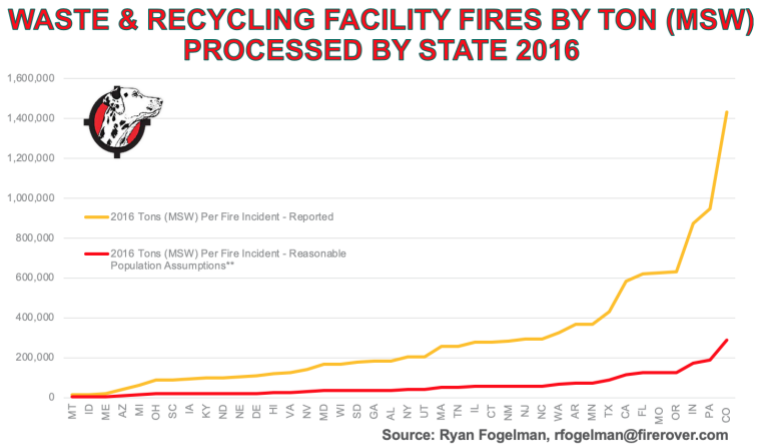
States w/Lowest Tons (MSW) Processed Per Fire Incident: Montana, South Carolina, Maine, Hawaii & Idaho



States w/Lowest Tons (MSW) Processed Per Fire Incident: Idaho, Delaware, Louisiana, Montana & Wyoming



States w/Lowest Tons (MSW) Processed Per Fire Incident: Idaho, Maine, Montana, West Virginia & Wyoming



States w/Lowest Tons (MSW) Processed Per Fire Incident: Montana, Idaho, Maine, Arizona & Michigan

The Consequences—Injuries, Illnesses, and Deaths

The waste and recycling industry is No. 6 on the list of most dangerous occupations, and unfortunately, it's an industry where injuries, illnesses, and even deaths can happen at a moment's notice.

However, with that in mind, members of the industry are constantly looking for ways to operate more safely and to ensure that workers return home safely at the end of each workday. Some of these efforts include supporting and implementing Slow Down to Get Around legislation, ramping up safety training for employees, and utilizing more safety technology.

In 2021, the industry experienced two deaths and 37 direct and indirect injuries. This is down from three deaths and up from 23 direct and indirect injuries in 2020.

REPORTED WASTE & RECYCLING FACILITY FIRES INJURIES & DEATHS IN US/CAN

	2018	2019	2020	2021	2021 v. 2020	Ave '18-'20	2021 v. '18-'20 Ave
Injuries	19	49	23	37	37.8%	30	23.3%
Deaths	2	2	3	2	-50.0%	2.33	-14.3%
Incidents w/Death or Injury	12	25	14	22	36.4%	17	29.4%
Total Fires	365	343	317	367	13.6%	342	7.3%
% of Incidents w/Death or Injury	3.3%	7.3%	4.4%	6.0%	26.3%	5.0%	19.9%

Source: Ryan Fogelman, rfogelman@firerover.com

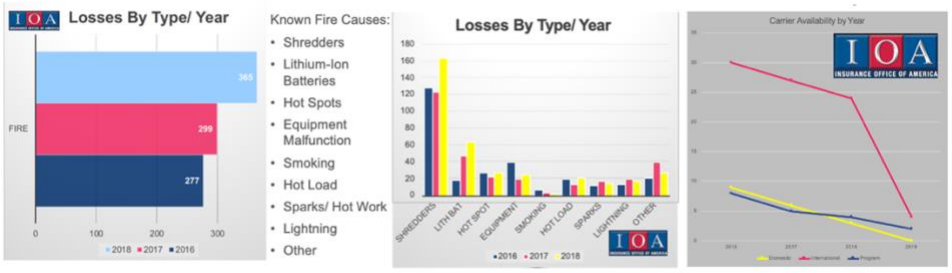
As we look at these numbers and continue to focus on improving our safety efforts, we must also keep in mind that most of the injuries occur to the fire professionals who come on scene to fight the fires and face the dangers that come along with these fires. Therefore, the fewer major fires that occur means the fewer firefighters are required to fight these fires, which should inevitably lead to fewer injuries.

The Consequences—Insurance Companies Leaving the Industry

It's no secret that the insurance and reinsurance industry sees the waste and recycling industry as high risk and has been running from our industry for years. But the reasoning behind that assumption lies within insurance companies' actual claims data.

According to data provided by IOA's Brainard, 2018 was the banner year for claims, and consequently, insurance companies began to leave the market at a hurried pace. The

increases were mainly caused by an uptick in lithium-ion batteries in our waste stream as well as in shredders, which many would attribute to the additional spark risks caused by the same culprit. As you can see from the charts below, 2018 was the year that many of the insurance companies decided to leave the waste and recycling industry.



Source: Nathan Brainard, nathan.brainard@ioausa.com

Brainard's number of incidents is eerily similar to the publicly reported number I share. The only difference that I see is that his numbers also include landfill fires. Although the numbers are similar, the real story in Brainard's data is the consequences the industry is experiencing due to these fire incidents.

In addition to the possible injuries, illnesses, and even deaths caused by fire incidents, the industry is seeing insurance companies flee from the sector. In 2016, the industry had almost 50 insurance options. Now, it has less than 10.

When asked in 2019 what this contraction meant to the private waste and recycling facility operator, Brainard said, "Those with no losses could expect a 25 to 35 percent premium increase, those with moderate losses would have a 75 percent-plus increase, those with catastrophic losses could see their premiums double, and those with multiple issues could be uninsurable."

His predictions have become a reality for some, as higher premiums are starting to pop up across the industry. The South Bayside Waste Management Authority in Northern California, for example, saw its MRF's insurance premium increase from $100,000-plus to more than a million after its first major fire, and the MRF was told it would be uninsurable if it had another incident.

In Alexandria, Minn., the Pope/Douglas Solid Waste Management-owned waste-to-energy facility faced a possible increase of $300,000-plus for insurance fees in 2021 due to claims in other parts of the country. In a nearby area, the Perham waste-to-energy facility saw a $76,000 increase in insurance costs in 2021.

Also, in 2021, a misplaced lithium-ion battery ignited in a machine after-hours at Tulsa Recycle & Transfer in Tulsa, Okla., sparking a large fire that operator American Waste

Control is still recovering from. While insurance covered basic costs, the company was left with the displacement of 40 workers and repair costs upward of $11.4 million.

These are just a few examples of what our industry is facing, and I think we can all agree that we need to make safety changes to mitigate insurance companies' risk. These changes need to be implemented at the site level, and the insurability of each site needs to be evaluated by each insurance company based on a variety of factors such as historical claims, incident data, response, training, the rest of the sites in a portfolio, and so on.

To get the ball rolling on bringing insurance companies back to our occupancy, I have helped several insurance companies understand the risk we face in our industry. I have explained that **good operators definitely have fewer fires than bad operators. But, when good operators are still having fires, new solutions outside of basic fire prevention tactics are needed.**

That being said, we need to continue to implement real fire prevention and disaster response plans at all our facilities. This alone can work in industries where the fire hazard can be removed. In the waste and recycling industry, where good operators still have fires, we need to take more steps to help solve the problem.

Insurance companies want to protect our industry occupancy. According to Ryan Butler, vice president of risk mitigation for Cottingham & Butler, which provides insurance for several different high-hazard industries, "Carriers become hesitant to enter or write complex classes of business when they see systemic losses. However, underwriters gain another level of confidence when they see operators investing time, capital, and resources into auditing and analyzing their exposures, as this shows there is a wiliness to improve and avoid mistakes.

"To many people, auditing certain exposures on an annual basis can be a double-edged sword, as there is concern the insurance carrier will penalize and increase rates on any deficiency or issue unveiled during the audit. However, generally, it is the exact opposite; when a carrier sees that an operator is investing and openly illustrating issues, and the remediation and capital expenditures that will be undertaken to fix the issues, they will have a different viewpoint and interest in the account.

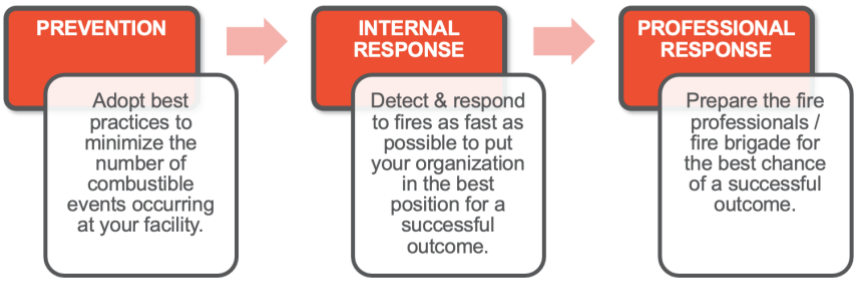
"If an operator invests in an audit, they will be on the path to better risk management practices, which can actually help them reduce a catastrophic loss. It is imperative, irrespective of insurability and coverage options, that operators take the necessary precaution to avoid losses wherever possible, as experiencing a large loss will tarnish the reputation of the business for three to five years."

The insurance companies want to see real effort defining the real scope of the problem, solutions, and paths forward for strategies that will mitigate the specific risks of the

occupancy. If they do not see this, the only thing they have to go on is historical claims data. **Fire prevention plans and disaster preparedness plans are the basic blocking and tackling strategies insurance underwriters already expect good operators to have in place. If they do not have those in place, they are not considered good operators.** The insurance companies want to see operators that will face problems head-on and not try to avoid them and wish they would just go away.

One way that operators can prove to insurance companies that they are taking fire prevention seriously is by investing in effective technologies. According to Stuart Kinsella of Rokstone Underwriting, "Early detection methods linked with monitoring stations and installation of suppression systems that are fit for purpose are key in reducing exposure and ultimately enticing the insurance market to provide terms."

Another way that operators can prove they are taking fire prevention seriously is by planning for a live event.



After prevention, the real opportunity is improvement in internal response time!

Prevention. The most important part of fire prevention is to develop a plan of attack. Prevention is the basic blocking and tackling and should include all components of minimizing the potential number of events that can occur at your facility. Examples of this include having limits on the size and height of your in-feed and feedstock piles; regularly cleaning the facility so it is free of dust that can combust; developing a disciplined hot works program; clearing your working floor; keeping proper pile separation so fire professionals have room to maneuver; having the proper fire protection in place commensurate to the amount of material being processed at your facility; identifying aerosols or propane tanks during presort; having frequent safety training of employees; and, last but not least, educating the public on proper disposal of non-hazardous material in the waste and recycling stream. For more specifics around the Combinational Approach to fighting waste and recycling facility fires, take a look at my article on how to reduce the fire risk profile of your waste and recycling facility.

Internal Response. I typically tell folks that early detection is the key to catching and mitigating a fire early. The goal is not just to catch a fire when there are flames but to understand that there are situations where hot spots can be cooled before they flame. Overlaying smoke analytics into detection is imperative, as it helps when we are dealing with deep-seated fires where smoke is the first sign. The faster we can detect a fire and apply an environmentally friendly cooling agent to the affected area, the better the chance the firefighters will arrive on scene with the fire fully suppressed or under control.

The goal is to set the tripwire as early in the process as possible. This can be done through top-grade thermal detection in combination with smoke and other analytics and, most importantly, a highly trained agent who can weed through false positives in an effort to fight only the incidents that need fighting. It's important to note that anyone can purchase a top-grade thermal camera, but just like most hardware and software are not off-the-shelf solutions, neither are these highly sophisticated pieces of equipment. To work properly in our highly active environments takes investment, skill, training, and experience. Just as I would not know the first thing about running a recycling or hazardous materials facility, I would suggest leaving the highly specialized skill to the experts.

Professional Response. Another extremely important part of the internal response is to prepare the professional response. Investing in the proper equipment for the fire department to use onsite can be a huge timesaver. Even going as far as having attached and rollout hoses so the firefighters can immediately start applying suppressant to the affected area can make a huge difference. Investing in a compressed air foam system can save valuable time for the fire professionals as well, as they can fight a fire within less than a minute of arrival.

Most importantly, having an active relationship with your local fire department is imperative. They are the folks who will decide whether they actively fight the fire or take a defensive position where they do their best to contain the fire to the immediate area. The truth is that the goal of the fire department is to ensure that all of its department members, and anyone else on scene, make it home to their families. Fighting waste and recycling fires is hard enough when the fire department has a relationship and is familiar with the facility, exits, equipment, piles, and storage, among other factors. Fighting these fires without this knowledge, however, would bring trepidation to any rational fire chief.

Ultimately, as an industry, we need to make a choice. We need to focus on dealing with the inherent risk of fires we encounter by developing processes and solutions that catch and suppress fires as quickly as possible. We spend so much of our time and resources on educating the public about the hazards of improper recycling in an effort to get these hazards out of the recycling stream. However, the issue that we face is that education only focuses on one piece of the problem. We see these hazards in

construction and demolition, metal recycling, municipal solid waste processing, and more. Don't get me wrong, educating the public on their unintended effects is important, but in my opinion, we can get more bang for our buck by investing in safety processes, plans, and technologies that truly mitigate the fire risks before they have a chance to become major incidents.

The Solutions—The Fire Rover

I spent my first five years in the market trying to understand the problem and being cautious about saying that our patented product is the solution to the problem. Sometimes you need to call a spade a spade, and I am now 100 percent confident that our solution is the only solution on the market today that can lower the risk profile of a good operator to levels seen before the lithium-ion hazards hit our industry.

To prevent and eliminate fire incidents, you need to invest in solutions that actually work for your facility type. This means that traditional fire suppression methods such as water sprinkler systems and smoke alarms may not be the best option to stop a fire at a facility where there's a lot of activity such as a MRF, scrap metal facility, transfer station, or waste-to-energy facility.

It is great to provide fire protection equipment for employees to use onsite, but no employer can force any employee to fight a fire incident at their facility. According to the Occupational Safety and Health Administration (OSHA), "If a fire breaks out in the workplace, employees have two options: Fight or Flight. What employees don't have, however, is an obligation to do one action or the other. The decision on whether to Fight or Flight is entirely up to the employee. Proper employee training helps people take the right action faster."

This is why we developed Fire Rover, a comprehensive firefighting solution that combats incipient fires and explosions within seconds from ignition. This system is specifically designed for the waste and recycling industry and has eliminated thousands of fires in waste and recycling facilities across the U.S. and Canada.

There are many advantages to using the patented Fire Rover system, including:

1. Equipped with FLIR thermal cameras that can be paired with listed optical flame detectors to satisfy code compliance, the Fire Rover provides early heat abnormality detection before visible smoke or flames are present.
2. Once a heat abnormality is detected, alarms received from the detectors are transmitted to a UL central station, where a Fire Rover agent verifies if it's a false positive or if it's a threat and action needs to be taken.
3. If action needs to be taken, the Fire Rover agent alerts the facility, the fire department, and authorities and then shoots an environmentally friendly cooling

agent from the Fire Rover's nozzles onto the hot spot to eliminate a fire before or after it starts. This allows ample time for fire professionals to arrive on scene and for the facility operator and fire professionals to provide an appropriate response to the level of hazard.

4. Lastly, the Fire Rover is capable of superior suppression, which is partially due to the elevated water density a monitor delivers when compared to the design densities of a typical sprinkler system and partially due to the targeted suppression from controlling the monitor from the central station.

By detecting early when the fire is small, targeting the fire, and putting large amounts of water in this initial growth stage, the total water usage is significantly reduced. This was the finding of a 2020 FM Research Technical Report entitled "Reducing Water Demands with Innovative Fire Protection Solutions." In this report, smart monitors demonstrated the ability to reduce the amount of water necessary for un-cartoned unexpanded plastic and cartoned unexpanded plastic fire sources by up to 88 percent. According to James Andy Lynch, founder and CEO of Fire Solutions Group, Fire Rover will be classified as a smart monitor by Factory Mutual (FM) and is defined in the FM standard 1421 Approval Standard for Fire Protection Monitor Assemblies.

"Having been in the fire industry for more than 20 years, and working with a number of new and emerging technologies, I feel comfortable saying that Fire Rover has positioned itself as a must-have tool in the box of fire protection equipment we as engineers must consider when designing fire protection for a facility," says Lynch, who has worked with Fire Rover in multiple capacities including designing systems for proper coverage, preparing variances utilizing technical data to support its use, assisting with the FM approval process, and submitting text changes to various fire codes.

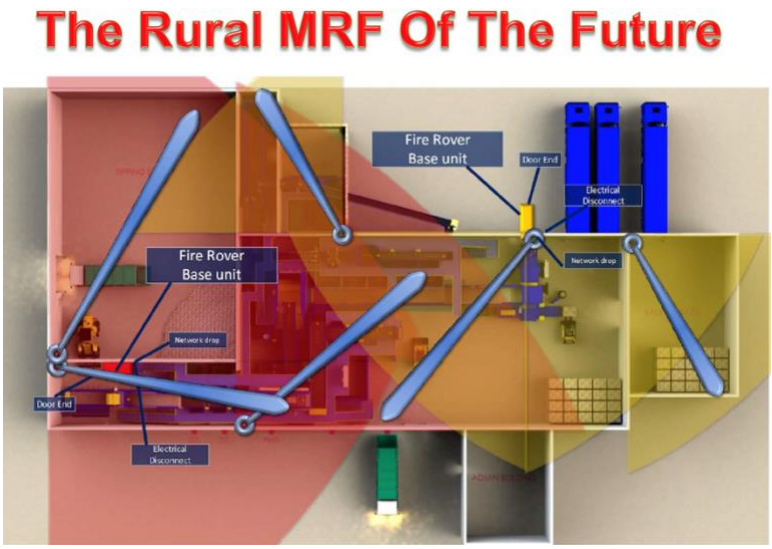
Keeping pace with the changes and needs of the industry, in 2020, we took our solution a step further by adding an additional "quick connection" for fire professionals. The quick connect allows fire professionals to take a defensive approach to fighting a lithium-ion battery fire effectively while remaining safely outside the facility.

This solution, which is currently installed in 200 facilities across the U.S. and Canada, received NWRA's 2020 Innovator of the Year – Recycling Equipment award, which celebrates innovation in design and manufacturing that increases the effectiveness or efficiency of recycling equipment and operations.

Also in 2020, our Fire Rover solution had the honor of being part of FCC Environmental Services' MRFs in Houston and Dallas, Waste Management's MRF of the Future in Chicago, and a complete fire sprinkler replacement at the Rural MRF of the Future installed by Brad "The Landfill Warrior" Austin in Marquette, Mich.

When I asked Austin why he chose our solution versus the traditional path, he said, "When we started this process, I had heard from others regarding different solutions

they had, and it became extremely apparent to my team that sprinklers offered very little protection in our type of facility. I felt the Fire Rover system was designed specifically for the waste and recycling industry, as it has eyes onsite and the ability to target fire quickly. Preventing the loss of equipment is critical, and we felt this was the best option to protect the investment we made into our facility. We were fortunate that our local authorities were so supportive and formerly provided a variance for the Fire Rover system to operate in place of the fire sprinkler requirement."



Our solution has been blessed to be accepted in the waste and recycling industry, but there is also a strong case for occupancies outside of waste and recycling such as refineries, construction sites, demolitions sites, historical structures, airplane hangars, and garages specifically housing lithium-powered electronic vehicles. As you can see from our submissions for inclusion in the National Fire Protection Association codes, our solution is making progress due to its results proven in the waste and recycling occupancy.

FIRE ROVER

PROFESSIONAL ADOPTION - NFPA

Code Name and Number	Text Submission	Result	Next Step
NFPA 18A Standard on Water Additives for Fire Control and Vapor Mitigation	Text submitted	Accepted	NITNAM
NFPA 80A Recommended Practice for Protection of Buildings from Exterior Fire Exposures	Waiting for revision cycle to open		
NFPA 102 Standard for Grandstands, Folding and Telescopic Seating, Tents, and Membrane Structures	Waiting for revision cycle to open		
NFPA 120 Standard for Fire Prevention and Control in Coal Mines	Waiting for revision cycle to open		
NFPA 122 Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities	Text submitted	Committee meeting March 2021	Attend Meeting
NFPA 140 Standard on Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations	Text submitted	Waiting on committee meeting announcement	
NFPA 241 Standard for Safeguarding Construction, Alteration, and Demolition Operations	Text Submitted	Accepted as Appendix material	NITNAM
NFPA 303 Fire Protection Standard for Marinas and Boatyards	Open for input (2023)		
NFPA 307 Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves	Text Submitted	Waiting on committee meeting announcement	
NFPA 409 Standard of Airport Hangars	Text Submitted	Accepted as Appendix Material	NITNAM
NFPA 418 Standard for Heliports	Open for input (2024)		
NFPA 914 Code for Fire Protection of Historic Structures	Text Submitted	Committee meeting June 2021	Attend meeting

Additionally, in 2020, Fire Rover designed and installed a box-less solution for waste-to-energy and industrial facilities that utilizes the operators' existing water infrastructure. The targeted deluge solution can replace a traditional deluge system with the ability to target any fire with water, providing more control of the event, alleviating the issue of accidental discharge, and allowing dual control of the system by both the Fire Rover agents as well as the operators. This solution is currently installed and working successfully in large industrial operations across the country. When allowed, these fire elimination videos are shared on our Fire Rover YouTube Channel.

In 2021, we developed and piloted a new solution called OnWatch powered by Fire Rover, which is a mobile unit that utilizes both solar and wind power to remotely monitor thermal cameras and detects abnormal heat signatures at landfills. The system communicates via a 4G/5G cellular network and connects to the Fire Rover Monitoring Center for a quick detection, identification, and dispatch of emergency personnel. The OnWatch mobile unit is heavy-duty for landfill environments, including dust, wind, and uneven surfaces, and has been proven to work in the field by successfully getting to landfill fires before they became too large to easily extinguish.

As we continue to innovate and evolve our solution, our customers can be assured of one thing that is not typically true of most equipment or any fire protection equipment that I know of: our solution gets better with age.

We partner with our clients to understand their business and work with them on their solutions. Be it remote control, cameras for preemptive maintenance on parts of their equipment, or helping them build a new operation from the ground up, we are there with them every step of the way. Are we perfect? Absolutely not, but fighting fires is not a science. Human beings have been trying to control fire since the beginning of time. Anyone who says they can "guarantee" your operation will not have a fire is off their

rocker. We are an outsourced fire department, like the Pinkertons of fire, that is there to help you fight fires early. No fire professional would argue that the earlier you identify and start fighting a fire, the better the end result. One hundred percent success is impossible, but insurers are not looking for 100 percent success—they are looking for risk mitigation to a level that allows them, and our customers, to sleep at night, which is our goal.

The Solutions—EPR For Batteries

In 2021, Oregon and Maine announced new packaging policies at the state level, making them the first in the nation to officially pass extended producer responsibility (EPR) laws for packaging sold or distributed in their states. This move has paved the pathway for other states to create and likely implement their own EPR policies in the near future.

Also in 2021, Washington, D.C.'s all-battery bill officially passed into law, making it the first all-battery EPR law in the country. Under the law, producers now fund and manage an effective recycling program in Washington, D.C., for both single-use and rechargeable consumer batteries. This new law, along with Vermont's EPR law that covers all household primary batteries, is setting the bar for the changes that need to happen to ensure that costs shift from operators and taxpayers to product manufacturers.

While some view EPR policies as problematic, I view them as an opportunity. I've said it before, and I'll say it again: battery manufacturers need to be held responsible for the products they are bringing to market and for the costs their products cause down the supply chain. Currently, our operators and fire professionals who protect our facilities are footing the bill for the costs generated by fires. The industry needs help from the government and associations, but the industry deserves help from the battery manufacturers. 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.

During a recent conversation with Courtney Scott, household hazardous waste (HHW) program manager for Zero Waste Sonoma, she explained why she backs EPR policies and is currently trying to get her idea approved.

"A few years ago, we looked into creating a new battery collection program at either retail locations or at government buildings like fire stations and community centers. However, with the uptick in lithium-ion battery fires, we realized that it would be both expensive and dangerous to have batteries collected at more locations.

"During that same time period, EPR for batteries was being discussed at the state level, so we wanted to see how that played out. Since a couple of different battery bills failed in recent years, Zero Waste Sonoma was approached by the California Product Stewardship Council to see if we were interested in joining a handful of other local jurisdictions to implement our own battery EPR ordinances.

"We recently brought the idea to our Zero Waste Sonoma Board of Directors in September 2021 to gauge their interest. We received support to create a model ordinance for true EPR of all battery chemistries, both loose and embedded. I'm currently working on a more specific draft ordinance based on their feedback and will bring it back to the board soon. This will be a long process, but it's one we really believe in because batteries are so prolific," she said.

On the other side of the globe, the European Commission published a Proposal for a Regulation concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020. The European Parliament Committee on the Internal Market and Consumer Protection voted and decided that there was a need for a deposit refund scheme (DRS), which could ensure the safe and selective collection of batteries and accumulators and help avoid fire risks in waste facilities.

According to an article in *RECYCLING* magazine, "Incorrectly disposed lithium batteries and accumulators pose a high risk of fire incidents everywhere, and not only in waste battery installations. When this arises, sorting systems for lightweight packaging, paper-collection, commercial waste processing, etc., can be considerably damaged by fires, and workers and other people from the wider community can be put under great risk. As a result, the purpose of making batteries more circular is weakened because processing and treatment facilities are damaged, sometimes beyond repair, reducing the overall capacity to recycle batteries. Consequently, mandatory DRS is essential if we are to: achieve high collection rates, safe battery flows, and safeguard treatment facilities."

It will be interesting to see how that process works overseas and how our EPR policies in the U.S. will play out. Since awareness around this issue has increased, it is now time for the stakeholders to come together and solve this problem.

Thank You

For those of you who know me well, you know that I am passionate about solving problems and bringing solutions to market. When I received a phone call from my childhood friend, Brad Gladstone, in summer 2015, he said something to the effect of, "Ryan, I know you love innovative things. Come to Detroit … I have something cool to show you." Well, he was right. What he showed me that day changed my life. I met Gladstone's partners and co-inventors, Pete Marry and Jeremy Dusing, in the back of a scrap metal facility in Detroit, and they proudly showed me a Fire Rover solution they

had developed from scratch. By August, I was on board, and in September, I was at the first Paper and Plastics Recycling Conference in Chicago sharing the Fire Rover solution with all of those in attendance.

I met several great folks at the show, but one person left a lasting impression on me. After I shared with him our solution, I asked him what he thought. His response was, “I like it a lot, but why do I need it?” Naively I said, “Because you have fires.” He said abruptly, “Do, I?” My response was, “Don’t you?” Then he asked me the question that started my path down finding and consolidating any data to truly understand the fire problem the waste and recycling industry was facing: “Do my competitors?”

Five reported waste and recycling facility fire reports later, I have learned so much from the waste and recycling and firefighting industries. I have gained friends, colleagues, and compatriots along the way. As I continue down my path to learn, educate, and help alleviate the solvable fire problems our industry faces, I think about the monetary losses we face and about the fire professionals who are typically the ones who are injured while fighting these unnecessary fires.

Those folks who know me well understand that the passion I have for our solution, industry, and fire professionals goes way past an occupation. I truly believe that we all have the right to go home to our loved ones at the end of the workday. I attended my first FDIC International in 2016. At that show, so many firefighters came by our booth and said, “You’re going to put us out of a job with your solution!” And the follow-up most of these guys would say was, “I am just kidding. We hate fighting these fires—they are dangerous and messy.” The truth is that no firefighter wants to fight a fire at a facility where the product, piles, and operations change on a daily basis. Once all the employees are evacuated safely, they focus on getting home to their families using “containment strategies” versus “aggressive firefighting tactics.” My guess is that most of us reading this feel the same way.

Unfortunately, Gladstone passed away a few years back. He was a giver, and he would have given the shirt off his back to anyone who needed it. He would always tell the story about how he invented the Fire Rover. He was providing security services for scrap metal facilities, and after a catastrophic fire melted one of their cameras, Gladstone asked the owner-operator if there was anything he could do. The owner responded to him stating, “Next time, put the fire out.” From that statement, Gladstone, Marry, and Dusing developed the Fire Rover solution. I am sure Gladstone is looking down every time we put out a fire for one of our clients and smiling, knowing that if not for his idea, passion, and dedication, the situation or non-situation could have been much worse.

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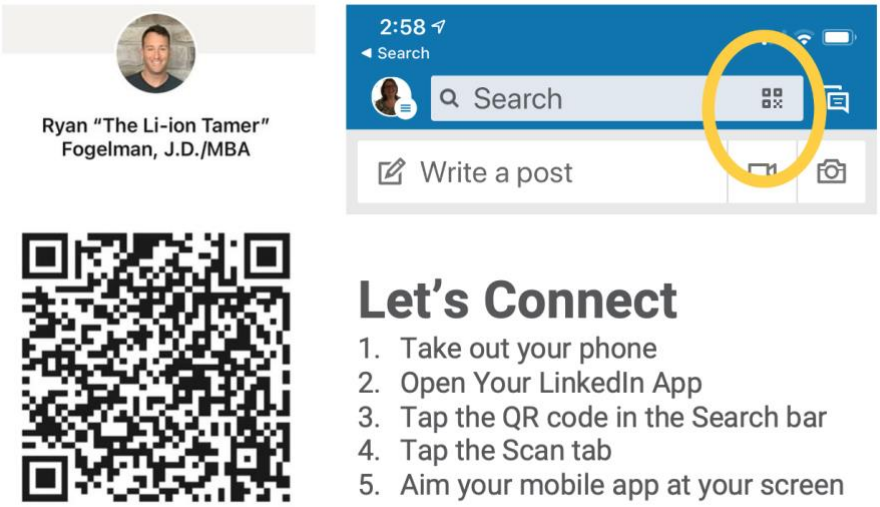
Interested in Learning More?
https://share.hsforms.com/1BfbGLhtpQMaVg2Haf73tqg4ljm3



Appendix A. 2021 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2021	Reported Fire Incidents 2020	Reported Fire Incidents 2019	Reported Fire Incidents 2018	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Average Annual Fire Per Year ('16-'20)	2021 Increase (Decrease) Compared To Average ('16-'20)	2021 Increase (Decrease) % Compared To Average ('16-'20)	Number Of Recycling Facilities*	Tonnage Processed By State*	2021 % Facilities Affected By Fire Incident - Reported	2021 Reasonable Population Assumption**	2021 % Facilities Affected By Fire Incident - Reasonable Population Assumptions **	2021 Tons (MSW) Per Fire Incident - Reported	2021 Tons (MSW) Per Fire Incident - Reasonable Assumptions**
ID	USA	2	2	1	4	4	4	3	(1)	-33%	22	67,000	9%	10	45%	33,500	6,700
UT	USA	6	4	2	4	1	1	2	4	150%	37	206,000	16%	30	81%	34,333	6,867
NE	USA	6	2	2	5	1	2	2	4	150%	38	211,000	16%	30	79%	35,167	7,033
WV	USA	4	1	1	0	4	0	1	3	233%	56	141,000	7%	20	36%	35,250	7,050
MS	USA	3	0	1	1	1	0	1	2	400%	38	111,000	8%	15	39%	37,000	NA
AZ	USA	12	5	5	7	3	12	6	6	88%	50	465,000	24%	60	120%	38,750	7,750
ME	USA	4	13	4	4	8	9	8	(4)	-47%	15	173,000	27%	20	133%	43,250	8,650
ND	USA	2	1	1	0	1	1	1	1	150%	36	100,230	6%	10	28%	50,115	10,023
SC	USA	9	12	12	11	6	5	9	(0)	-2%	83	452,000	11%	45	54%	50,222	10,044
KS	USA	4	3	2	5	4	0	3	1	43%	109	289,000	4%	20	18%	72,250	14,450
OH	USA	15	12	11	25	15	13	15	(0)	-1%	130	1,119,000	12%	75	58%	74,600	14,920
LA	USA	2	2	0	6	3	0	2	(0)	-9%	24	171,000	8%	10	42%	85,500	17,100
SD	USA	2	2	1	0	0	1	1	1	150%	58	180,000	3%	10	17%	90,000	18,000
AL	USA	8	2	8	6	1	4	4	4	90%	148	739,000	5%	40	27%	92,375	18,475
WI	USA	13	8	8	9	6	8	8	5	67%	109	1,346,000	12%	65	60%	103,538	20,708
IA	USA	6	5	4	3	6	7	5	1	20%	108	673,000	6%	30	28%	112,167	22,433
GA	USA	8	4	6	3	2	5	4	4	100%	62	906,000	13%	40	65%	113,250	22,650
NH	USA	3	7	4	3	2	0	3	(0)	-6%	70	355,000	4%	15	21%	118,333	23,667
MA	USA	13	13	11	10	2	6	8	5	55%	44	1,551,000	30%	65	148%	119,308	23,862
AR	USA	3	5	2	1	1	1	2	1	50%	139	366,000	2%	15	11%	122,000	24,400
MN	USA	6	10	9	5	5	2	6	(0)	-3%	41	733,000	15%	30	73%	122,167	24,433
MI	USA	7	9	9	15	12	15	12	(5)	-42%	65	911,000	11%	35	54%	130,143	26,029
NC	USA	15	1	7	10	12	7	7	8	103%	108	2,071,000	14%	75	69%	138,067	27,613
PA	USA	13	9	7	7	17	2	8	5	55%	98	1,893,000	13%	65	66%	145,615	29,123
KY	USA	3	3	6	12	4	5	6	(3)	-50%	126	482,000	2%	15	12%	160,667	32,133
IN	USA	15	4	11	3	6	3	5	10	178%	109	2,626,000	14%	75	69%	175,067	35,013
TX	USA	14	14	17	15	13	6	13	1	8%	51	2,591,000	27%	70	137%	185,071	37,014
CT	USA	9	9	12	9	5	6	8	1	10%	85	1,674,000	11%	45	53%	186,000	37,200
IL	USA	11	9	15	14	8	8	11	0	2%	92	2,211,000	12%	55	60%	201,000	40,200

NV	USA	2	5	1	0	4	3	3	(1)	-23%	45	425,000	4%	10	22%	212,500	42,500
NJ	USA	16	6	7	3	5	12	7	9	142%	54	3,500,000	30%	80	148%	218,750	43,750
NY	USA	13	11	14	14	12	14	13	-	0%	134	2,880,000	10%	65	49%	221,538	44,308
MD	USA	4	3	3	4	5	6	4	(0)	-5%	69	996,000	6%	20	29%	249,000	49,800
NM	USA	1	2	2	3	2	1	2	(1)	-50%	78	282,000	1%	5	6%	282,000	56,400
VA	USA	5	8	5	5	12	12	8	(3)	-40%	37	1,473,000	14%	25	68%	294,600	58,920
WA	USA	7	9	10	8	6	7	8	(1)	-13%	182	2,297,000	4%	35	19%	328,143	65,629
FL	USA	13	11	22	16	6	7	12	1	5%	119	4,354,000	11%	65	55%	334,923	66,985
MO	USA	6	8	3	4	6	4	5	1	20%	206	2,506,000	3%	30	15%	417,667	83,533
OR	USA	4	4	8	8	8	4	6	(2)	-38%	134	2,516,000	3%	20	15%	629,000	125,800
CA	USA	30	29	33	32	26	34	31	(1)	-3%	256	19,774,000	12%	150	59%	659,133	131,827
TN	USA	1	5	12	11	3	6	7	(6)	-86%	66	1,553,000	2%	5	8%	1,553,000	310,600
CO	USA	2	4	3	10	3	3	5	(3)	-57%	154	4,292,000	1%	10	6%	2,146,000	429,200
HI	USA	0	3	2	3	1	1	2	(2)	-100%	37	121,364	0%	0	0%	NA	NA
VT	USA	0	2	0	1	2	0	1	(1)	-100%	10	88,056	0%	0	0%	NA	NA
MT	USA	0	1	2	1	1	2	1	(1)	-100%	19	29,000	0%	0	0%	NA	NA
WY	USA	0	1	0	1	1	0	1	(1)	-100%	39	36,136	0%	0	0%	NA	NA
AK	USA	0	0	2	1	0	0	1	(1)	-100%	40	142,366	0%	0	0%	NA	NA
DE	USA	0	0	1	4	2	1	2	(2)	-100%	13	110,000	0%	0	0%	NA	NA
OK	USA	9	5	0	3	0	0	2	7	463%	59	NA	15%	45	76%	NA	NA

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

Appendix B. 2020 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2020	Reported Fire Incidents 2019	Reported Fire Incidents 2018	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Average Annual Fire Per Year ('16-'19)	2020 Increase (Decrease) Compared To Average ('16-'19)	2020 Increase (Decrease) % Compared To Average ('16-'19)	Number Of Recycling Facilities*	Tonnage Processed By State*	2020 % Facilities Affected By Fire Incident - Reported	2020 Reasonable Population Assumption**	2020 % Facilities Affected By Fire Incident - Reasonable Population Assumptions**	2020 Tons (MSW) Per Fire Incident - Reported	2020 Tons (MSW) Per Fire Incident - Reasonable Assumptions**
CA	USA	29	33	32	26	34	31	(2)	-7%	256	19,774,000	11%	145	57%	681,862	136,372
TX	USA	14	17	15	13	6	13	1	10%	51	2,591,000	27%	70	137%	185,071	37,014
MA	USA	13	11	10	2	6	7	6	79%	44	1,551,000	30%	65	148%	119,308	23,862
ME	USA	13	4	4	8	9	6	7	108%	15	173,000	87%	65	433%	13,308	2,662
SC	USA	12	12	11	6	5	9	4	41%	83	452,000	14%	60	72%	37,667	7,533
OH	USA	12	11	25	15	13	16	(4)	-25%	130	1,119,000	9%	60	46%	93,250	18,650
FL	USA	11	22	16	6	7	13	(2)	-14%	119	4,354,000	9%	55	46%	395,818	79,164
NY	USA	11	14	14	12	14	14	(3)	-19%	134	2,880,000	8%	55	41%	261,818	52,364
MN	USA	10	9	5	5	2	5	5	90%	41	733,000	24%	50	122%	73,300	14,660
IL	USA	9	15	14	8	8	11	(2)	-20%	92	2,211,000	10%	45	49%	245,667	49,133
CT	USA	9	12	9	5	6	8	1	13%	85	1,674,000	11%	45	53%	186,000	37,200
WA	USA	9	10	8	6	7	8	1	16%	182	2,297,000	5%	45	25%	255,222	51,044
MI	USA	9	9	15	12	15	13	(4)	-29%	65	911,000	14%	45	69%	101,222	20,244
PA	USA	9	7	7	17	2	8	1	9%	98	1,893,000	9%	45	46%	210,333	42,067
WI	USA	8	8	9	6	8	8	0	3%	109	1,346,000	7%	40	37%	168,250	33,650
VA	USA	8	5	5	12	12	9	(1)	-6%	37	1,473,000	22%	40	108%	184,125	36,825
MO	USA	8	3	4	6	4	4	4	88%	206	2,506,000	4%	40	19%	313,250	62,650
NH	USA	7	4	3	2	0	2	5	211%	70	355,000	10%	35	50%	50,714	10,143
NJ	USA	6	7	3	5	12	7	(1)	-11%	54	3,500,000	11%	30	56%	583,333	116,667
TN	USA	5	12	11	3	6	8	(3)	-38%	66	1,553,000	8%	25	38%	310,600	62,120
AZ	USA	5	5	7	3	12	7	(2)	-26%	50	465,000	10%	25	50%	93,000	18,600
IA	USA	5	4	3	6	7	5	-	0%	108	673,000	5%	25	23%	134,600	26,920
AR	USA	5	2	1	1	1	1	4	300%	139	366,000	4%	25	18%	73,200	14,640
NV	USA	5	1	0	4	3	2	3	150%	45	425,000	11%	25	56%	85,000	17,000
OK	USA	5	0	3	0	0	1	4	567%	59	NA	8%	25	42%	NA	NA
IN	USA	4	11	3	6	3	6	(2)	-30%	109	2,626,000	4%	20	18%	656,500	131,300
OR	USA	4	8	8	8	4	7	(3)	-43%	134	2,516,000	3%	20	15%	629,000	125,800
GA	USA	4	6	3	2	5	4	-	0%	62	906,000	6%	20	32%	226,500	45,300
CO	USA	4	3	10	3	3	5	(1)	-16%	154	4,292,000	3%	20	13%	1,073,000	214,600
UT	USA	4	2	4	1	1	2	2	100%	37	206,000	11%	20	54%	51,500	10,300
KY	USA	3	6	12	4	5	7	(4)	-56%	126	482,000	2%	15	12%	160,667	32,133
MD	USA	3	3	4	5	6	5	(2)	-33%	69	996,000	4%	15	22%	332,000	66,400
HI	USA	3	2	3	1	1	2	1	71%	37	121,364	8%	15	41%	40,455	8,091
KS	USA	3	2	5	4	0	3	0	9%	109	289,000	3%	15	14%	96,333	19,267
AL	USA	2	8	6	1	4	5	(3)	-58%	148	739,000	1%	10	7%	369,500	73,900

NM	**USA**	**2**	**2**	3	2	1	2	-	0%	78	282,000	3%	10	13%	141,000	28,200
NE	**USA**	**2**	**2**	5	1	2	3	(1)	-20%	38	211,000	5%	10	26%	105,500	21,100
SD	**USA**	**2**	**1**	0	0	1	1	2	300%	58	180,000	3%	10	17%	90,000	18,000
ID	**USA**	**2**	**1**	4	4	4	3	(1)	-38%	22	67,000	9%	10	45%	33,500	6,700
VT	**USA**	**2**	**0**	1	2	0	1	1	167%	10	88,056	20%	10	100%	44,028	8,806
LA	**USA**	**2**	**0**	6	3	0	2	(0)	-11%	24	171,000	8%	10	42%	85,500	17,100
NC	**USA**	**1**	**7**	10	12	7	9	(8)	-89%	108	2,071,000	1%	5	5%	2,071,000	414,200
MT	**USA**	**1**	**2**	1	1	2	2	(1)	-33%	19	29,000	5%	5	26%	29,000	5,800
ND	**USA**	**1**	**1**	0	1	1	1	0	33%	36	100,230	3%	5	14%	100,230	20,046
WV	**USA**	**1**	**1**	0	4	0	1	(0)	-20%	56	141,000	2%	5	9%	141,000	28,200
WY	**USA**	**1**	**0**	1	1	0	1	1	100%	39	36,136	3%	5	13%	36,136	7,227
AK	**USA**	**0**	**2**	1	0	0	1	(1)	-100%	40	142,366	0%	0	0%	NA	NA
MS	**USA**	**0**	**1**	1	1	0	1	(1)	-100%	38	111,000	0%	0	0%	NA	NA
DE	**USA**	**0**	**1**	4	2	1	2	(2)	-100%	13	110,000	0%	0	0%	NA	NA

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

Appendix C. 2019 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2019	Reported Fire Incidents 2018	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Average Annual Fire Per Year ('16-'18)	2019 Increase (Decrease) Compared To Average ('16-'18)	2019 Increase (Decrease) % Compared To Average ('16-'18)	Number Of Recycling Facilities*	Tonnage Processed By State*	2019 % Facilities Affected By Fire Incident - Reported	2019 Reasonable Population Assumption**	2019 % Facilities Affected By Fire Incident - Reasonable Population Assumptions**	2019 Tons (MSW) Per Fire Incident - Reported	2019 Tons (MSW) Per Fire Incident - Reasonable Assumptions**
CA	USA	33	32	26	34	31	2	8%	256	19,774,000	13%	165	64%	599,212	119,842
FL	USA	22	16	6	7	10	12	128%	119	4,354,000	18%	110	92%	197,909	39,582
TX	USA	17	15	13	6	11	6	50%	51	2,591,000	33%	85	167%	152,412	30,482
IL	USA	15	14	8	8	10	5	50%	92	2,211,000	16%	75	82%	147,400	29,480
NY	USA	14	14	12	14	13	1	5%	134	2,880,000	10%	70	52%	205,714	41,143
TN	USA	12	11	3	6	7	5	80%	66	1,553,000	18%	60	91%	129,417	25,883
CT	USA	12	9	5	6	7	5	80%	85	1,674,000	14%	60	71%	139,500	27,900
SC	USA	12	11	6	5	7	5	64%	83	452,000	14%	60	72%	37,667	7,533
IN	USA	11	3	6	3	4	7	175%	109	2,626,000	10%	55	50%	238,727	47,745
MA	USA	11	10	2	6	6	5	83%	44	1,551,000	25%	55	125%	141,000	28,200
OH	USA	11	25	15	13	18	(7)	-38%	130	1,119,000	8%	55	42%	101,727	20,345
WA	USA	10	8	6	7	7	3	43%	182	2,297,000	5%	50	27%	229,700	45,940
MN	USA	9	5	5	2	4	5	125%	41	733,000	22%	45	110%	81,444	16,289
MI	USA	9	15	12	15	14	(5)	-36%	65	911,000	14%	45	69%	101,222	20,244
AL	USA	8	6	1	4	4	4	118%	148	739,000	5%	40	27%	92,375	18,475
OR	USA	8	8	8	4	7	1	20%	134	2,516,000	6%	40	30%	314,500	62,900
WI	USA	8	9	6	8	8	0	4%	109	1,346,000	7%	40	37%	168,250	33,650
NJ	USA	7	3	5	12	7	0	5%	54	3,500,000	13%	35	65%	500,000	100,000
PA	USA	7	7	17	2	9	(2)	-19%	98	1,893,000	7%	35	36%	270,429	54,086
NC	USA	7	10	12	7	10	(3)	-28%	108	2,071,000	6%	35	32%	295,857	59,171
GA	USA	6	3	2	5	3	3	80%	62	906,000	10%	30	48%	151,000	30,200
KY	USA	6	12	4	5	7	(1)	-14%	126	482,000	5%	30	24%	80,333	16,067
AZ	USA	5	7	3	12	7	(2)	-32%	50	465,000	10%	25	50%	93,000	18,600
VA	USA	5	5	12	12	10	(5)	-48%	37	1,473,000	14%	25	68%	294,600	58,920
NH	USA	4	3	2	0	2	2	140%	70	355,000	6%	20	29%	88,750	17,750
IA	USA	4	3	6	7	5	(1)	-25%	108	673,000	4%	20	19%	168,250	33,650
ME	USA	4	4	8	9	7	(3)	-43%	15	173,000	27%	20	133%	43,250	8,650
MO	USA	3	4	6	4	5	(2)	-36%	206	2,506,000	1%	15	7%	835,333	167,067
MD	USA	3	4	5	6	5	(2)	-40%	69	996,000	4%	15	22%	332,000	66,400
CO	USA	3	10	3	3	5	(2)	-44%	154	4,292,000	2%	15	10%	1,430,667	286,133
AK	USA	2	1	0	0	0	2	500%	40	142,366	5%	10	25%	71,183	14,237
AR	USA	2	1	1	1	1	1	100%	139	366,000	1%	10	7%	183,000	36,600
MT	USA	2	1	1	2	1	1	50%	19	29,000	11%	10	53%	14,500	2,900

HI	**USA**	**2**	3	1	1	2	0	20%	37	121,364	5%	10	27%	60,682	12,136
UT	**USA**	**2**	4	1	1	2	-	0%	37	206,000	5%	10	27%	103,000	20,600
NM	**USA**	**2**	3	2	1	2	-	0%	78	282,000	3%	10	13%	141,000	28,200
NE	**USA**	**2**	5	1	2	3	(1)	-25%	38	211,000	5%	10	26%	105,500	21,100
KS	**USA**	**2**	5	4	0	3	(1)	-33%	109	289,000	2%	10	9%	144,500	28,900
SD	**USA**	**1**	0	0	1	0	1	200%	58	180,000	2%	5	9%	180,000	36,000
ND	**USA**	**1**	0	1	1	1	0	50%	36	100,230	3%	5	14%	100,230	20,046
MS	**USA**	**1**	1	1	0	1	0	50%	38	111,000	3%	5	13%	111,000	22,200
WV	**USA**	**1**	0	4	0	1	(0)	-25%	56	141,000	2%	5	9%	141,000	28,200
DE	**USA**	**1**	4	2	1	2	(1)	-57%	13	110,000	8%	5	38%	110,000	22,000
NV	**USA**	**1**	0	4	3	2	(1)	-57%	45	425,000	2%	5	11%	425,000	85,000
ID	**USA**	**1**	4	4	4	4	(3)	-75%	22	67,000	5%	5	23%	67,000	13,400
WY	**USA**	**0**	1	1	0	1	(1)	-100%	39	36,136	0%	0	0%	NA	NA
VT	**USA**	**0**	1	2	0	1	(1)	-100%	10	88,056	0%	0	0%	NA	NA
OK	**USA**	**0**	3	0	0	1	(1)	-100%	59	NA	0%	0	0%	NA	NA
LA	**USA**	**0**	6	3	0	3	(3)	-100%	24	171,000	0%	0	0%	NA	NA

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

Appendix D. 2018 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2018	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Average Annual Fire Per Year ('16-'17)	2018 Increase (Decrease) Compared To Average ('16-'17)	2018 Increase (Decrease) % Compared To Average ('16-'17)	Number Of Recycling Facilities*	Tonnage Processed By State*	2018 % Facilities Affected By Fire Incident - Reported	2018 Reasonable Population Assumption**	2018 % Facilities Affected By Fire Incident - Reasonable Population Assumptions**	2018 Tons (MSW) Per Fire Incident - Reported	2018 Tons (MSW) Per Fire Incident - Reasonable Assumptions**
CA	USA	32	26	34	30	2	7%	256	19,774,000	13%	160	63%	617,938	123,588
OH	USA	25	15	13	14	11	79%	130	1,119,000	19%	125	96%	44,760	8,952
MI	USA	15	12	15	14	2	11%	65	911,000	23%	75	115%	60,733	12,147
NY	USA	14	12	14	13	1	8%	134	2,880,000	10%	70	52%	205,714	41,143
VA	USA	5	12	12	12	(7)	-58%	37	1,473,000	14%	25	68%	294,600	58,920
NC	USA	10	12	7	10	1	5%	108	2,071,000	9%	50	46%	207,100	41,420
TX	USA	15	13	6	10	6	58%	51	2,591,000	29%	75	147%	172,733	34,547
PA	USA	7	17	2	10	(3)	-26%	98	1,893,000	7%	35	36%	270,429	54,086
NJ	USA	3	5	12	9	(6)	-65%	54	3,500,000	6%	15	28%	1,166,667	233,333
ME	USA	4	8	9	9	(5)	-53%	15	173,000	27%	20	133%	43,250	8,650
IL	USA	14	8	8	8	6	75%	92	2,211,000	15%	70	76%	157,929	31,586
AZ	USA	7	3	12	8	(1)	-7%	50	465,000	14%	35	70%	66,429	13,286
WI	USA	9	6	8	7	2	29%	109	1,346,000	8%	45	41%	149,556	29,911
WA	USA	8	6	7	7	2	23%	182	2,297,000	4%	40	22%	287,125	57,425
FL	USA	16	6	7	7	10	146%	119	4,354,000	13%	80	67%	272,125	54,425
IA	USA	3	6	7	7	(4)	-54%	108	673,000	3%	15	14%	224,333	44,867
OR	USA	8	8	4	6	2	33%	134	2,516,000	6%	40	30%	314,500	62,900
CT	USA	9	5	6	6	4	64%	85	1,674,000	11%	45	53%	186,000	37,200
MD	USA	4	5	6	6	(2)	-27%	69	996,000	6%	20	29%	249,000	49,800
SC	USA	11	6	5	6	6	100%	83	452,000	13%	55	66%	41,091	8,218
MO	USA	4	6	4	5	(1)	-20%	206	2,506,000	2%	20	10%	626,500	125,300
TN	USA	11	3	6	5	7	144%	66	1,553,000	17%	55	83%	141,182	28,236
KY	USA	12	4	5	5	8	167%	126	482,000	10%	60	48%	40,167	8,033
IN	USA	3	6	3	5	(2)	-33%	109	2,626,000	3%	15	14%	875,333	175,067
MA	USA	10	2	6	4	6	150%	44	1,551,000	23%	50	114%	155,100	31,020
ID	USA	4	4	4	4	-	0%	22	67,000	18%	20	91%	16,750	3,350
GA	USA	3	2	5	4	(1)	-14%	62	906,000	5%	15	24%	302,000	60,400
NV	USA	0	4	3	4	(4)	-100%	45	425,000	0%	0	0%	NA	NA

MN	**USA**	5	5	2	4	2	43%	41	733,000	12%	25	61%	146,600	29,320
CO	**USA**	10	3	3	3	7	233%	154	4,292,000	6%	50	32%	429,200	85,840
AL	**USA**	6	1	4	3	4	140%	148	739,000	4%	30	20%	123,167	24,633
KS	**USA**	5	4	0	2	3	150%	109	289,000	5%	25	23%	57,800	11,560
WV	**USA**	0	4	0	2	(2)	-100%	56	141,000	0%	0	0%	NA	NA
NE	**USA**	5	1	2	2	4	233%	38	211,000	13%	25	66%	42,200	8,440
MT	**USA**	1	1	2	2	(1)	-33%	19	29,000	5%	5	26%	29,000	5,800
NM	**USA**	3	2	1	2	2	100%	78	282,000	4%	15	19%	94,000	18,800
DE	**USA**	4	2	1	2	3	167%	13	110,000	31%	20	154%	27,500	5,500
LA	**USA**	6	3	0	2	5	300%	24	171,000	25%	30	125%	28,500	5,700
AR	**USA**	1	1	1	1	-	0%	139	366,000	1%	5	4%	366,000	73,200
HI	**USA**	3	1	1	1	2	200%	37	121,364	8%	15	41%	40,455	8,091
UT	**USA**	4	1	1	1	3	300%	37	206,000	11%	20	54%	51,500	10,300
ND	**USA**	0	1	1	1	(1)	-100%	36	100,230	0%	0	0%	NA	NA
NH	**USA**	3	2	0	1	2	200%	70	355,000	4%	15	21%	118,333	23,667
VT	**USA**	1	2	0	1	-	0%	10	88,056	10%	5	50%	88,056	17,611
SD	**USA**	0	0	1	1	(1)	-100%	58	180,000	0%	0	0%	NA	NA
WY	**USA**	1	1	0	1	1	100%	39	36,136	3%	5	13%	36,136	7,227
MS	**USA**	1	1	0	1	1	100%	38	111,000	3%	5	13%	111,000	22,200
OK	**USA**	3	0	0	-	3	NA	59	NA	5%	15	25%	NA	NA
AK	**USA**	1	0	0	-	1	NA	40	142,366	3%	5	13%	142,366	28,473

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

Appendix E. 2017 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Yr/Yr. Increase (Decrease)	Yr./Yr. % Increase (Decrease)	Number of Recycling Facilities*	Tonnage Processed by State*	2017 % Facilities Affected by Fire Incident - Reported	2017 Reasonable Population Assumption**	2017 % Facilities Affected by Fire Incident - Reasonable Population Assumptions**	2017 Tons (MSW) Per Fire Incident - Reported	2017 Tons (MSW) Per Fire Incident - Reasonable Assumptions**
AL	USA	1	4	(3)	-75%	148	739,000	0.7%	5	3%	739,000	147,800
AB	CAN	4	4	0	0%	NA	NA	NA	20	NA	NA	NA
AZ	USA	3	12	(9)	-75%	50	465,000	6.0%	15	30%	155,000	31,000
AR	USA	1	1	0	0%	139	366,000	0.7%	5	4%	366,000	73,200
BC	CAN	10	5	5	100%	NA	NA	NA	50	NA	NA	NA
CA	USA	26	34	(8)	-24%	256	19,774,000	10.2%	130	51%	760,538	152,108
CO	USA	3	3	0	0%	154	4,292,000	1.9%	15	10%	1,430,667	286,133
CT	USA	5	6	(1)	-17%	85	1,674,000	5.9%	25	29%	334,800	66,960
DE	USA	2	1	1	100%	13	110,000	15.4%	10	77%	55,000	11,000
FL	USA	6	7	(1)	-14%	119	4,354,000	5.0%	30	25%	725,667	145,133
GA	USA	2	5	(3)	-60%	62	906,000	3.2%	10	16%	453,000	90,600
HI	USA	1	1	0	0%	37	121,364	2.7%	5	14%	121,364	24,273
ID	USA	4	4	0	0%	22	67,000	18.2%	20	91%	16,750	3,350
IL	USA	8	8	0	0%	92	2,211,000	8.7%	40	43%	276,375	55,275
IN	USA	6	3	3	100%	109	2,626,000	5.5%	30	28%	437,667	87,533
IA	USA	6	7	(1)	-14%	108	673,000	5.6%	30	28%	112,167	22,433
KS	USA	4	0	4	100%	109	289,000	3.7%	20	18%	72,250	14,450
KY	USA	4	5	(1)	-20%	126	482,000	3.2%	20	16%	120,500	24,100
LA	USA	3	0	3	100%	24	171,000	12.5%	15	63%	57,000	11,400
ME	USA	8	9	(1)	-11%	15	173,000	53.3%	40	267%	21,625	4,325
MB	CAN	1	0	1	100%	NA	NA	NA	5	NA	NA	NA
MD	USA	5	6	(1)	-17%	69	996,000	7.2%	25	36%	199,200	39,840
MA	USA	2	6	(4)	-67%	44	1,551,000	4.5%	10	23%	775,500	155,100
MI	USA	12	15	(3)	-20%	65	911,000	18.5%	60	92%	75,917	15,183
MN	USA	5	2	3	150%	41	733,000	12.2%	25	61%	146,600	29,320
MS	USA	1	0	1	100%	38	111,000	2.6%	5	13%	111,000	22,200
MO	USA	6	4	2	50%	206	2,506,000	2.9%	30	15%	417,667	83,533
MT	USA	1	2	(1)	-50%	19	29,000	5.3%	5	26%	29,000	5,800
NE	USA	1	2	(1)	-50%	38	211,000	2.6%	5	13%	211,000	42,200
NV	USA	4	3	1	33%	45	425,000	8.9%	20	44%	106,250	21,250
NH	USA	2	0	2	100%	70	355,000	2.9%	10	14%	177,500	35,500
NJ	USA	5	12	(7)	-58%	54	3,500,000	9.3%	25	46%	700,000	140,000
NM	USA	2	1	1	100%	78	282,000	2.6%	10	13%	141,000	28,200
NY	USA	12	14	(2)	-14%	134	2,880,000	9.0%	60	45%	240,000	48,000
NC	USA	12	7	5	71%	108	2,071,000	11.1%	60	56%	172,583	34,517

ND	USA	1	1	0	0%	36	100,230	2.8%	5	14%	100,230	20,046
NS	CAN	2	1	1	100%	NA	NA	NA	10	NA	NA	NA
OH	USA	15	13	2	15%	130	1,119,000	11.5%	75	58%	74,600	14,920
ON	CAN	11	12	(1)	-8%	NA	NA	NA	55	NA	NA	NA
OR	USA	8	4	4	100%	134	2,516,000	6.0%	40	30%	314,500	62,900
PA	USA	17	2	15	750%	98	1,893,000	17.3%	85	87%	111,353	22,271
SK	CAN	1	0	1	100%	NA	NA	NA	5	NA	NA	NA
SC	USA	6	5	1	20%	83	452,000	7.2%	30	36%	75,333	15,067
SD	USA	0	1	(1)	-100%	58	180,000	0.0%	0	0%	NA	NA
TN	USA	3	6	(3)	-50%	66	1,553,000	4.5%	15	23%	517,667	103,533
TX	USA	13	6	7	117%	51	2,591,000	25.5%	65	127%	199,308	39,862
UT	USA	1	1	0	0%	37	206,000	2.7%	5	14%	206,000	41,200
VT	USA	2	0	2	100%	10	88,056	20.0%	10	100%	44,028	8,806
VA	USA	12	12	0	0%	37	1,473,000	32.4%	60	162%	122,750	24,550
WA	USA	6	7	(1)	-14%	182	2,297,000	3.3%	30	16%	382,833	76,567
WV	USA	4	0	4	100%	56	141,000	7.1%	20	36%	35,250	7,050
WI	USA	6	8	(2)	-25%	109	1,346,000	5.5%	30	28%	224,333	44,867
WY	USA	1	0	1	100%	39	36,136	2.6%	5	13%	36,136	7,227

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

Appendix F. 2016 ANNUAL REPORTED WASTE & RECYCLING FACILITY FIRES US/CAN - Published by Ryan Fogelman, Fire Rover, rfogelman@firerover.com

State	Country	Reported Fire Incidents 2017	Reported Fire Incidents 2016	Yr/Yr. Increase (Decrease)	Yr./Yr. % Increase (Decrease)	Number of Recycling Facilities*	Tonnage Processed by State*	2016 % Facilities Affected by Fire Incident - Reported	2016 Reasonable Population Assumption**	2016 % Facilities Affected by Fire Incident - Reasonable Population Assumptions**	2016 Tons (MSW) Per Fire Incident - Reported	2016 Tons (MSW) Per Fire Incident - Reasonable Population Assumptions**
AL	USA	1	4	(3)	-75%	148	739,000	2.7%	20	14%	184,750	36,950
AB	CAN	4	4	0	0%	NA	NA	NA	20	NA	NA	NA
AZ	USA	3	12	(9)	-75%	50	465,000	24.0%	60	120%	38,750	7,750
AR	USA	1	1	0	0%	139	366,000	0.7%	5	4%	366,000	73,200
BC	CAN	10	5	5	100%	NA	NA	NA	25	0%	NA	NA
CA	USA	26	34	(8)	-24%	256	19,774,000	13.3%	170	66%	581,588	116,318
CO	USA	3	3	0	0%	154	4,292,000	1.9%	15	10%	1,430,667	286,133
CT	USA	5	6	(1)	-17%	85	1,674,000	7.1%	30	35%	279,000	55,800
DE	USA	2	1	1	100%	13	110,000	7.7%	5	38%	110,000	22,000
FL	USA	6	7	(1)	-14%	119	4,354,000	5.9%	35	29%	622,000	124,400
GA	USA	2	5	(3)	-60%	62	906,000	8.1%	25	40%	181,200	36,240
HI	USA	1	1	0	0%	37	121,364	2.7%	5	14%	121,364	24,273
ID	USA	4	4	0	0%	22	67,000	18.2%	20	91%	16,750	3,350
IL	USA	8	8	0	0%	92	2,211,000	8.7%	40	43%	276,375	55,275
IN	USA	6	3	3	100%	109	2,626,000	2.8%	15	14%	875,333	175,067
IA	USA	6	7	(1)	-14%	108	673,000	6.5%	35	32%	96,143	19,229
KS	USA	4	0	4	100%	109	289,000	0.0%	0	0%	0	0
KY	USA	4	5	(1)	-20%	126	482,000	4.0%	25	20%	96,400	19,280
LA	USA	3	0	3	100%	24	171,000	0.0%	0	0%	0	0
ME	USA	8	9	(1)	-11%	15	173,000	60.0%	45	300%	19,222	3,844
MB	CAN	1	0	1	100%	NA	NA	NA	0	0%	NA	NA
MD	USA	5	6	(1)	-17%	69	996,000	8.7%	30	43%	166,000	33,200
MA	USA	2	6	(4)	-67%	44	1,551,000	13.6%	30	68%	258,500	51,700
MI	USA	12	15	(3)	-20%	65	911,000	23.1%	75	115%	60,733	12,147
MN	USA	5	2	3	150%	41	733,000	4.9%	10	24%	366,500	73,300
MS	USA	1	0	1	100%	38	111,000	0.0%	0	0%	0	0
MO	USA	6	4	2	50%	206	2,506,000	1.9%	20	10%	626,500	125,300
MT	USA	1	2	(1)	-50%	19	29,000	10.5%	10	53%	14,500	2,900
NE	USA	1	2	(1)	-50%	38	211,000	5.3%	10	26%	105,500	21,100
NV	USA	4	3	1	33%	45	425,000	6.7%	15	33%	141,667	28,333
NH	USA	2	0	2	100%	70	355,000	0.0%	0	0%	0	0

NJ	**USA**	5	12	(7)	-58%	54	3,500,000	22.2%	60	111%	291,667	58,333
NM	**USA**	2	1	1	100%	78	282,000	1.3%	5	6%	282,000	56,400
NY	**USA**	12	14	(2)	-14%	134	2,880,000	10.4%	70	52%	205,714	41,143
NC	**USA**	12	7	5	71%	108	2,071,000	6.5%	35	32%	295,857	59,171
ND	**USA**	1	1	0	0%	36	100,230	2.8%	5	14%	100,230	20,046
NS	**CAN**	2	1	1	100%	NA	NA	NA	5	NA	NA	NA
OH	**USA**	15	13	2	15%	130	1,119,000	10.0%	65	50%	86,077	17,215
ON	**CAN**	11	12	(1)	-8%	NA	NA	NA	60	NA	NA	NA
OR	**USA**	8	4	4	100%	134	2,516,000	3.0%	20	15%	629,000	125,800
PA	**USA**	17	2	15	750%	98	1,893,000	2.0%	10	10%	946,500	189,300
SK	**CAN**	1	0	1	100%	NA	NA	NA	0	NA	NA	NA
SC	**USA**	6	5	1	20%	83	452,000	6.0%	25	30%	90,400	18,080
SD	**USA**	0	1	(1)	-100%	58	180,000	1.7%	NA	5%	180,000	36,000
TN	**USA**	3	6	(3)	-50%	66	1,553,000	9.1%	30	45%	258,833	51,767
TX	**USA**	13	6	7	117%	51	2,591,000	11.8%	30	59%	431,833	86,367
UT	**USA**	1	1	0	0%	37	206,000	2.7%	5	14%	206,000	41,200
VT	**USA**	2	0	2	100%	10	88,056	0.0%	0	0%	0	0
VA	**USA**	12	12	0	0%	37	1,473,000	32.4%	60	162%	122,750	24,550
WA	**USA**	6	7	(1)	-14%	182	2,297,000	3.8%	35	19%	328,143	65,629
WV	**USA**	4	0	4	100%	56	141,000	0.0%	0	0%	0	0
WI	**USA**	6	8	(2)	-25%	109	1,346,000	7.3%	40	37%	168,250	33,650
WY	**USA**	1	0	1	100%	39	36,136	0.0%	0	0%	0	0

*** EREF Data Published 2016 (Source: *https://erefdn.org/product/municipal-solid-waste-management-u-s-2010-2013/*)**

**** Chief Fire Officers Association (CFOA) reported from the EA an average of 332 documented fires at waste facilities between 2001 and 2014. The CFOA also reported* 250 fires in 2015 at waste and recycling companies.**

APPENDIX G. The Combinational Approach™ to Fighting a Waste and Recycling Fire:

Combinational Approach

A combinational approach uses the best pieces, people, equipment, communications and training in order to provide your operations with the best chance of catching and eliminating a fire incident before it becomes a major fire incident and shuts down your business.

***-Ryan Fogelman**, Fire Rover, and **Jim Emerson**, Starr Technical Risk Agency*

The Combinational Approach™ to Fighting a Waste and Recycling Fire

1. Thermal cameras (automatic thermal detection can often sense dangerous temperature differentials before a fire even starts).
2. Use of a pre-wetting foam agent, possibly in combination with twin 1-1/2-inch or 1-3/4-inch water nozzles.
3. Remote, human-verified, manual control of foam agent dispersal from a safe location.
4. Pre-wetting should be configured so that it reaches a 180-degree area with the best line-of-site coverage available, and the ability to operate for sweeping and pre-wetting around the fire perimeter and collateral assets.
5. Eliminate fire brigade as it puts valued employees at risk and is difficult to administer in compliance with OSHA requirements. (OSHA allows a limited fire brigade that can monitor evacuation and address incipient stage fires as long as they are not interior structural fires.)
6. Configure an emergency response such as providing a lancing nozzle, hookup, and rollout of a fire service hose and a deck gun in order to be prepared for the fire professionals' arrival.
7. Ensure that a pathway is maintained for the fire professionals to safely enter and move around the facility.
8. Train employees to start the fire pump and shut off the proper electrical circuits to save time for the fire response professionals.
9. Have a trained bulldozer/loader operator with the proper equipment, or make sure the fire department is trained on your equipment.

10. Have a working automatic sprinkler system and adequate water supply. The water supply may be lacking at some locations, so having a tank system is highly recommended.
11. Have a solid worker training program. This means regular inspections and testing of fire equipment. Also, have a simple but effective fire emergency response plan. Good housekeeping, contractor, and hot work controls are essential.
12. Have manually operable roof vents to let heat escape. Heat is likely to get out through roll up doors and melt light panels on exterior walls but having the ability to open roof vents is much safer since the fire service will not have to manually cut a vent in the top of the roof. However, let the firefighters decide about whether to open the vents.
13. Have secondary rally points in a safe place, potentially even offsite, for personnel who can stay and help the fire service with tasks such as crane operation and ensuring the plant is safely shut down. The fire service may wish to have personnel leave the site either immediately or shortly due to smoke and the need to assure personnel safety. Having a place offsite where you can rally and stay in communication can be very instrumental.
14. Develop a rapport with the fire department, which includes training with the Texas A&M Engineering Extension Service/National Fire Protection Association on how to fight a fire in a recycling and trash tipping floor/pit operation.

Benefits of the Combinational Approach™ to Fighting a Waste and Recycling Facility Fire:

- Early detection with fire detection technology and application of pre-wetting foam can eliminate fires, prepare for the firefighter response, and greatly reduce or eliminate major fire incidents.
- Adding additional compressed air foam systems allows for more manual applications of foam from a safe distance for employees.
- Installing a deck gun and setting it up for the fire department's arrival will save valuable time upon arrival. This process takes a lot longer than what we see in the movies and allows the fire department to get right to work.
- If you can only provide one form of a sprinkler head, protect the structural steel columns in combination with an early detection and suppression system.
- Roof vents can be opened. Let the fire department do this as it will want to be able to control this important aspect. Being able to do this with a button versus mounting the roof manually and cutting with a saw protects emergency responders from a potentially dangerous situation.

This approach allows the threat to structural steel elements to be greatly reduced. This is the main inflection point in firefighting. At this point, the fire department can become the most effective on the interior attack toward the seat of the fire.