CHARACTERISATION OF FIRES CAUSED BY BATTERIES IN WEEE

Survey results from the WEEE management chain – Part A

26 May 2020

EuRIC weeeforum EUCOBAT EERA European Electronics Recyclers Association mwe MUNICIPAL WASTE EUROPE WEEELABEX

Disclaimer

This report intends to provide a summary of the responses obtained from a survey run in 2019. While the information contained in this report is believed to provide good insights on the situation of the market in scope of the survey, it should be noted that it concerns industry averages based on a sample of 109 companies and there might be exemptions that have not been identified.

Refer to this report as:

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Cover photo by Benny Van den Steen

Executive summary

Batteries are increasingly used in all sorts of electrical and electronic products, some of them are very cheap and have a short lifespan. This trend has a direct impact on the end-of-life treatment of these devices containing batteries and gives rise to thermal events.

In 2019, a number of organisations representative of the industry that manages the collection and treatment of spent batteries and waste electrical and electronic equipment (WEEE) and of manufacturers of home appliances and consumer electronics gathered to exchange views about the growing issue of fires associated with WEEE that contain batteries in order to design measures to address the problem. A survey was designed at EU scale to better understand the issue of fires in the WEEE management chain and collect good practices. This report, prepared by EuRIC and the WEEE Forum, presents the results of the first part of the survey (part A), and tries to better characterize fires associated with WEEE containing batteries and assess the severity of the issue.

Responses to the survey confirm that the number of fires in the WEEE management chain is growing. Both in the case of recurrent fires and of severe fires occurring at collection and treatment facilities, mixed WEEE is the most affected waste stream, and damaged batteries are seen as responsible for those fires in the large majority of cases.

The thermal events identified happened at every stage of the WEEE collection and treatment chain, but the study reveals a higher prevalence at the shredding stage during treatment and during storage at the logistics and pre-treatment stages.

When looking at the majority of cases happening in 2018, it can be deduced that there is a high prevalence of frequent yet small thermal events with no or little severity. More than half of the respondents (53%) reports about frequently occurring fires (on a daily to weekly basis) that did not seem to cause significant damages and were self-extinguished or controlled with onsite fire extinction measures. For four out of ten respondents, most thermal events did not require insurance coverage. However, the average cost of all those incidents in 2018 was estimated at €190,000[1], which can represent a significant burden for an individual company.

The most severe fires occurring at respondents' facilities in the last four years gave rise to an average reported cost of damages of €1.3 million[2]. More than a third of the respondents reports one of those severe fires, mostly described as intense fires and lasting between 1 to 6 hours. The intervention of a fire brigade was required in the most severe cases, and the insurance coverage of those incidents is unclear.

This first analysis of the results of the survey will be followed by a second report analyzing the different good practices applied by the respondents to tackle the battery fires issue.

[1] Sample of 34 respondents out of 57 that reported a fire in 2018. Deviation: €444,000

[2] Sample of 26 respondents out of 38 that reported a severe fire. Deviation: €4.1 million

The organisations involved in the study recommend to further investigate some aspects that were addressed in this survey, but for which an in-depth analysis is key to have a better grasp of the issue. This includes for instance consequences for the reuse sector, the efficiency of the rules concerning the international carriage of dangerous goods by road (ADR), or the detailed cost breakdown of damages caused by battery fires. To sustain the results of this survey in time, it is also recommended to assess the feasibility to establish an EU-wide observatory of batteries' fires, as this phenomenon is expected to grow in the short and long term. Though it was not the main part of the study, the lack of adequate insurance coverage appears to be an issue mentioned several times by treatment operators handling waste batteries and WEEE.

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1. Introduction

Fires and other thermal events are directly associated with high energy density[3] batteries, and in particular lithium-ion (Li-ion) batteries, in end-of-life appliances (Kong et al., 2018). The number of batteries with a high energy density in the devices is on the rise, which also increases the risk of future incidents and thermal events in recycling or handling these appliances.

In the United Kingdom, for instance, an industry association, ESA – Environmental Services Association, reported that, *"(…) of the 510 fires reported by its members across the UK in 2017-18, a quarter (25%) were attributed to Li-ion batteries*" (Let's recycle, 2019). This phenomenon is causing damages to an industry already more prone to fires than other sectors (see Figure 1).

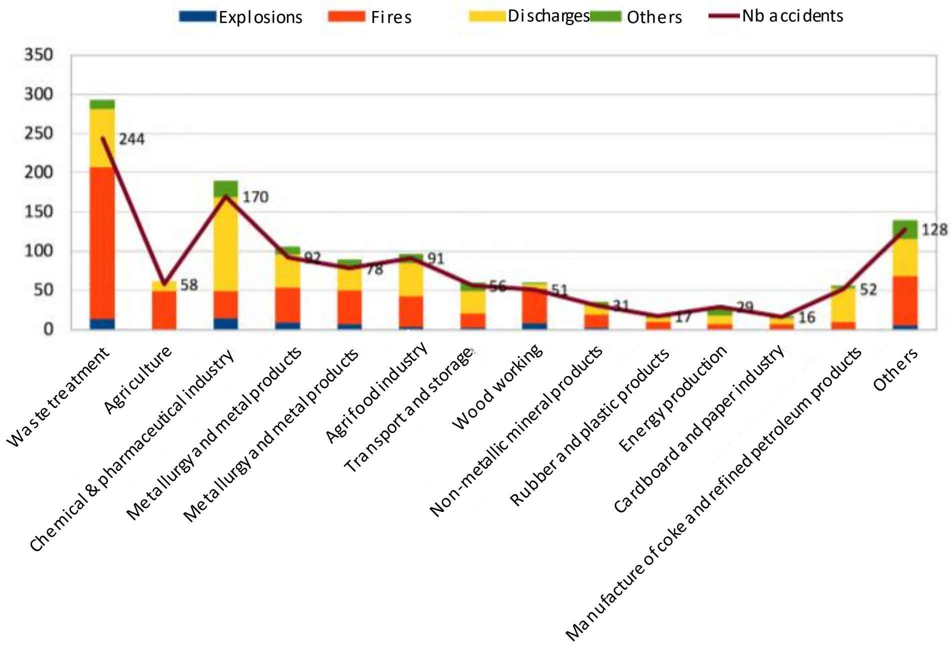

Figure 1. Distribution of hazardous events and accidents by sector in France in 2018 (BARPI, 2019)

It should be noted that Li-ion batteries can cause issues in several waste streams, since they are not only treated by batteries collection and recycling schemes, but are also found in Waste Electric and Electronic Equipment (WEEE) streams, notably in small electrical appliances and in mixed municipal waste. Studies conducted by Montan Universität Leoben (Austria) have shown that Mixed Municipal Waste in Austria contain 1-2 lithium-ion batteries per ton[4] (0,002%) (Nigl, 2017), while small electrical appliances contain up to 90 batteries per ton[5], and up to 15 batteries per ton for lithium-ion batteries (Walch, 2017). Batteries should be removed from WEEE according to the WEEE Directive (Directive 2012/19/UE), and these are

[3] The amount of energy which can be obtained from a single cell by weight or by volume. Measured in units of Wh / kg or Wh / l (Panasonic, n.d.)

[4] 0,002% w/w. 10 tons of mixed municipal solid waste from Vienna and Styria were analyzed.

[5] 0,77 % w/w. For this figure, it is not known if it has been calculated for Austria or for the whole EU.

often present in all stages of the WEEE treatment chain for certain types of appliances such as small appliances.

New risks are associated to the management of batteries and WEEE containing batteries for the waste management industry and require the implementation of specific safety measures. The handling of waste can lead to mechanical shocks or short circuits likely to provoke thermal runaway[6] events in lithium-ion batteries and, ultimately, fires. This risk may lead to incompatibilities for treatment plants that are managing other types of waste, in particular flammable materials (BARPI, 2018).

Lithium-ion batteries are commonly used for portable electronics and electric vehicles. Therefore, the issues related to lithium-ion batteries are likely to increase in the future due to the rising number of products containing this type of batteries that are put on the market, as shown in the figure below. Market data from a recent study commissioned by a German battery recycling company ACCUREC, shows that the quantities of lithium-ion batteries put on the market are increasing, with a higher diversity of usages (Figure 2).

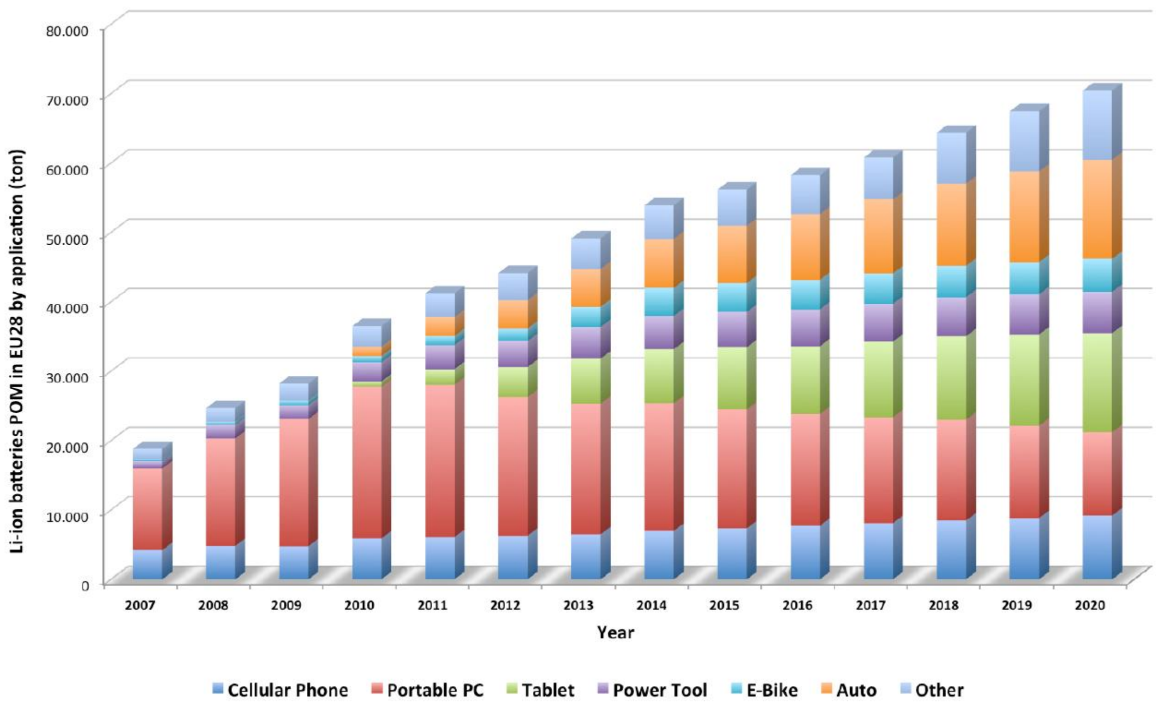

Figure 2. Put-On-Market (POM) of lithium-ion batteries in EU28 by application (2007-2020), (Weyhe & Yang, 2018)

This fact is confirmed by several other studies and reports, such as the one produced within the framework of the European project ProSUM[7] (Huisman et al., 2017), which confirms an exponential increase in sales volumes for lithium-ion batteries in the last 10 years.

[6] "If the Li-ion battery is short-circuited or exposed to high temperature, exothermic reactions can be triggered, resulting in a self-enhanced increasing temperature loop known as "thermal runaway" that can lead to battery fires and explosions" (Kong et al., 2018).

[7] ProSUM, Prospecting Secondary Raw Materials in the Urban Mine and Mining Wastes (Horizon 2020) (2015-2017), www.prosumproject.eu.

Although very few data at EU scale exist on the quantities of batteries present in WEEE (see Figure 3), because the number of lithium-ion batteries in EEE put on the market is increasing, it is highly likely that the amount of those batteries in WEEE will increase in the same proportions eventually.

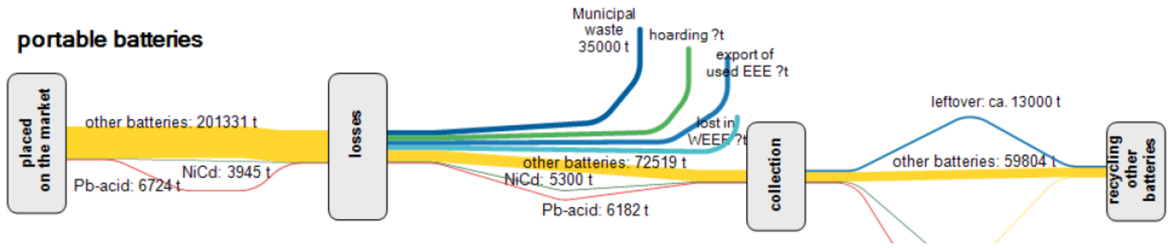

Figure 3. Figure extracted from a Mass flow diagram of batteries, EU28 for reference year 2015 (in tonnes), (Stahl et al., 2018)

The amount of WEEE, in particular small appliances , present in mixed residual waste adds another layer of complexity in tracking down Li-ion batteries in waste flows. Flows of WEEE into the mixed residual waste stream have been identified in projects such as ProSUM[7] and CWIT[8]. Despite the scarce statistics available, the CWIT project concluded with some average values for WEEE disposed of in the waste bin based on studies conducted in the Netherlands, the United Kingdom and Denmark (see Table 1). Such studies confirmed that, mostly, the type of WEEE that can be found in the mixed residual waste stream are small equipment and small IT, both types of appliances that may contain batteries.

Table 1. Weight percentage of product categories of the WEEE in residual waste (Source: CWIT project, 2015)

WEEE category (WEEE Directive)	Average of NL, UK, DK
Temperature exchange equipment	0.2%
Screens	12%
Lamps	4%
Large Equipment	1.3%
Small Equipment	59%
Small IT	24%

Furthermore, the Urban Mine Platform[9] shows estimations of the share of WEEE placed in the waste bin in 2015 in the EU Member States (see
Figure 4 representing the average figures for all categories of WEEE): the values range from 3% to 12% of the total estimated WEEE generated. For Small Household Appliance specifically, the figures raise from 6% to 29%, and for IT equipment, the ranges cover from 5% to 43% of the total WEEE generated estimated.

[8] CWIT, Countering WEEE Illegal Trade (FP7/2007-2013) (2013-2015), www.cwitproject.eu
[9] Urban Mine Platform, UMP, ProSUM project, www.urbanmineplatform.eu

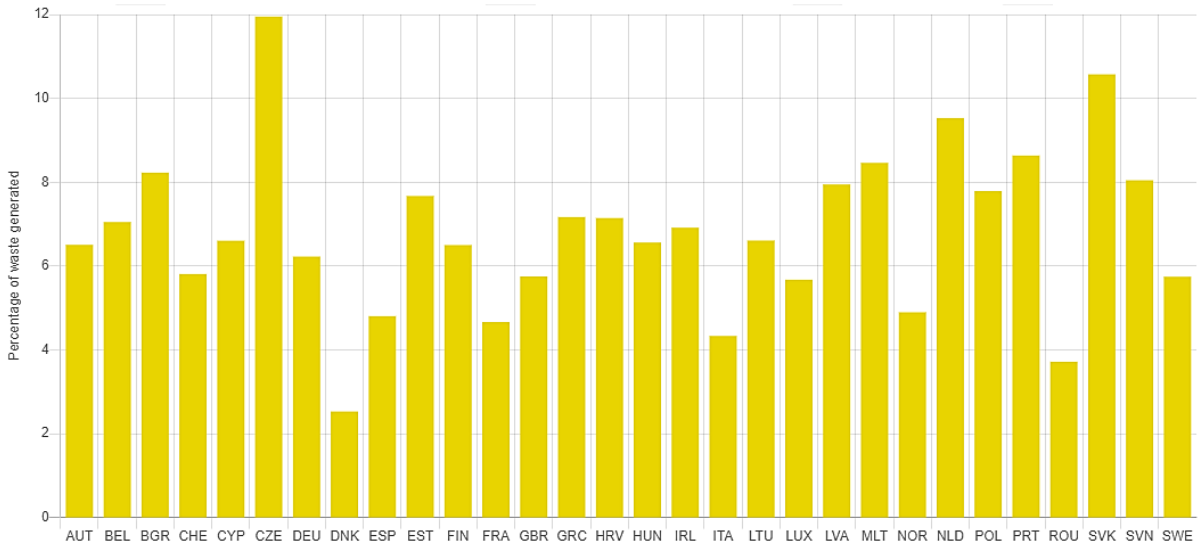

Figure 4. Percentage of WEEE generated estimated as going into the mixed residual waste stream, 2015 (Source: Urban Mine Platform, ProSUM project, 2017)

For the abovementioned reasons, a group of organisations aiming at tackling the safety issues regarding the recycling of WEEE containing batteries got together on June 26th, 2019. It gathered EU level associations of recyclers, Extended Producer Responsibility schemes, and Electric and Electronic Equipment (EEE) manufacturers (see Composition of the Roundtable of batteries at the end of this report).

Some of the members (EuRIC, WEEE Forum, WEEELABEX, EERA[10]) that met in June committed themselves to participate in a survey, having a double target:

- Characterize fires associated to WEEE containing batteries (Part A);
- Collect good practices at all stages of WEEE management (from collection to recycling), aimed at tackling the fires (Part B).

The survey, in the form of an online questionnaire, was launched on October 4th, 2019 and intended to facilities carrying out collection, sorting, transporting and recycling of WEEE containing batteries and batteries. It was disseminated by associations representing the (WEEE and batteries) waste management and recycling industry, producer extended responsibility organisations and manufacturing industry.

Based on the results of the questionnaire, the final goal is to draft and disseminate recommendations for different types of stakeholders.

[10] EuRIC: European recycling industries Confederation; EERA: European Electronics Recyclers Association; WEEE Forum: International Association of Electronic Waste Producer Responsibility Organisations; WEEELABEX: International non-profit legal entity to promote the adoption of the WEEELABEX standards as a means to improve WEEE management practices in Europe.

A total of 109 duly completed questionnaires were received in the period in which the survey was open. This report, drafted by EuRIC and the WEEE Forum, presents the results of the first part (Part A) of the survey (see) in an anonymous[11] and aggregated manner. It tries to better understand and characterize the fires associated to WEEE containing batteries and evaluate the extent of the issue for the WEEE management chain. It should be noted that the report does not intend to be a statistically representative survey on the topic, but rather to provide a description of the results obtained in the survey, reflecting the knowledge of the respondents on this issue.

[11] Only EuRIC had access to raw (non-anonymized) individual answers. Only EuRIC and WEEE forum had access to anonymized and non-aggregated answers

2. Results of the survey on types of fires caused by WEEE containing batteries (Part A)

2.1. Description of types of respondents

109 respondents in total participated in the survey, from all segments of the WEEE value chain (collection, sorting, pre-treatment, shredding, post-shredding), and with various management capacities and localisation. The following part intends to describe and classify those respondents.

2.1.1. Type of facilities: waste, activity and capacity

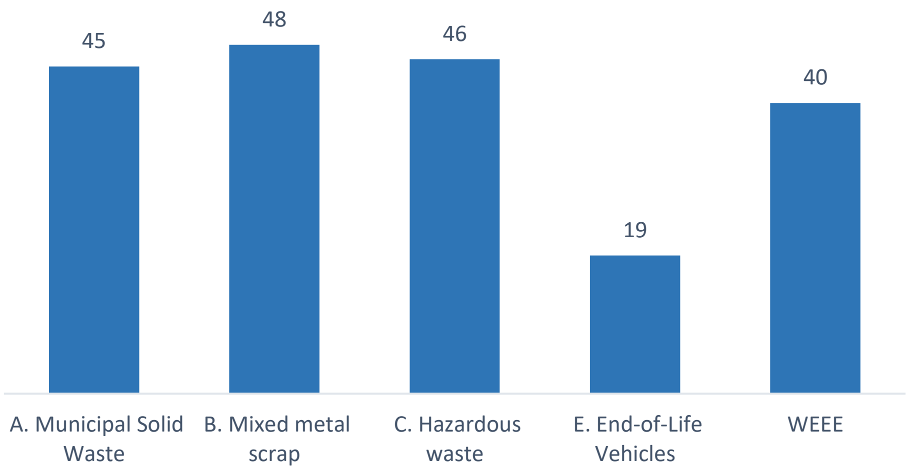

Figure 5. Number of times respondents selected each option (Waste streams managed on-site), 109 responses – Q1.1

Respondents provided information about the type of waste managed on site. They could select more than one item from a list in the form (A, B, C, E options appearing in Figure 5)[12] and also write detailed responses in the ''other'' option. Most of the ''other'' responses included WEEE (mentioned 40 times), and in lower extent, also paper, furniture, wood, tires, construction and demolition waste, and batteries (2 cases).

In theory, no WEEE should be present anymore in waste streams other than WEEE displayed in Figure 5, although waste management field experience shows that it can be the case. In addition, respondents may have considered WEEE within the category of hazardous waste or municipal solid waste.

Figure 6 shows an overview of the types of activities carried out at the facilities. Respondents could select more than one option among the available ones (A, B, C, E, F options described in the figure caption)[12] and the five most selected combinations of the possible ones are shown, covering 61% of the total responses. Respondents reproduced a total of 20 different combinations, but the frequency values are significantly below the five represented in the graph.

[12] There was not option with letter D.

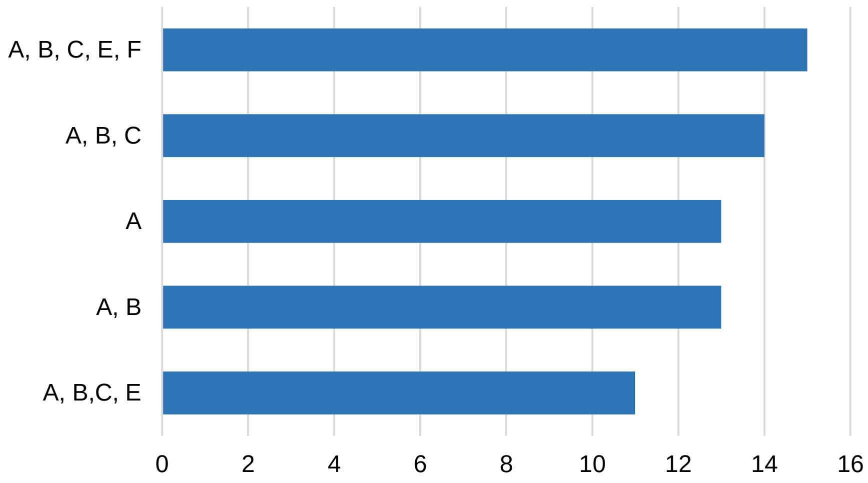

Figure 6. Five type of activities most frequently carried out on site by respondents: A. Collection of WEEE; B. Sorting of WEEE; C. Pre-treatment of WEEE (dismantling, depolluting); E. Shredding (e.g. crushing, pressing, cutting); F. Post shredding treatment. 66 responses – Q1.3

The total number of times respondents selected each of the options provided is summarised in the figure below. As this question also provided an open text "other" alternative, this is also included. In this case, activities such as "storage", "sorting of batteries", "preparation for re-use" or "repair" were mentioned, either alone or accompanying the other reference activities.

No specific definition of "collection" was provided in the questionnaire, so it is possible that respondent's interpretation of the term varies depending on its country or position in the value chain (Figure 6 and Figure 7).

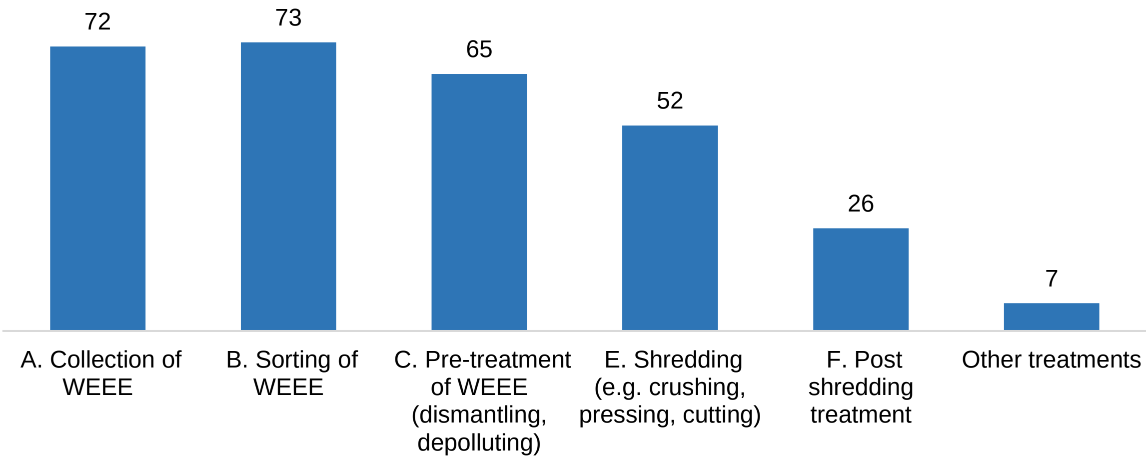

Figure 7. Type of activities performed by respondents (frequency of answers), 109 responses – Q1.3

The majority of the respondents manage WEEE on an annual basis in quantities below 25,000 tons, and 43% of the total sample manage less than 5,000 tons of WEEE per year. Only three respondents manage more than 100,000 tons a year of WEEE usually containing batteries (Figure 8). Respondents' WEEE treatment capacities do not appear to differ significantly from typical WEEE treatment capacities in the EU.

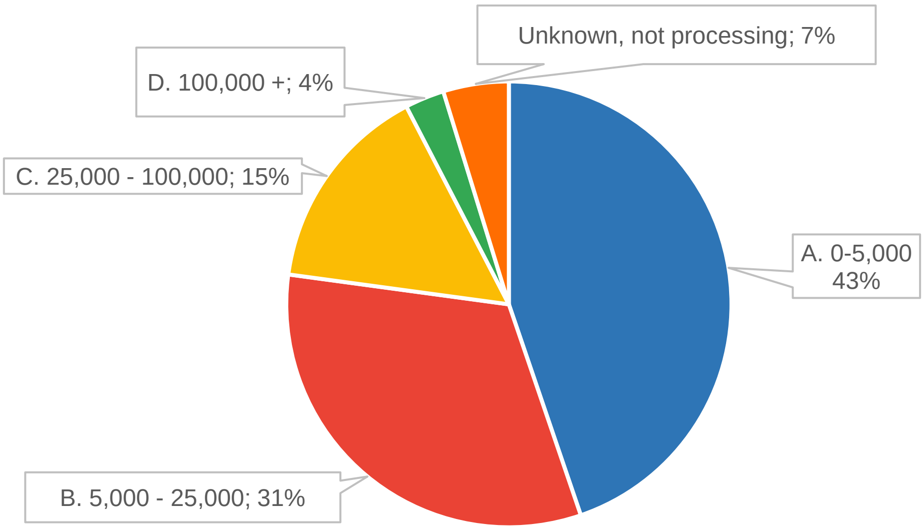

Figure 8. Annual capacity of the site (tons/year) for WEEE usually containing batteries, 106 responses – Q1.4

2.1.2. Geographical coverage

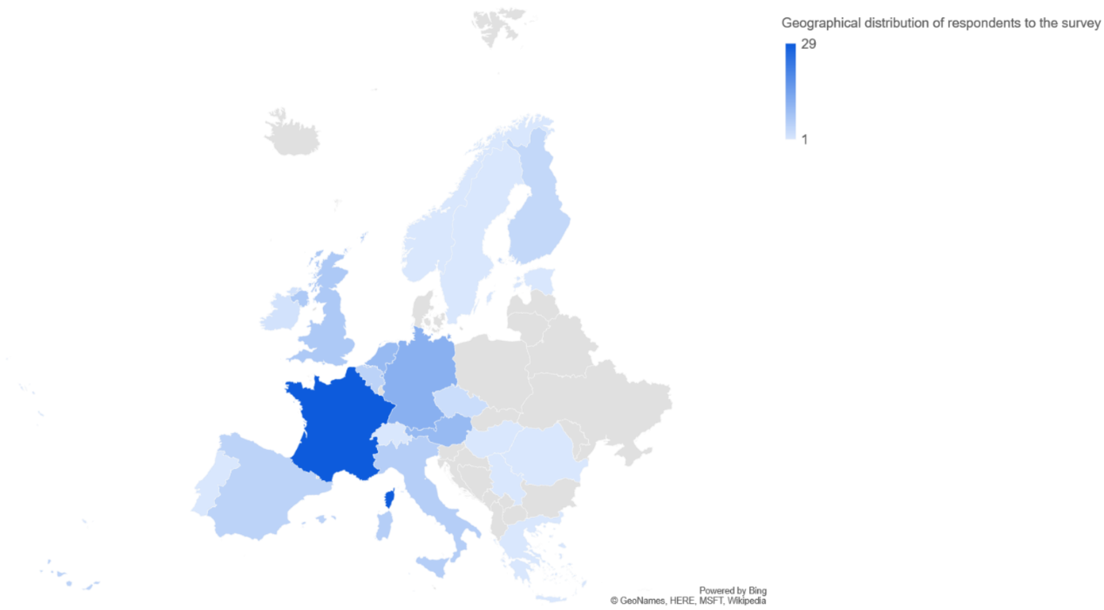

Figure 9. Geographical distribution of respondents (country where the WEEE treatment site is based) within the EU & EFTA, 102 responses – Q0.2

Figure 9 shows the geographical distribution by country of the WEEE treatment facilities of which a response was obtained. In 6 other cases, the country was not indicated, and in one other case, the respondent's site was located outside Europe. The survey has a good geographical coverage since most of the EU & EFTA countries are represented. In summary, 109 respondents from 20 EU + EFTA countries participated in the survey.

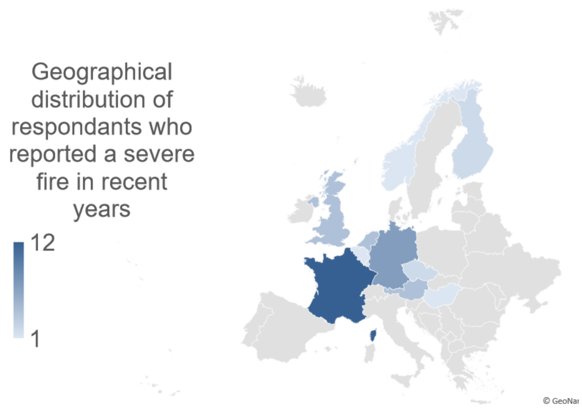

Figure 10. Geographical distribution of respondents who reported a severe fire in recent years, 38 responses – Q4.0

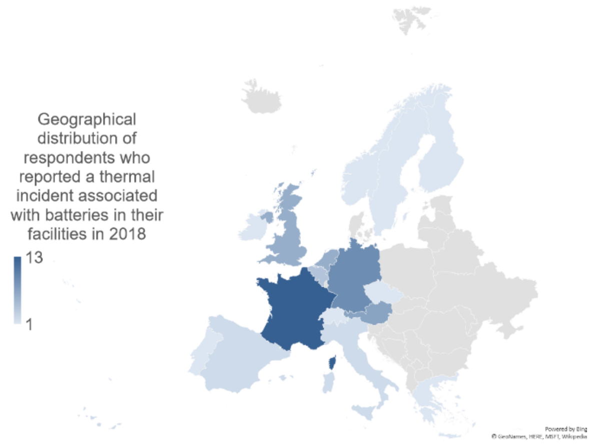

Figure 11. Geographical distribution of respondents who reported a thermal incident associated with batteries in their facilities in 2018, 58 responses – Q2.0

Figure 10 and Figure 11 represent, respectively, the geographical coverage of respondents declaring a severe fire in recent years and those reporting a thermal incident in 2018. In Figure 10, the total number of respondents to the question of severe fire incidents is 39, but data on geographical localisation was not provided by one of the respondents.

2.2. Results on characterisations of fires associated to WEEE containing batteries

This part summarizes and compares the results of two distinct sections into which the survey on fire incidents caused by WEEE batteries was divided in relation to two types of events:

- Majority of fires occurring in 2018: 58 respondents out of 109 (53%) indicated that thermal incidents occurred at their facilities in 2018. Given that answers to the following parts of the questionnaire were conditioned by reporting thermal incidents associated with batteries in 2018, the maximum number of respondents in this part should be 58 for all questions.
  Among those 58 respondents, 31 (53%) reported a severe incident in recent years.
- Most severe fire in recent years: 39 respondents out of 109 (36%) reported a severe incident in the past 4 years (2016, 2017, 2018 and 2019). Given that answers to the following parts of the questionnaire were conditioned by reporting a severe incident associated with batteries in recent years, the maximum number of answers in this part should be 39 for all questions.
  Among those 39 respondents, 31 (80%) reported about the fires they had in 2018.

In this part, **results of the survey regarding the majority of fires occurring in 2018 are presented, and compared with results regarding the most severe fire in recent years**. A more detailed assessment of the results on most severe fires is presented in

Annex A – Detailed results on most severe fire.

2.2.1. Type of activities having thermal incidents

The following chart shows the number of times that a specific type of activity is selected as carried out on-site (109 respondents, see Figure 7); the chart shows as well the percentage of those who reported having had a thermal incident in 2018 (58 out of 109 respondents). The number of actors decreases down in the value chain, from collection to post-shredding treatments, while the frequency of fires incidents increases. This indirect relationship is not shown for most severe cases.

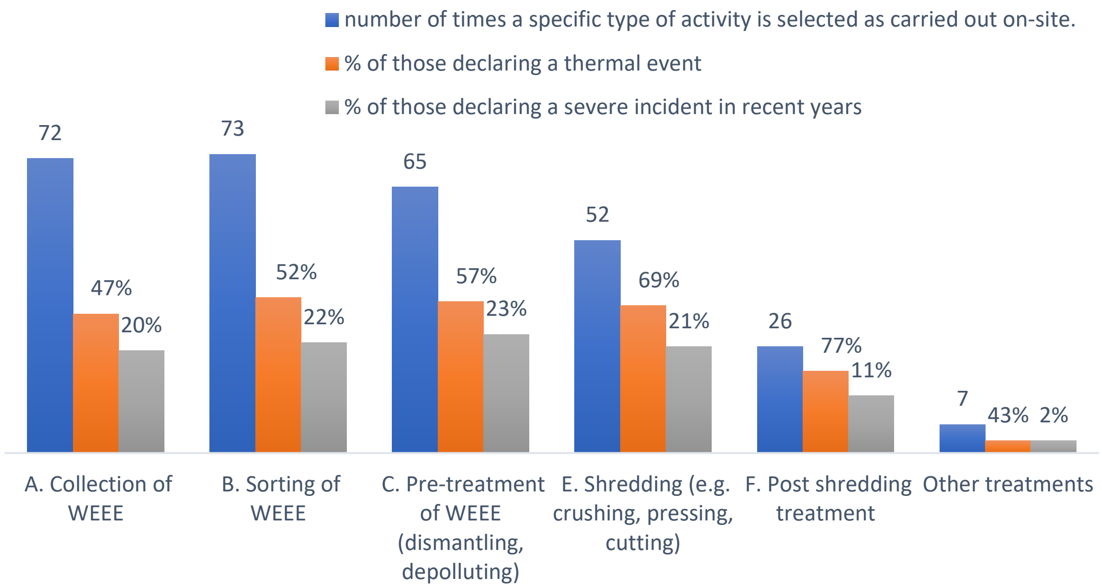

Figure 12. Respondents declaring thermal incidents during 2018 grouped by type of activities on-site, 109 responses – Q1.3

Thermal incidents were defined in the survey with different degrees of severity, ranging from sparks and hot spots to explosions and rapid fires (see part 2.2.2). Not all respondents indicated WEEE in the type of waste treated at their facilities, and in some cases generic terms were provided to answer this question, such as ''municipal solid waste'', ''hazardous waste'' or ''mixed metal scrap''. However, **100% of them selected at least one activity performed with WEEE**. Table 2 provides an overview of the types of activities on-site that respondents carry out with WEEE.

Table 2. Types of activities carried out in the facilities with thermal incidents in 2018, 58 responses – Q1.3&Q2.0

Activities / Frequency of activities' combination	A. Collection	B. Sorting	C. Pre-treatment	E. Shredding	F. Post-shredding
6					
3					

1					
1					
6					
7					
11					
1					
1					
2					
5					
4					
1					
2					
3					
1					
Totals	**34**	**38**	**37**	**36**	**20**

Table 2 shows the types of activities carried out in the facilities that indicated having had thermal incidents in 2018. Other activities that do not appear on the table: sorted batteries (one facility), sorted municipal solid waste (one facility) and stored waste (one facility). The pattern displayed in Table 2 does not seem to differ from the activities carried out by respondents reporting a severe fire[13].

Other types of waste that were managed at the facilities in which thermal incidents occurred in 2018 were described as municipal solid waste, scrap, end of life vehicles, batteries and hazardous waste.

! No definitions of the terms used in Table 2 were provided to the respondents. This typology aimed at having gross categories respondents could understand regardless of e.g. their country of origin.

The next chart shows the number of facilities with thermal incidents in 2018 in relation to their WEEE management capacities. 63% of respondents had capacity for managing less than 25,000 tons of WEEE usually containing batteries in 2018.

[13] See
Annex A – Detailed results on most severe fire. Section A.1.1

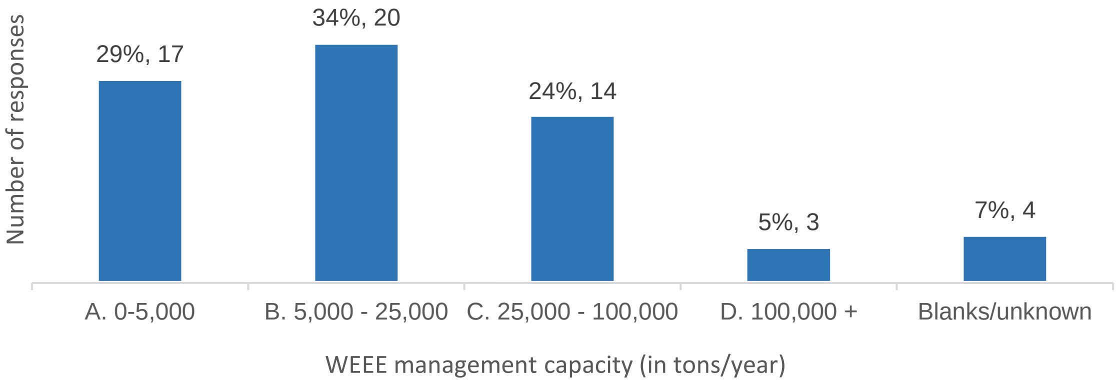

Figure 13. WEEE management capacity (tons/year), 58 responses – Q1.4

The WEEE management capacity of respondents reporting a severe fire incident does not significantly differ from the pattern displayed in

Figure 13. Respondents reporting severe fires and more regular fires were of similar capacities[14].

Figure 14 clearly shows that there are more thermal incidents associated to WEEE that usually contain batteries, such as mixed WEEE (considered a mixture of IT, small appliances, tools, toys, etc.) and small domestic appliances (as opposed to ‘’large domestic appliances”). Respondents considered here all types of thermal incidents, from hot spots to explosions and rapid fires. The chart shows the frequency of such episodes in 2018 corresponding to the 58-total sample of respondents declaring thermal incidents in 2018 (100% = 58 respondents).

14

Annex A – Detailed results on most severe fire – see A.1.1

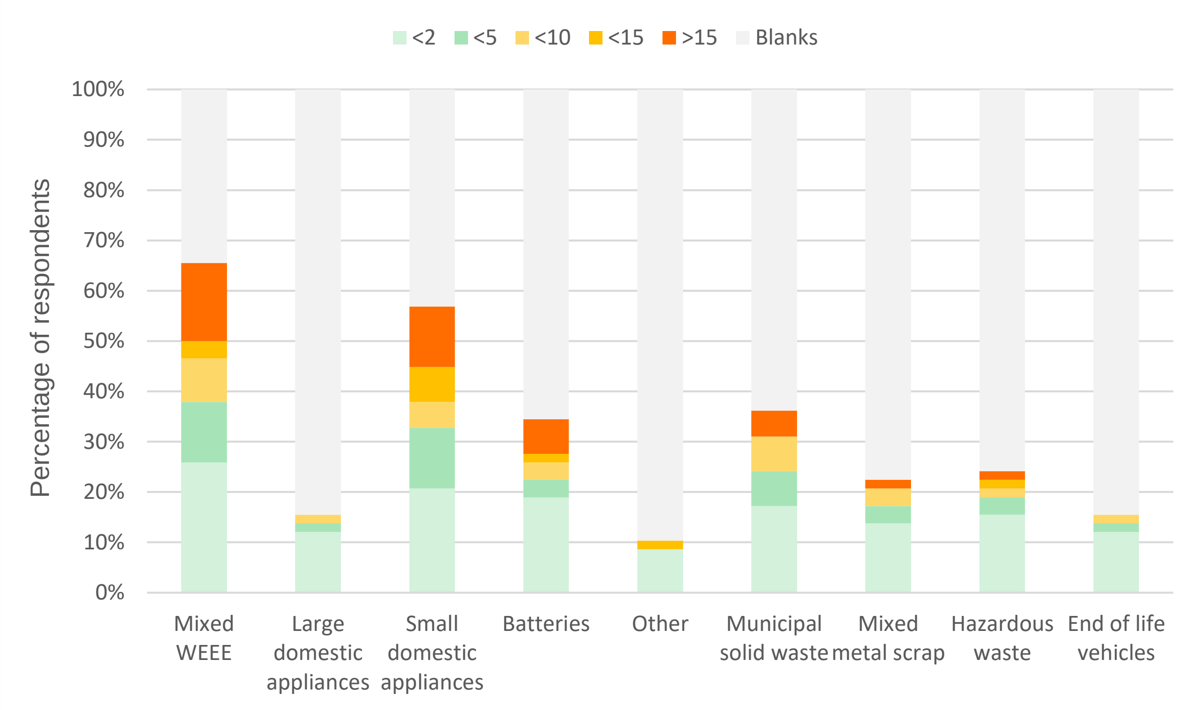

Figure 14. Waste stream(s) where thermal events (from hot spots to explosions) happened in 2018 and frequency, 58 responses – Q3.1

The waste stream where thermal events happened for the majority of fires (Figure 14) is roughly the same as for the most severe cases[15]. However, it can be noted that the most important stream for severe fires were small appliances (16 cases), whilst here "mixed WEEE" is the most quoted waste stream.

! The terms used in Figure 14 "small domestic appliances" do not correspond to the typology used in the Directive 2012/19/UE ("WEEE Directive"). This typology was elaborated with members of the Roundtable, as opposed to large domestic appliances, to simply refer to small items and avoid the need to refer to too strict definitions and have a wording meaningful to the reader.

2.2.2. Characteristics of the thermal incidents

7 respondents out of 44 indicated that there were hot spots occurring on a daily basis during 2018. This seems to be the highest number of responses allocated to the higher frequency available to choose. **In summary, it seems that hot spots, smokes and sparks are the types of thermal incidents that occurred most often, whilst explosions occurred with less frequency**. It should be noted, however, that 7 participants responded that explosions took place from 2 to 6 times a year in their facilities (compared to 18 that responded that this never happened to them in 2018).

[15] see
Annex A – Detailed results on most severe fire - A.1.1

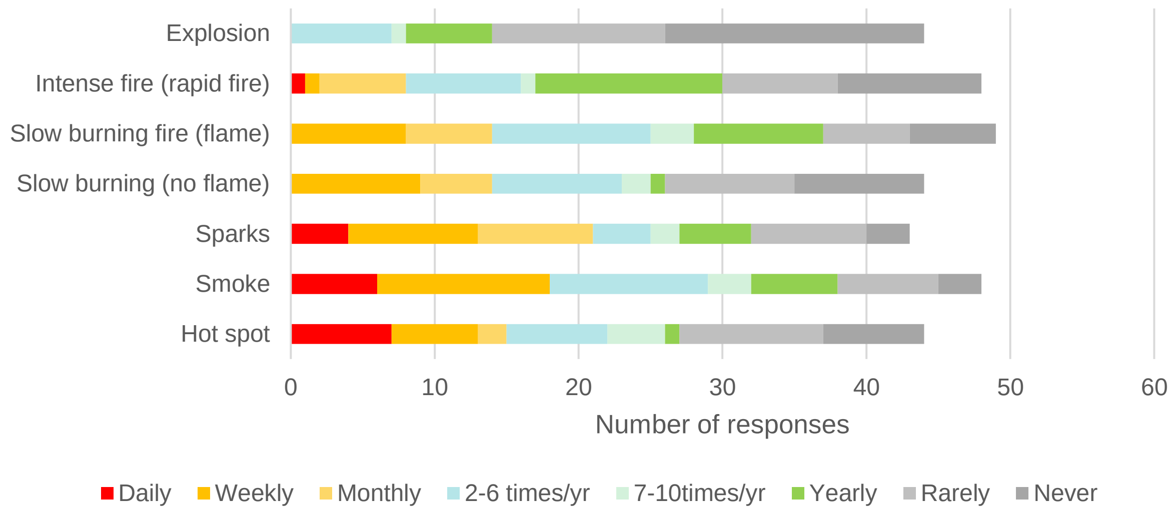

Figure 15. Types and frequency of most thermal events that occurred in 2018 – Q2.1

On the contrary, for most severe cases occurred in recent years, Figure 16 shows that **a majority of reported severe incidents were intense fires (27 responses - 69% of cases)**, followed by smoke (14 responses), hot spots (10 responses) and explosions (8 responses).

In this question, respondents could choose more than one characteristic for the most severe incident and the chart shows the number of times an option was selected. **The most frequent combination recorded is smoke associated to intense fire.**

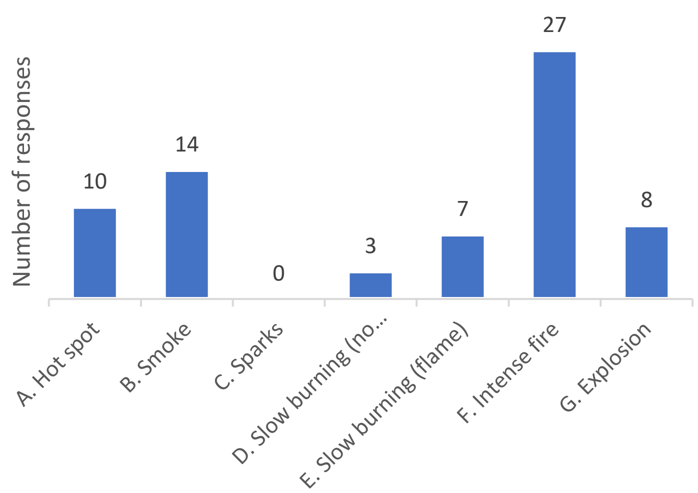

Figure 16. Characteristics of the most severe fire incident, 39 responses – Q4.7

> **!** No definitions of the terms used in *Figure 15* and *Figure 16* were provided to the respondents. This typology was elaborated with members of the Roundtable, to avoid the need to refer to stricter definitions not fitting the reality on the ground, and have a list of thermal events meaningful to the reader.

76% of respondents reporting about fires in 2018 indicated that the frequency of thermal incidents at their facilities had increased in the past two years.

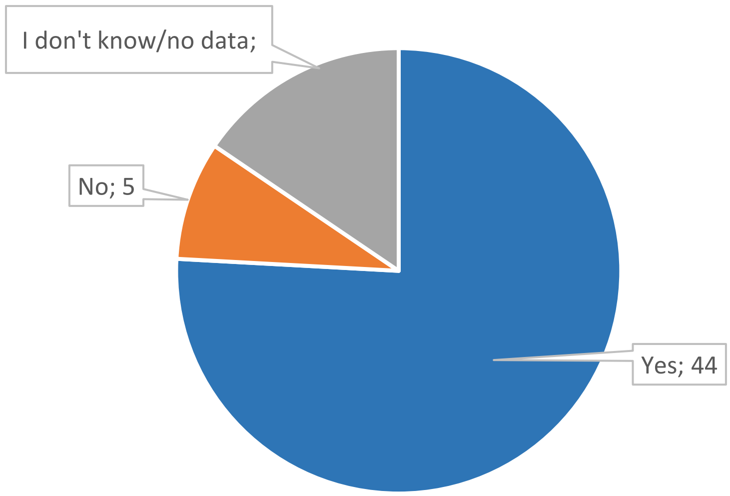

Figure 17. Has the frequency of thermal events increased in the past 2 years? 58 responses – Q2.2

As shown in Figure 18, 52 respondents provided data about the total number of intense fires and explosions caused by WEEE containing batteries in 2018 (fires/year). Responses ranged between none to 200 and 700, the latter responses were discarded from the statistics of this study[16]. In average, there were between 5 to 6 intense fires and explosions per year in 2018, being the most frequent values responded: zero (13 responses) and one (12 responses).

[16] In the first case (200 fires cases in 2018), the respondent was contacted and clarified that the number of fires provided in the survey was obtained by census of the fires at the output of the shredder, by the operator in charge of extinguishing those fires. According to the respondent, those fires correspond to the options "smoke" and "slow burning flame". Therefore, this answer does not match the criteria of Q2.3, focused on "Intense fires", and "explosions". It was not possible to reach the respondent in the second case (700 fires cases in 2018).

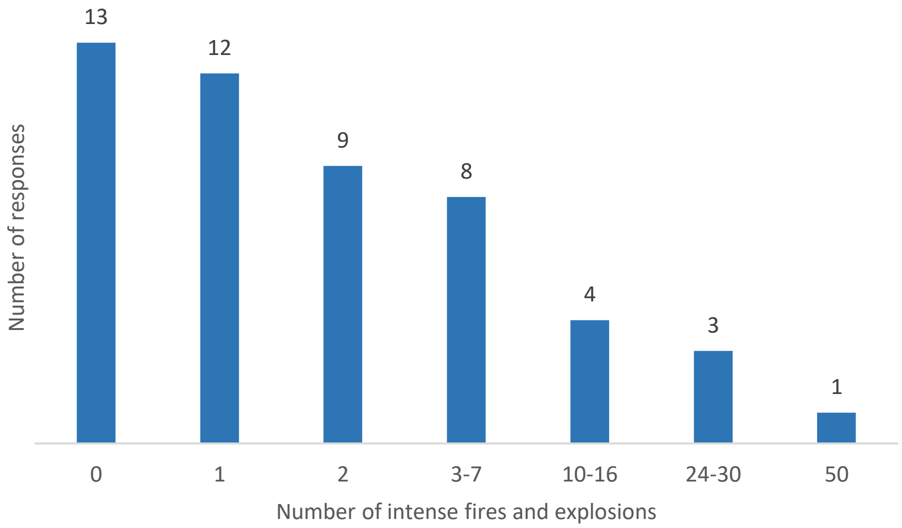

Figure 18. Number of intense fires and explosions in 2018, 52 responses – Q2.3

65% of respondents indicated that they do not find any relation between the season of the year and the number of fires occurred, whilst around 20% indicated summer as a season in which more fires occurred. **Although expert's feedback reveals that batteries show more reactive behaviour at high temperature[17], no clear correlation was found between the geographical location of the respondent and the season were most fires occurred**.

2.2.3. Process stages where the thermal incidents happened

Results obtained in this section are related to working practices (treatment, storage, transport, etc.), and intend to provide a snapshot of the issue's impact on the WEEE treatment value chain. How those working practices are practically related to batteries' fires frequency, and how can they be improved to mitigate the issue cannot be deduced from those results, and would require further investigation.

Responses to the question about where the majority of thermal incidents occurred in the WEEE treatment process during 2018 is represented in Figure 19. Respondents had the possibility to choose more than one stage within the process, and the chart shows the number of times each option was selected by respondents.

[17] For instance, related to a short-circuit.

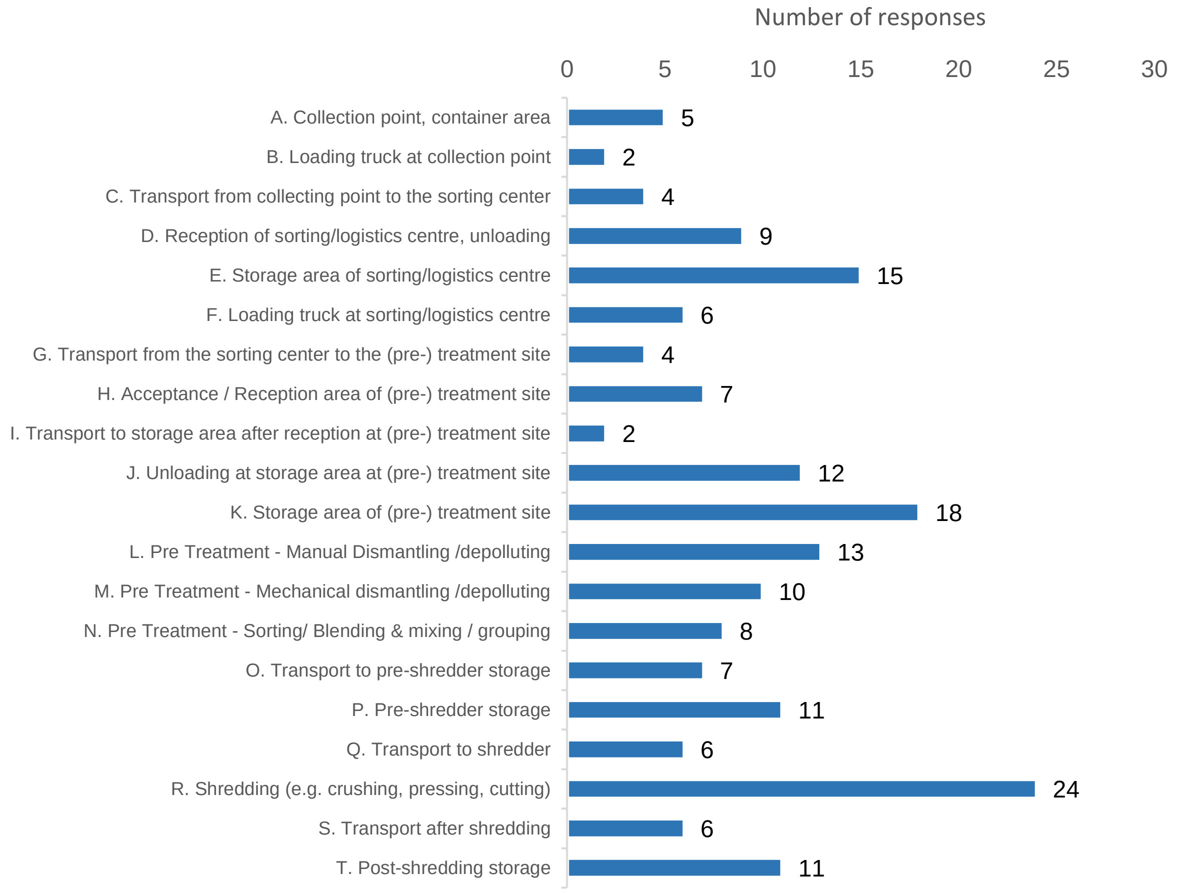

Figure 19. Stage in the process where the majority of thermal events started (frequency of answers), 58 respondents – Q3.2

Regarding the majority of fires, the stages in the process that were most mentioned by respondents were:

- R. Shredding (e.g. crushing, pressing, cutting), 24 times
- K. Storage area of (pre-) treatment site, 18 times
- E. Storage area of sorting/logistics centre, 15 times
- L. Pre Treatment - Manual Dismantling /depolluting, 13 times and
- J. Unloading at storage area at (pre-) treatment site, 12 times

However, they were rarely mentioned alone, but as part of a response containing a combination of other areas.

Following expert's advice to harmonize the differences in collection systems depending on the country and the size of recycling operation[18], previous stages in the process have been grouped into the following broader procedural groups: 1. Collection (options A. and B.), 2. Transport from collection to sorting and logistics center (C. to G. options), 3. Treatment facility: pre-treatment (H. to N. options), 4. Treatment facility: mechanical treatment / shredding (O. to S. options) and 5. Post-shredding storage (option T.). The results of this exercise are shown in the following table:

[18] stages C. to S. may be concentrated in one or two locations

Table 3. Stages grouping where the majority of thermal events started in 2018 (frequency of answers), 58 respondents – Q3.2

Treatment stages group	% of share
1. Collection (options A. and B)	4%
2. Transport from collection to sorting and logistics centre (C. to G.)	30%
3. Treatment facility – pre-treatment (H. to N.)	39%
4. Treatment facility – mechanical treatment/shredding (O. to S.)	21%
5. Post-shredding storage (T.)	6%

The grouping of stages mirrors to a major incidence of fires within pre-treatment procedures (39%); followed by transport operations from collection to sorting and logistics (30%), and mechanical treatment/shredding stages (21%); on the other hand, incidents in the collection handling and the post-shredding storage are far from those values with only a share of 4% and 6% of the cases, respectively.

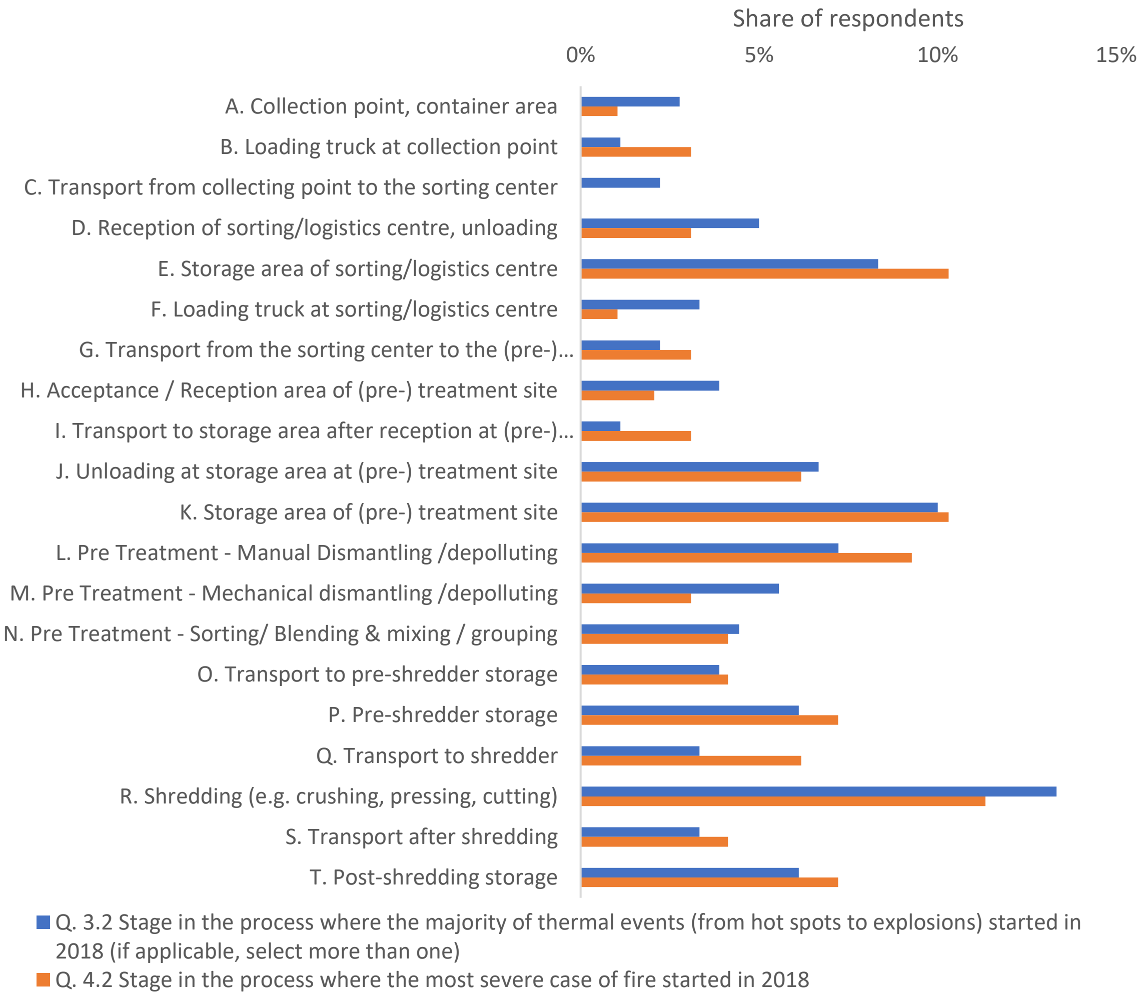

Figure 20. Process stage where the most severe fire incident happened, compared to majority of the cases – Q3.2&Q4.2

Figure 20 compares the share (in %) of each process stage reported for most severe incidents in recent years and the majority of incidents in 2018. The pattern is similar in both cases; however, it can be noted that step R (shredding), although highly reported in the most severe cases, is significantly more representative for the majority of fires.

Regarding the majority of fires in 2018, when thermal events occurred **during transport** (Q3.2.1):

- C. From collecting point to the sorting centre, or
- G. From the sorting centre to the treatment site;

WEEE was in most cases (17 responses out of 23) transported in bulk/skip/roll-off containers (20-44 cubic meters). Other responses (5/23) included small containers and/or cages (< 3 cubic meters). One respondent indicated the WEEE was transported in a big-bag, and another respondent in drums**. Those responses rather indicate standard transport procedure than a specific feature of thermal events**.

Regarding most severe cases, the breakdown of responses does not significantly differ from the responses mentioned above: bulk/skip/roll-off containers (20-44 cubic meters) was the most chosen answer, also reflecting standard transport procedure.

15 respondents out of 22 could not indicate whether the transport in these particular stages were compliant with ADR rules (Q3.2.2); 4 responses showed the transport was not ADR compliant. However, from the obtained responses, it was not possible to know if ADR was applicable or not in such cases. 3 responses stated the opposite (ADR compliant). Therefore, no conclusion can be drawn from the responses to this question.

As regards **transport on site** (Q3.2.3), and when thermal incidents started in the following stages:

- I. Transport to storage area after reception at (pre-) treatment site,
- O. Transport to pre-shredder storage,
- Q. Transport to shredder,
- S. Transport after shredding;

Figure 21 shows that **most of the thermal incidents identified in 2018 started when unloading the WEEE, by tipping, sliding or using a scrap handler, bulldozer and forklift trucks for containers**. Another option mainly mentioned by respondents (22 responses in total) were conveyor belts (10 responses).

One respondent indicated the baler as the starting point of fires, the option on pneumatic conveyors was not selected by any participant.

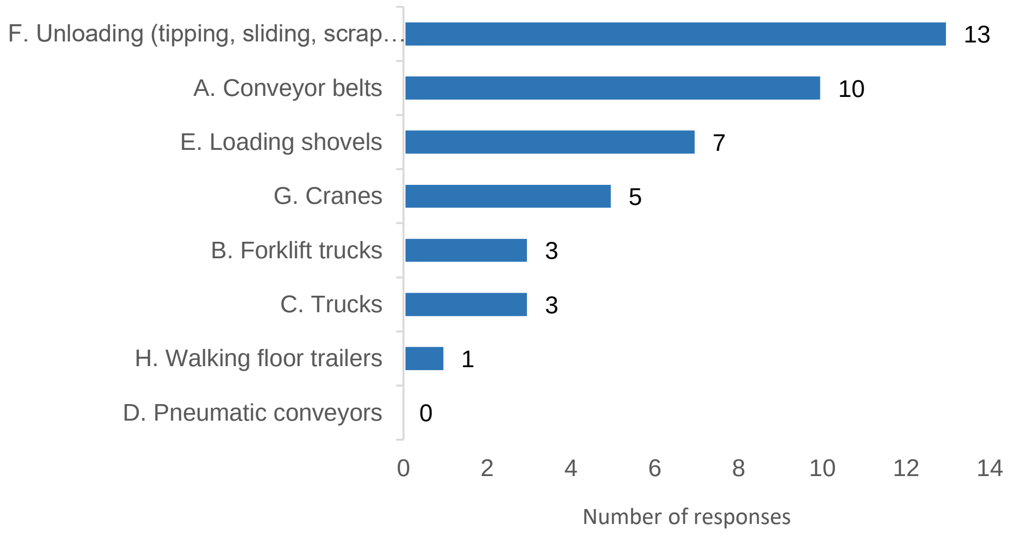

Figure 21. On-site transport type where the majority of thermal events in 2018 started, 22 responses – Q3.2.3

Regarding most severe cases, the most frequent answer to this question is also the unloading stage on site. Interestingly, the conveyor belt is never quoted as the cause of the most severe incident, whereas it is in Figure 21. This result is consistent with experts' feedback, who explained that on moving conveyors, the material is spread out on the belt (rather than in a pile), depending on speed and the width of the belt. Therefore, less material is accumulated in one spot and this reduces the risk of fires. Besides, fires might be detected and extinguished easier and there might be less flammable material around the battery. In some operations, detectors and/or sprinklers above conveyor belts have been installed, lowering the fire risk. Finally, firefighting access to belts might be comparatively easier than access to bunkers and large heaps.

In principle, although this conclusion cannot be drawn from

Figure 21, experts views indicate that it would not be surprising to see that waste handling implying external shocks (in forklifts, scrap handlers, etc.) would lead to fire incidents.

When fires were identified in **storage areas** (Q3.2.4) such as:

- A. Collection point, container area
- E. Storage area of sorting/logistics centre
- K. Storage area of (pre-) treatment site
- P. Pre-shredder storage
- T. Post-shredding storage

Respondents indicated that the areas in which most fires in 2018 started were located outdoor (31 responses)[19], closely followed by the indoor option (23 responses). Heaps and bulk were more mentioned (16 times) than silos and bunkers (7 times); sacks, bags and cages (2 times) or tanks (1 time). Finally, maritime closed containers were not selected at all.

[19] Outdoor / indoor storage conditions can depend on the category of WEEE stored, following the requirements of the directive 2012/19/EU (WEEE directive) and CENELEC EN 50625 standards series where appropriate.

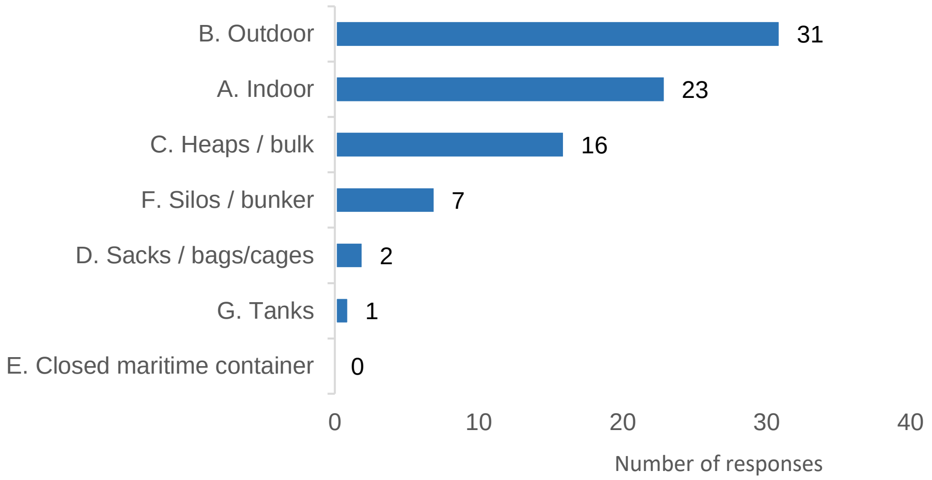

Figure 22. On-site storage type where the majority of thermal events in 2018 started, 45 responses – Q3.2.4

However, from an expert point of view, it is difficult to associate fires to outdoor storage. Especially since prior damages to batteries can lead to fires anywhere. A study conducted by IUTA and IfKU[20] (Grzib, 2018) on the hazardousness of high-energy batteries showed that climatic strain causes little fire hazard. It is possible though that external heat is an aggravating factor in some cases.

Regarding the type of storage on-site when most severe case happened[21], distribution of the answers mirrors the distribution for the majority of cases, which could imply that there's no aggravating factor in storage type where most severe fires happened, compared to the majority of fires.

2.2.4. Damages of thermal incidents

The survey enquired about the severity of most of the thermal events that occurred in 2018. The chart below provides an overview of the responses collected. Not all options obtained the same number of responses.

[20] IUTA: Institut für Energie und Umwelttechnik e.V., IfKU: Institut für Kreislaufwirtschaft und Umwelttechnik (IfKU) desVereins zur Förderung innovativer Verfahren in der Logistik (VVL) e.V.
[21] see
Annex A – Detailed results on most severe fire - A.1.4

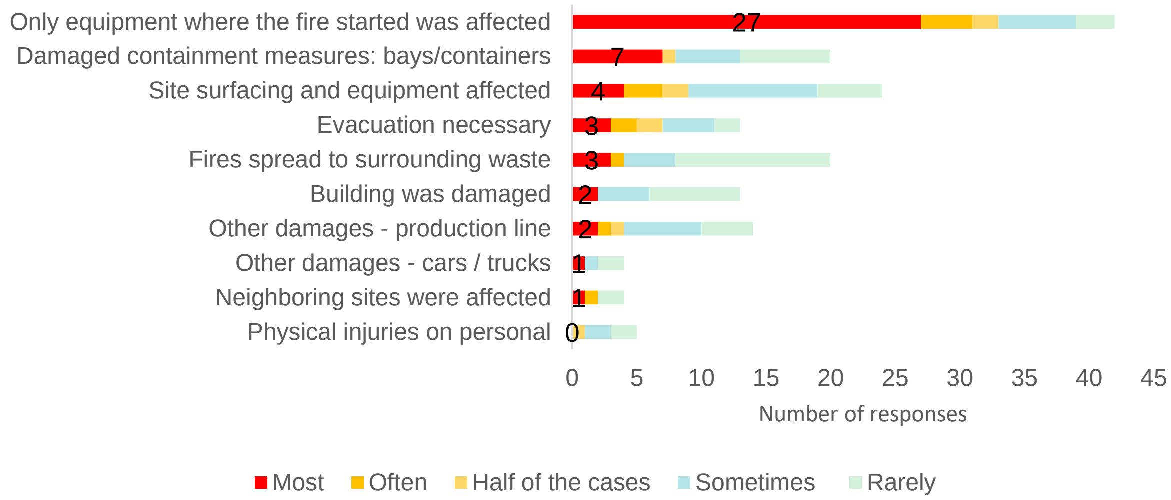

Figure 23. Severity of most thermal events that occurred in 2018, 56 responses – Q3.3

Figure 23 shows how the response most selected was ''only equipment where the fire started was affected''. Other damages received a significantly lower number of responses, and fires resulting in physical injuries on personnel rarely happened.

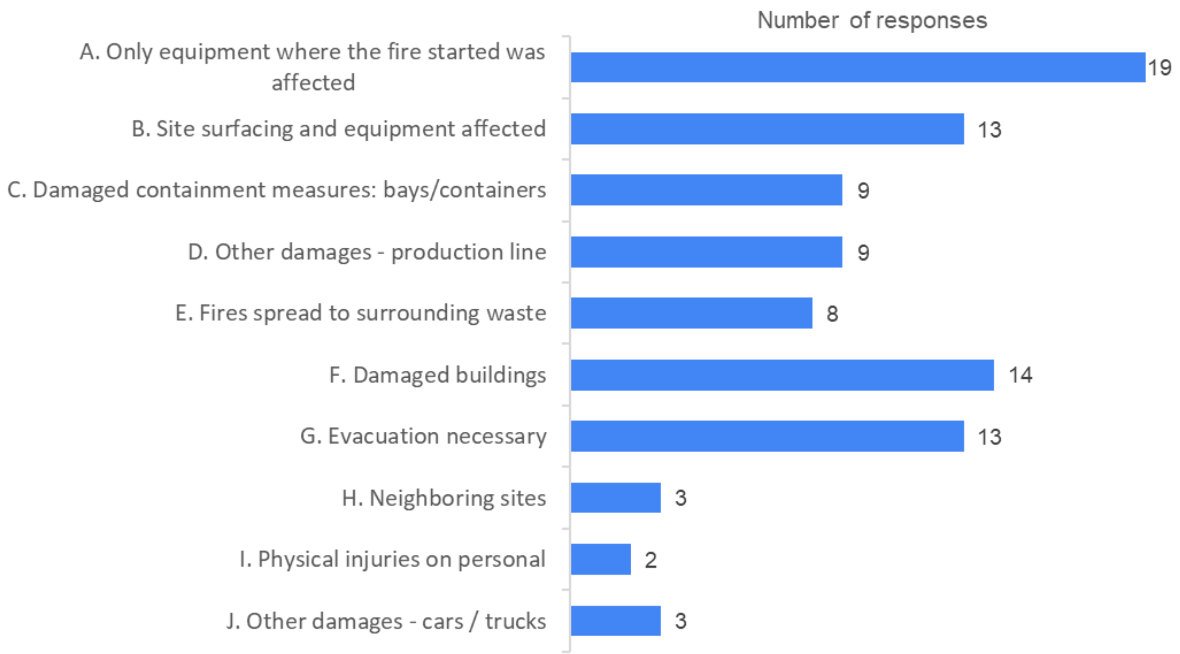

Figure 24. Characteristics of the most severe fire incident, 38 responses – Q4.3

The chart above provides an overview of the responses collected regarding the most severe fires. In line with the responses collected for the majority of the cases happened in 2018 (Figure 24), **for half of the respondents, the fire only affected the surrounding WEEE where**

the fire started. In contrast to Figure 23, however, his option is closely followed by the option in which fires affected buildings (14 responses), meaning that fires most likely affected the material surrounding the ignition point, the storage areas and /or containers (if any) in which WEEE was placed and eventually caused damages to the site building. In 13 cases, site surfacing and equipment were affected, and in another 13 cases, evacuation was necessary. Only in two cases there were physical injuries to working staff.

Regarding the duration of the majority of the fires, 68% of the respondents (39 responses) indicated that the fires lasted less than one hour in most of the cases and this is the most frequent response for this question (see Figure 25).

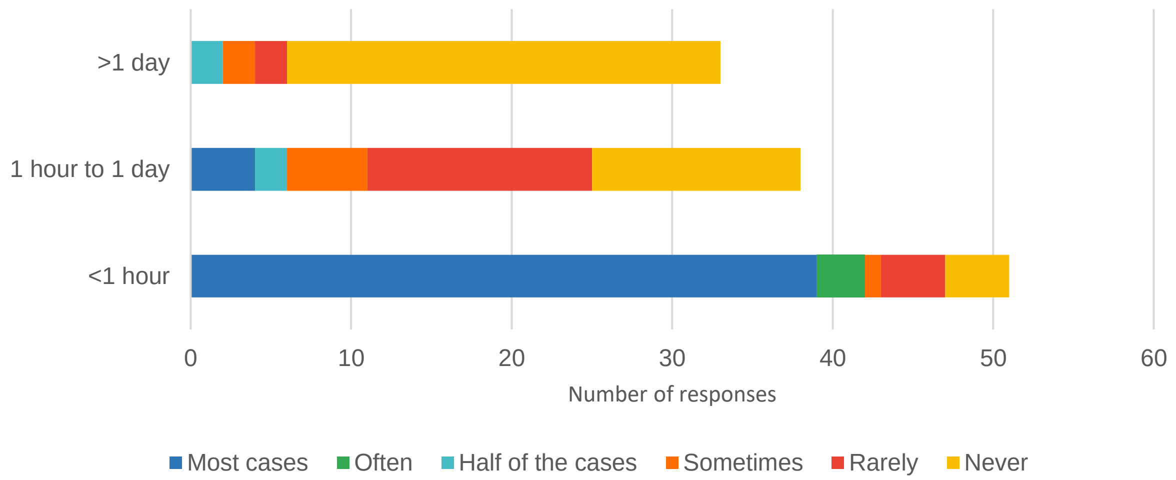

Figure 25. Duration of fires - 2018 incidents, 57 responses – Q3.4

Results above differ significantly with results obtained for most severe fires[22] in recent years. Figure 26 shows that the reported severe cases could lead to a site closure, the stop of a production line or of the whole site, for several days. However, those consequences lasted seldom more than a week. It should be noted that the number of respondents having either a site closure (9), production line (15) or site operations stopped (15) is well below the total number of respondents that reported a severe fire (39).

[22] See
Annex A – Detailed results on most severe fire - A.1.4

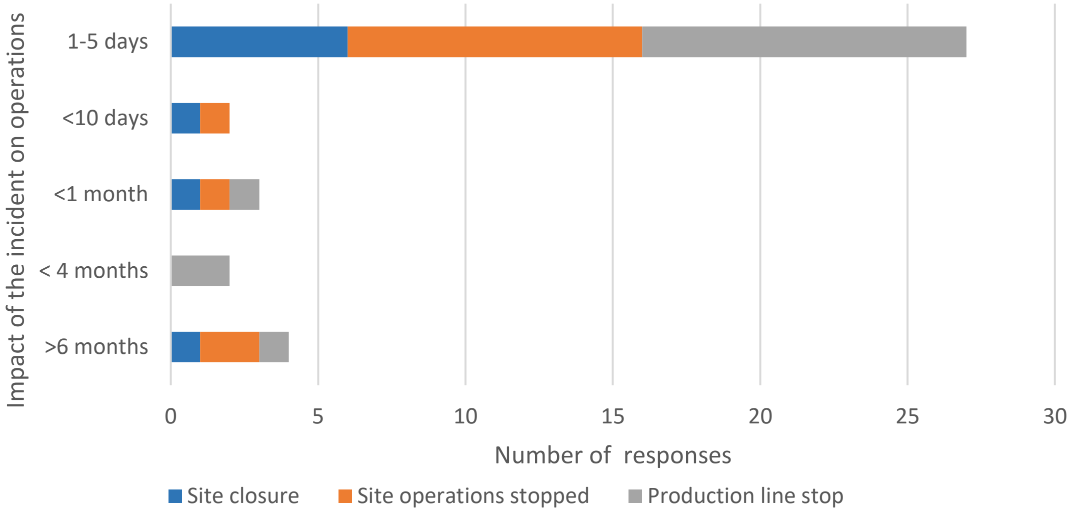

Figure 26. Consequence of the most severe cases – Q4.4

Respondents also provided information about the duration of the severe cases. Figure 27 shows that in most cases, representing almost half of the events, the **fires lasted less than six hours**. This response is followed by fires that lasted less than one hour, which was selected by 10 respondents. Nine respondents indicated that fires lasted one day.

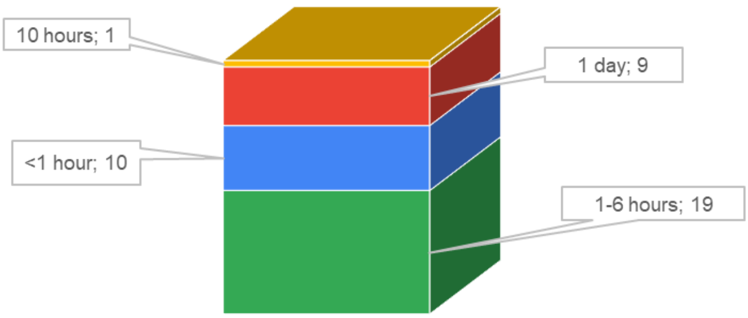

Figure 27. Duration of the most severe fire, 39 responses – Q4.5

2.2.5. Cause of the ignition (if known) of the thermal events

The cause of ignitions was also investigated (Figure 28), and in most cases (32 responses out of 49 responses) **damaged batteries were identified as the cause of the majority of thermal incidents** happened in 2018. Undamaged batteries was the second option happening in most cases (7 respondents out of 35 indicated this was the most frequent cause of fires).

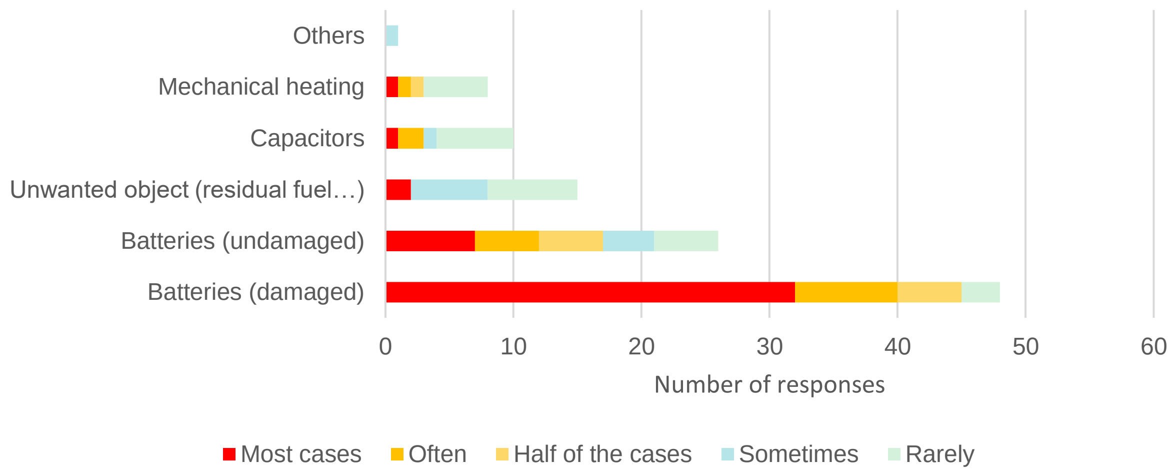

Figure 28. Cause of ignitions (2018 incidents), 53 responses – Q3.8

The responses regarding the causes of severe incidents show a similar trend[23]. Be it for the majority of cases as for most severe cases, damaged batteries are seen as the origin of the issue.

2.2.6. Control of the thermal incidents

Following the question above, participants provided information on the measures used to control the fires (Figure 29). **Almost half of the 58 respondents indicated that on-site extinction measures were enough to extinguish the majority of thermal incidents happening in 2018**. In 10 cases out of the 58 responses, the intervention of the fire brigade was required in most of the cases.

[23] see
Annex A – Detailed results on most severe fire -A.1.5

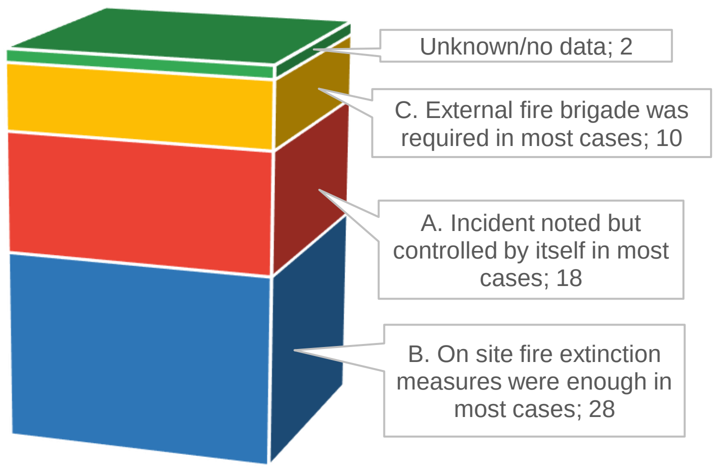

Figure 29. Control of thermal incidents in 2018, 58 responses – Q3.9

In the case of severe incidents, the results differ significantly. Figure 30 shows that in most cases (73% out of the 40 respondents[24]), the services of an external fire brigade were required for extinguishing the fires.

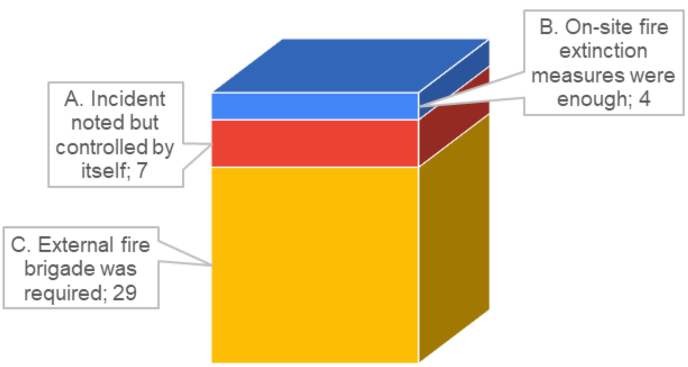

Figure 30. Control of the most severe incident, 40 responses – Q4.9

[24] The number of respondents here is larger than respondents who reported a severe case. This is due to the Q4.9 not being closed for respondents not declaring a severe fire case.

2.2.7. Costs associated to thermal events and insurance coverage

Participants were asked about the costs incurred due to the fires that took place at their facilities. Costs include waste damaged, extinction measures, repair of affected areas, interruption of activities, etc. Respondents were allowed to provide open cost figures, which have subsequently been grouped into ranges to easy further analysis and comparison of data.

The analysis of the responses, displayed in Figure 31, shows that out of the 58 respondents who had fires in 2018, 23 replied that the costs where unknown. Approximately one third of the remaining respondents pointed out that costs associated to the damages were below ten thousand euros. After this, the most frequent responses become ten to fifty thousand euros (7 responses) and one hundred to two hundred thousand euros (7 responses). **Amounts are quite high and reveal the relevance of the issue of fires at facilities managing waste containing batteries.** Two respondents indicated that costs surpassed the million euros. A larger sample of responses, however, would have been welcome to better assess this question, and it is suggested that further investigation focuses on the types of costs associated to the damages.

The fires that occurred in 2018 cost in average 190 k€, but varied a lot depending on the respondent[25].

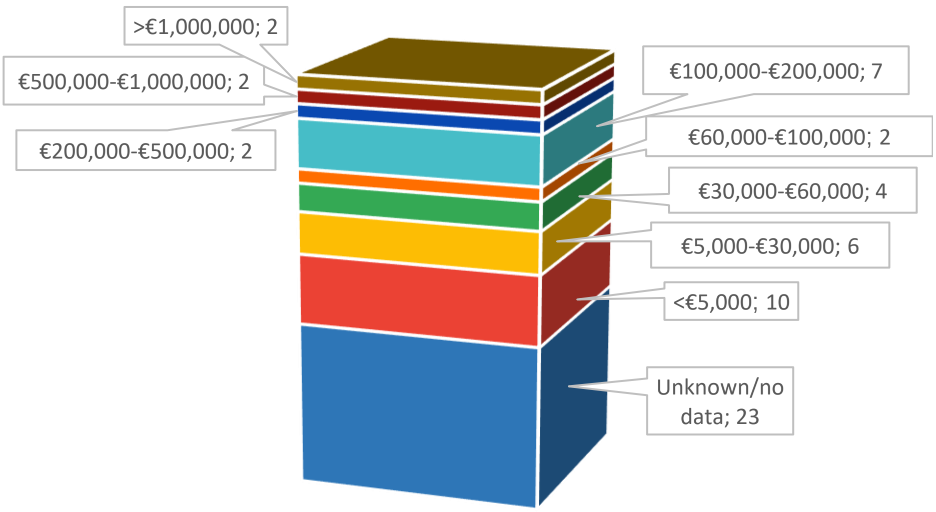

Figure 31. Estimated cost of incidents in 2018, 58 responses – Q3.5

[25] Estimated average based on 34 responses. Standard deviation: 444 k€

Figure 32 provides a comparison of the cost of the most severe fire ever happened at the facilities, also including costs of damaged waste, extinction measures, repair of affected areas, interruption of activities, etc. The breakdown of those costs depending on their cause was not detailed in the questionnaire and should be further investigated. Reported severe fires cost in average 1.3 M€, but varied a lot depending on the respondent[26].

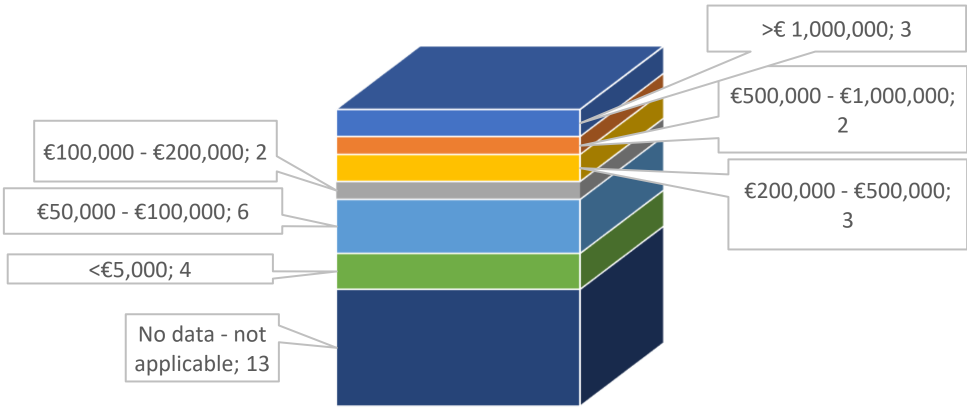

Figure 32. Estimated cost of the most severe case (€), 26 responses – Q4.6

As regards insurance coverage, out of the 51 responses received, **41% indicated that the intervention of the insurance company was not required in most cases occurring in 2018 (**Figure 33**)**. This response is followed by 19% of respondents indicating that the insurance provided full coverage of the incidents in most cases, and 16% of respondents showing that there was partial coverage (16%) or no coverage (18%) in most cases. The "other" category corresponds here to one case were the respondent was refused insurance and one case where insurance was not needed at all.

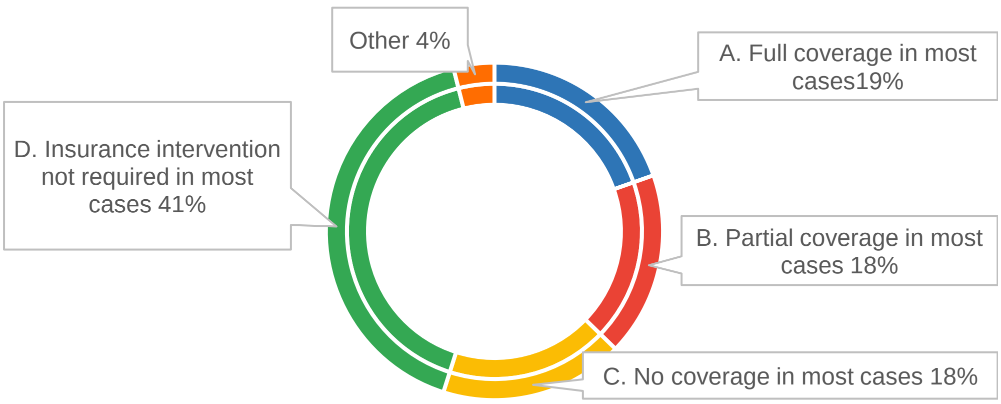

Figure 33. Insurance coverage - 2018 incidents, 51 responses – Q3.6.1

[26] Standard deviation: 4.1 M€

According to expert's views, the results presented in Figure 33 correspond to the reality, as many incidents are managed by the operators themselves. The partial coverage of incidents could be related to specific features of insurances policies, such as deductibles, or the damages covered[27]. It is also possible that responsibility for the incident is rightly or abusively attributed to the operator by the insurance. In any case, incident coverage varies, since there's no "standard" insurance policy.

Insurance coverage for the most severe cases differs to what was reported for the majority of thermal incidents in 2018. Here, most respondents (42%) answered that damages caused by the incidents were partially covered by insurance, while in Figure 33, insurance was not needed for a large part of the cases (41%), it is only the case for 22% of the cases here (Figure 34). However, the share of incidents not covered by insurance is similar (19% here against 18% in Figure 33). The outcome of the survey demonstrates that current insurance policies are not adapted to the emerging risks linked to battery fires from waste batteries and WEEE.

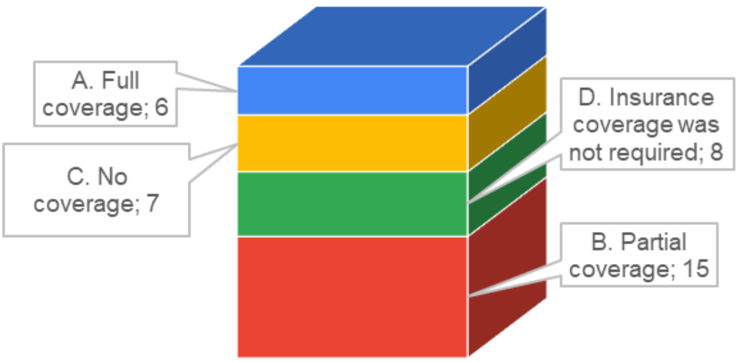

Figure 34. Insurance coverage of the incidents related to severe fire cases, 36 responses – Q4.6.1

In addition to the above, all[28] respondents were asked whether insurance costs increased because of handling WEEE containing batteries. Almost half of the respondents (49%) declared that this didn´t happen, compared to 38% that confirmed an increase in insurance costs due to the handling of WEEE (Figure 35). 7% unknew the response and 9% used the provided open text "other" alternative to detail the answer: "depending on group level" (2 times), "insurance was increased by fire risk in general" (1 time) and "being refused insurance" (1 time) were mentioned.

When it comes to insurance costs increase because of fires occurring at the facilities, the percentage of people assuring that it hasn't been the case reaches 67% (Figure 36) and those confirming this relation amounts to 23%. Answers to the open text "other" alternative were similar to those collected in the previous question: "depending on group level" (1 time),

[27] For instance, damage to buildings or equipment might me covered but not the disposal cost for the damaged material.

[28] Note: the number of respondents here was constrained by reporting of fires occurring in 2018 (57 respondents).

"insurance was increased by fire risk in general" (1 time) and "being refused insurance" (1 time). Expert's feedback reveals those results on insurance fees increase may be related to a potential delay between the fire events, and the modification of premiums in insurance contracts.

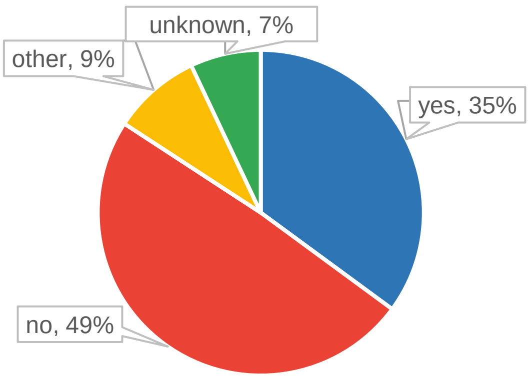

Figure 35. Insurance costs increase because of managing WEEE containing batteries, 57 respondents – Q2.5

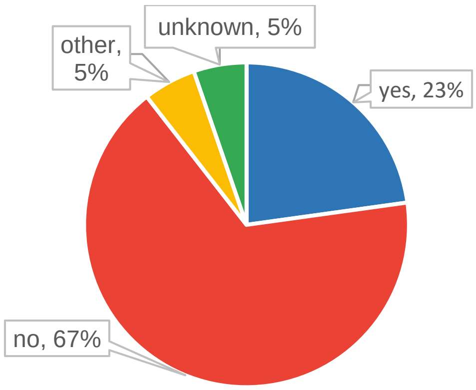

Figure 36. Insurance costs increase as a result of a fire caused by WEEE containing batteries, 57 responses –Q2.6

Respondents who confirmed an increase in insurance costs due to fires (including "yes" and "other" responses - 16 of 57, 28%), were then asked about the extent of the increase. The most selected range of increment is 25-50% and only one response is above that range. However, the low number of valid responses (8 out of 16) and the variety of figures provided do not allow to draw a clear conclusion on this regard.

3. Conclusions

This study reveals that there is a shared understanding in the WEEE value chain that fire cases related to batteries have increased in the last two years. The study investigated both the characteristics of the majority of fires occurring in 2018 (58 respondents), and the most severe fires that happened between 2016 and 2019 (39 respondents). In both cases, it confirms what has been increasingly reported by operators in the WEEE treatment chain in the EU, namely that:

- Small appliances and mixed WEEE are far more subject to thermal events than other waste streams[29];
- Batteries, and in particular damaged batteries, are identified as the cause of the ignition by a large majority of respondents.

The fires identified happened at every stage of the WEEE collection and treatment chain, but the study revealed a higher prevalence at shredding stage during treatment and during storage at the logistics and pre-treatment stages.

Most severe fires in most instances (69% of 39 respondents) were described as intense fires associated to short duration periods (less than 6 hours, according to 19 cases) that caused damages to the surrounding areas (equipment, waste) and in slightly less cases, damages to the building facilities. Operations and normal activity at the facilities were in most cases affected from 1 to 5 days by the most severe fires.

When looking at the majority of cases happening in 2018, it is worth noting that fires occurring most of the time were described as sparks, smoke or slow burning. In their vast majority, those fires lasted less than one hour and the damages associated to them affected waste and equipment surrounding the fire's starting point.

The burden of this growing phenomenon is very heavy for the WEEE treatment chain. As regards most severe fires, the damages they cause can cost up to several millions of euros: the average reported cost for the most severe fire in the last four years was 1.3M€[30]. The intervention of a fire brigade was required in most severe cases reported. According to expert's views, the total costs of those incidents can stretch over long periods of time, as extinction costs can be followed by long-lasting clean-up costs (e.g. water treatment).

According to survey results, for frequent but relatively small incidents, insurance was not necessarily required, but for most severe fire cases, insurance coverage was often only partial. This depends on the insurance policy of WEEE treatment companies, but experts feedback confirms that insurance do not always cover the entirety of damages (e.g. because of deductibles). Discussions with experts indicated that some treatment facilities and recyclers are refused insurance because of the risk associated to fires, which can act as a major obstacle for investments in the infrastructure for proper treatment of waste batteries and WEEE containing batteries.

In what concerns the majority of fires identified during 2018, most were controlled by themselves or with on-site fire extinction measures. For a large share of respondents (41%), most thermal events did not require insurance coverage. It can be deducted that there is a

[29] Regarding the definition of "Mixed WEEE" and "small appliances", see part 2.2.1

[30] Sample of 26 respondents out of 38 that reported a severe fire. Deviation: 4.1 M€

high prevalence of small thermal events with little or no severity. However, it is worth noting that the average cost of all those incidents in 2018 was estimated in 190 k€[31], which can represent a significant burden for an individual company.

From the scope of the survey, it can be stated that batteries' fires are an EU-wide issue. During an interview with an expert from the WEEE recycling industry, it was mentioned that occurrence of fires could be a threat to reach the EU objectives of WEEE recycling and recovery, and a deterrent for some companies that might shift away from WEEE collection and treatment.

The expected increase in the number of Li-ion batteries put on the market today reinforces the need to implement effective prevention and mitigation measures. It is expected that the number of waste batteries and WEEE containing batteries will increase eventually and may aggravate the problem over a medium to long term if no measures are put in place. The handling of WEEE containing batteries requires extreme care during the entire chain of collection and treatment.

The Roundtable agreed to follow this report with an investigation of the different good practices and strategies implemented in the WEEE value chain. Measures for preventing and mitigating the effects of fires caused by WEEE containing batteries will be identified, described and compiled in a subsequent report, which will also include the analysis of the results collected means the part B of the survey, focused on good practices aimed at tacking fires in all stages of WEEE management. A dissemination and communication plan will be designed for ensuring a good spread and long-lasting effect of this initiative.

Based on the survey results and discussions within the Roundtable and experts in the field, the members of the Roundtable identified a number of **recommendations**:

- A close monitoring of the fires occurring at EU level would be essential to understand the magnitude of this phenomenon and the effectiveness of prevention and mitigation measures proposed. We recommend assessing the feasibility to establish an EU-wide observatory to better monitor fires events and exchange best practices.
- The consequences of this issue also concern the preparing for reuse sector, as reuse of EEE, including dismantling and batteries' replacement, is meant to grow in coming years. It is recommended to investigate the impact of this phenomenon in the preparing for reuse sector. This sector was barely represented in this survey and feedback from an association consulted during the preparation of this report was not conclusive.
- ADR rules are known to be complex and demanding for Li-ion batteries. Responses collected in this survey were not conclusive and could not identify the impact and effectiveness of the implementation of the ADR rules. Further investigation of ADR effectiveness in preventing fires caused by WEEE containing Li-ion batteries during transport is recommended.
- The survey did not allow to identify the existing conditions in storage and WEEE treatment when fires took place. Additional investigation about the practices carried

[31] Sample of 34 respondents out of 58 that reported a fire in 2018. Deviation: 444 k€

out during storage and treatment associated to the occurrence of fires could be useful to identify good practices.

- The survey did roughly identify the costs associated to fires caused by WEEE containing Li-ion batteries; however, the analysis of the responses and the feedback provided from experts concluded that we should further investigate the different costs typologies associated to the fires and how they spread over time.
- This study revealed that there may be issues associated with insurance coverage affecting the WEEE recycling sector. Further investigation and definition of such issues is recommended.

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Weyhe R., Yang X. (2018), *Investigation about Lithium-Ion Battery Market Evolution and future Potential of Secondary Raw Material from Recycling*, report for ACCUREC Recycling GmbH.

5. Composition of the Roundtable of batteries

The European Recycling Industries' Confederation is the umbrella organisation for European Recycling Industries. Through its Members, EuRIC represents companies involved in the collection, processing, recycling, transport and trade of a variety of recyclables (metals, paper, plastics, glass and beyond) across Europe. By servicing its Members, EuRIC contributes to promote recycling, which is first and foremost a business activity driven by an ecosystem of thousands of Small and Medium-size Enterprises (SMEs) and fewer but equally important larger companies. All of them are local and global actors. They provide non-outsourceable job opportunities and produce locally commodities, which are traded and priced globally. Their activities offer massive environmental benefits by saving natural resources and drastically reduces energy consumption and pollution.

EERA, the European Electronics Recyclers Association is a professional association for recycling companies who are treating waste electrical and electronic equipment WEEE in Europe. Members recycle ± 2.500.000 tonnes of WEEE annually and have more than 100 locations in 22 European countries. EERA members are pre-processors and end processors. EERA is a non-profit organisation and is the voice of WEEE recyclers. It aims for the harmonization of international and national regulations for WEEE recycling and the creation of a level playing field in order to obtain a free market for demand and supply of services. The vision of EERA is for a circular economy where WEEE is managed as a resource and is returned into the economy as equipment for reuse or as a raw material. EERA calls for an appropriate and enforced legal framework, better collection processes, good treatment based on mandatory standards and Best Available Technologies and the eradication of illegal practices. EERA supports product design integrated in a life-cycle approach.

Eucobat is the European association of national collection schemes for batteries. They assure that all waste batteries are collected and recycled in an ecological sound way and contribute this way to a better environment. Eucobat has been created to deal with matters which are of scientific, economic and institutional interest for national compliance organizations in general; to represent the interests of the national compliance organizations for batteries in Europe; and to harmonise the procedures, in particular in regard to participating companies, and activities of national compliance organizations that assume the financial and/or organisational responsibility of manufacturers for the management of waste batteries and accumulators.

ecosystem is a French non-profit organisation accredited by the Public Authorities to collect, decontaminate and recycle household waste electrical and electronic equipment (WEEE), professional equipment (professional WEEE), lamps and small fire extinguishers. Many players are involved in this sector which is managed by ecosystem including manufacturers, importers, distributors, local authorities, solidarity networks, treatment and logistics suppliers, professionals in charge of electrical equipment maintenance, fire safety, waste managers and equipment users (both individuals and professionals). ecosystem is involved in many research projects and safety studies with several objectives: maximize depollution, improve treatment and separation of WEEE, protect workers, create circular loops for recycled materials.

Municipal Waste Europe is the European umbrella association representing public responsibility for waste. The members are national public waste associations and similar national or regional associations.

They are committed to sustainable waste management that minimises the impact of waste on the environment and promotes resource efficiency, taking into account local conditions. Municipal Waste Europe promotes the interests of its members at European level, through joint positions on waste management issues and legislation and keeps its members informed on the latest EU policy developments. The association encourages the sharing of information among its members, including the exchange of good practice in the local management of waste.

The WEEE Forum a.i.s.b.l. is an international association representing forty producer responsibility organisations across the globe. Together with our members, we are at the forefront of turning the extended producer responsibility principle into an effective electronic waste management policy approach through our combined knowledge of the technical, business and operational aspects of collection, logistics, de-pollution, processing, preparing for reuse and reporting of e-waste. Our mission is to be the world's foremost e-waste competence centre excelling in the implementation of the circularity principle.

WEEELABEX is an international non-profit legal entity, headquartered in Prague, that sets up qualification auditors in the WEEELABEX standards, as well as promoting the adoption of these standards by operators and member states as a means of improving WEEE management practices in Europe.

Three constituent bodies make up the WEEELABEX organisation: the WEEELABEX General Assembly, composed by all member WEEELABEX systems (WEEE producer compliance schemes), the WEEELABEX Government Council, which is the executive body, and the WEEELABEX Office, that functions as Secretariat and WEEELABEX notary.

Annex A – Detailed results on most severe fire

39 respondents out of 109 (36%) reported a severe incident in the last 4 years (2016, 2017, 2018 and 2019). Given that answers to the following parts of the questionnaire were conditioned by reporting a severe incident associated with batteries in recent years, the maximum number of answers in this part should be 39 for all questions.

Among those 39 respondents, 31 (80%) reported about the fires they had in 2018 (see part 2.2).

A.1.1. Type of activities having reported severe incidents

Table 4 provides an overview of the types of activities on-site that respondents carry out with WEEE.

Table 4. Types of activities carried out in the facilities reporting a most severe fire incident, 39 responses – Q1.3&Q4.0

Activities / Frequency of activities' combination	A. Collection	B. Sorting	C. Pre-treatment	E. Shredding	F. Post shredding
4		■	■	■	■
5	■	■	■		
6	■	■	■	■	
9	■	■	■	■	■
1					
2				■	
2		■	■	■	
4	■				
1					
1	■	■			
2			■	■	
1			■		
1				■	■
39	25	27	29	26	14

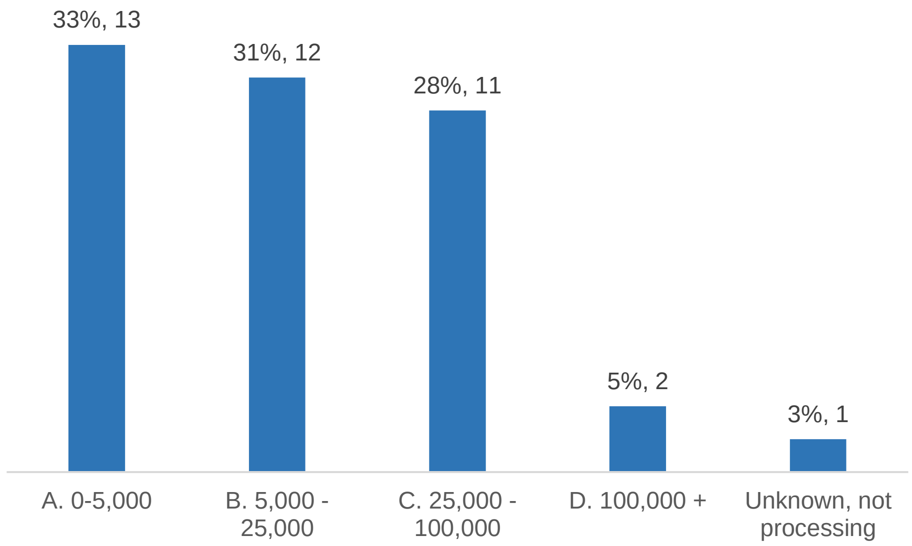

Figure 37. Capacity of facilities that reported a severe fire event, 39 responses

Figure 37 shows the capacity for WEEE (in tons/year) of facilities reporting to the survey a severe incident in the last 4 years (2016, 2017, 2018 and 2019). 64% of respondents had capacity for managing less than 25,000 tons of WEEE.

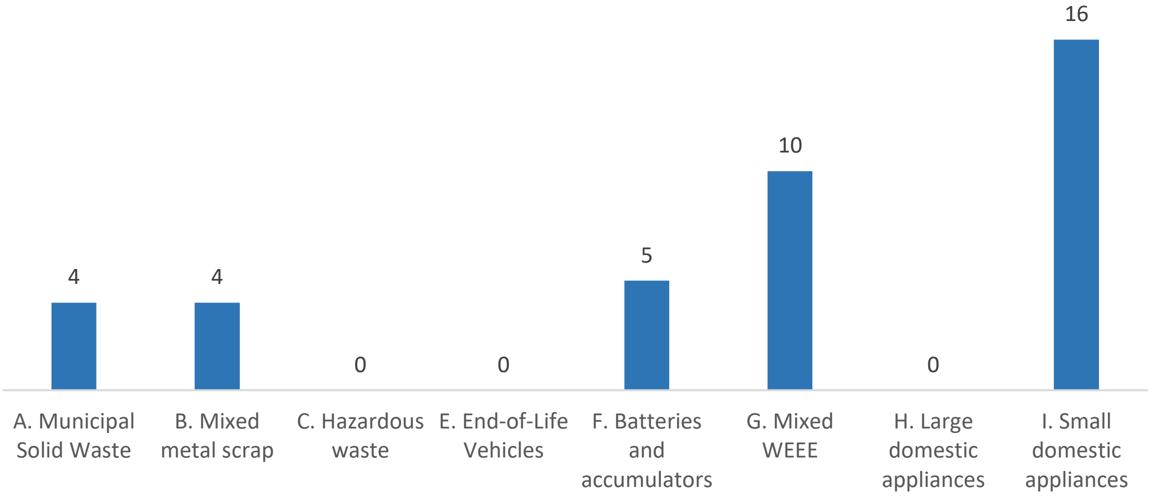

Figure 38. Waste stream where fire incident happened in facilities that reported a severe fire event, 39 responses – Q4.1

Small appliances (as opposed to ''large appliances") is the most concerned waste stream (41% of responses) were severe fire events are reported (see Figure 38). It remains unclear whether respondents may have considered generic terms such as ''municipal solid waste'' or ''mixed metal scrap'' as waste containing WEEE.

! The terms used in *Figure 38* "small domestic appliances" do not correspond to the typology used in the Directive 2012/19/UE ("WEEE Directive"). This typology was elaborated with members of the Roundtable, as opposed to large domestic appliances, to simply refer to small items and avoid the need to refer to too strict definitions and have a wording meaningful to the reader.

A.1.2. Characteristics of the most severe incident

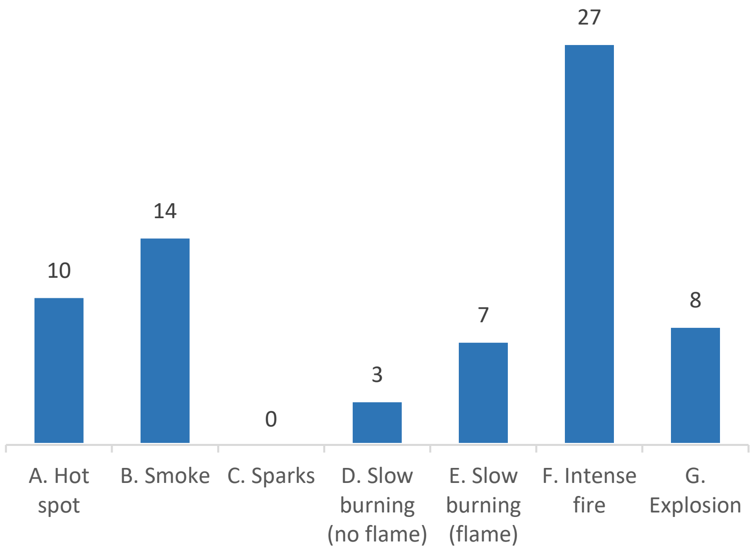

Figure 39. Characteristics of the most severe fire incident, 39 responses – Q4.7

Figure 39 shows that **a majority of reported severe incidents were intense fires (27 responses - 69% of cases)**, followed by smoke (14 responses), hot spots (10 responses) and explosions (8 responses).

In this question, respondents could choose more than one characteristic for the most severe incident and the chart shows the number of times an option was selected**. The most frequent combination recorded is smoke associated to intense fire.**

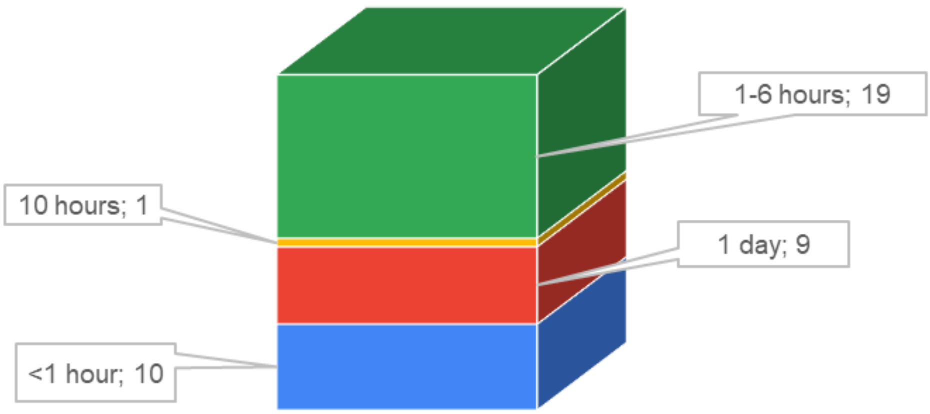

Figure 40. Duration of the most severe fire, 39 responses – Q4.5

Respondents provided information about the duration of the severe cases. Figure 40 shows that in most cases, representing almost half of the events, the **fires lasted less than six hours**.

This response is followed by fires that lasted less than one hour, which was selected by 10 respondents. Nine respondents indicated that fires lasted one day.

A.1.3. Process stage where severe thermal incidents happened

Results obtained in this section are related to working practices (treatment, storage, transport…), and intend to provide a snapshot of the issue's impact on the WEEE treatment value chain. How those working practices are practically related to batteries' fires frequency, and how can they be improved to mitigate the issue cannot be deduced from those results, and would require further investigation.

Regarding the treatment stage where the most severe fire event happened, respondents were given a list of the different steps of the WEEE value chain, starting from collection to disposal, and including transport, storage and processing stages. Respondents were to indicate the stages in which the most severe case occurred. As shown in Figure 41, the stages in the process that were most mentioned by respondents were:

- R. Shredding (e.g. crushing, pressing, cutting), 11 times
- K. Storage area of (pre-) treatment site, 10 times
- E. Storage area of sorting/logistics centre, 10 times
- L. Pre-Treatment - Manual Dismantling /depolluting, 9 times

Figure 41 also compares the responses given for the most severe cases and the responses given for the cases that occurred most often during 2018 (see section 2.2.3).

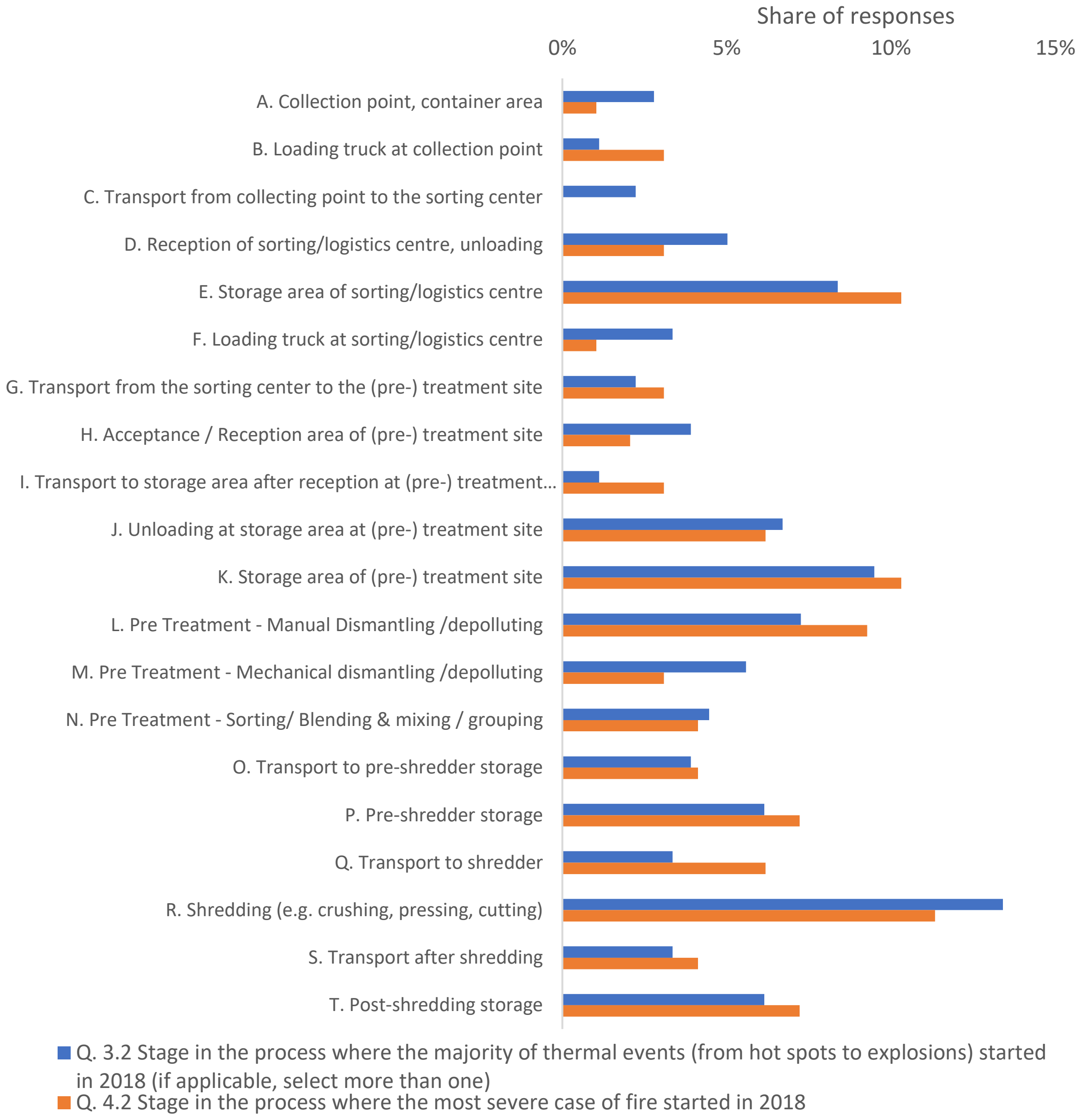

Figure 41. Process stage where the most severe fire incident happened, compared to most of the cases – Q3.2&Q4.2

The chart shows no significant divergence in the location in the process of the incidents between the majority of cases and the most severe case reported.

> **!**
>
> Results displayed in part A.1.3 (other than *Figure 41* can be nuanced: respondents answered on specificities of fires during storage or transport stages although they did not necessarily reported fires at those stages in Q4.2 (*Figure 41*). For instance, regarding transport before delivery (Q4.2.1, Q4.2.2); only 3 respondents ticked responses C or G to Q4.2
>
> However, it can be deduced that even if respondents answered that severe fires happened in e.g. shredding, they may have indicated how severe fires happened during transport.

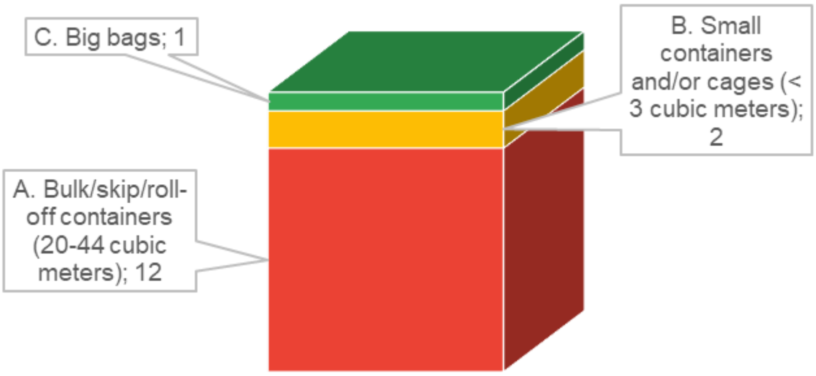

Figure 42. WEEE container type if incident happened during transport before delivery, 15 responses – Q4.2.1

When severe fires occurred during transport before delivery, participants were asked about the container type in which the WEEE was transported. The transport before delivery includes (see Figure 41):

- C. Transport from collection point to sorting centre, and
- G. Transport from the sorting centre to the (pre-)treatment site

Figure 42 above shows that, in most cases, WEEE was transported in bulk/roll-off containers. WEEE transported in small containers is only associated to two severe fires, whilst only one respondent experienced a severe fire for WEEE transported in a big-bag. In addition, one respondent specifically answered that “Fire happened in a container of externally depolluted material which was stored for transit to a sister company”, in addition to response “A. Bulk/skip/roll-off containers (20-44 cubic meters)”.

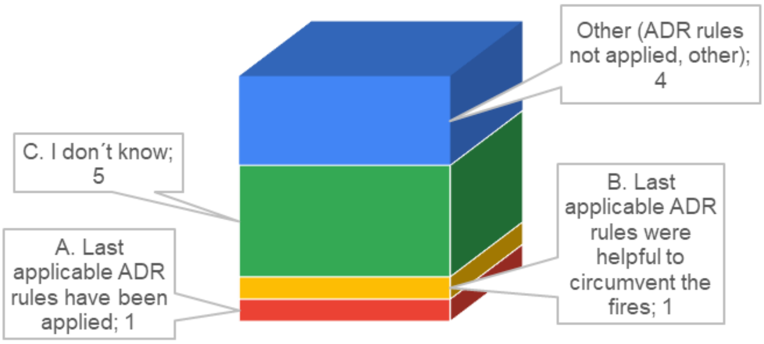

Figure 43. Application of ADR rules if incident happened during transport before delivery, 10 responses – Q4.2.2

The questionnaire enquired as well about compliance with ADR legislation. Ten responses were collected for this question. A category “Other”, with a free response, was possible and received four answers that do not appear represented in the Figure 43:

- ADR not compliant transport
- ADR rules not applied by the subcontractor
- ADR rules are not applied in the country of the respondent

- Incident did not happen during transport

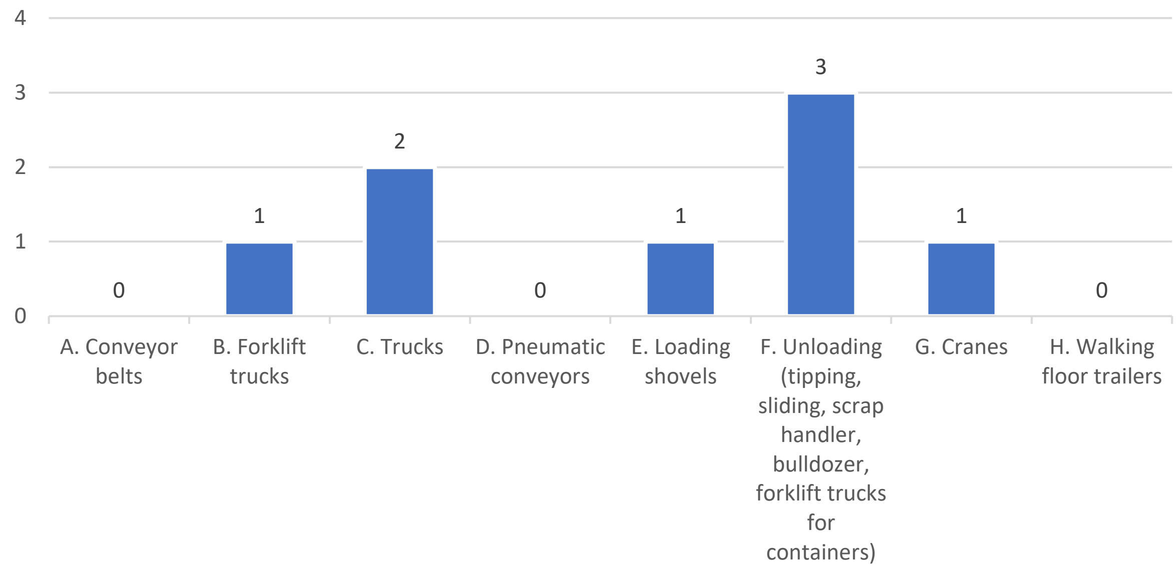

Figure 44. Type of transport on-site, 9 responses – Q4.2.3

Some of the respondents having reported a severe case declared that fires occurred while transport on site. This step comprises (see Figure 41):

- I. Transport to storage area after reception at (pre-) treatment site
- O. Transport to pre-shredder storage
- Q. Transport to shredder
- S. Transport after shredding

For such cases, respondents described how WEEE was transported or handled (Figure 44). A low number of responses does not allow to draw clear conclusions, however, most responses (3) indicated that the fire occurred while unloading the WEEE (tipping, sliding, scrap handler, bulldozer, forklift trucks for containers). Additionally, one respondent answered "storage" in the "Other" category. The criticality of the unloading phase mirrors what happens in the majority of thermal incidents observed in 2018 (see part 2.2.3).

Some of the respondents having reported a severe case also declared that fires could occur during storage on site. This step comprises (see Figure 41):

- A. Collection point, container area
- E. Storage area of sorting/logistics centre
- K. Storage area of (pre-) treatment site
- P. Pre-shredder storage
- T. Post-shredding storage

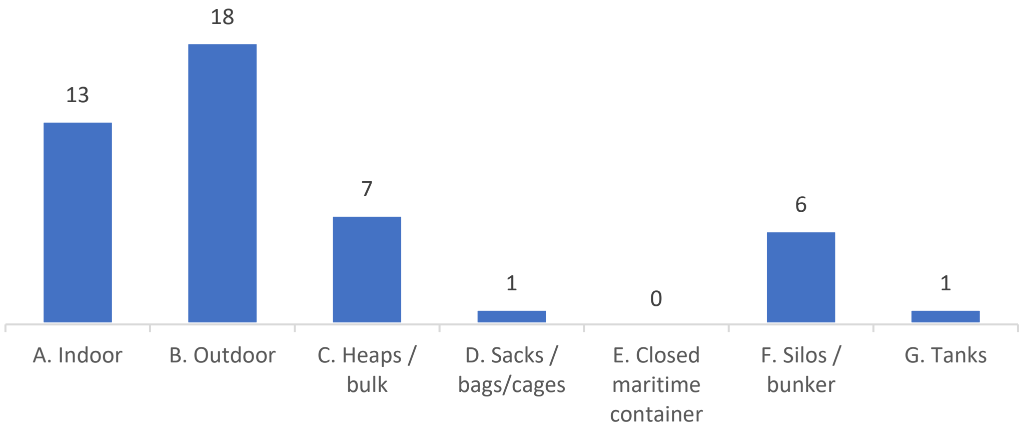

Figure 45. Type of storage on-site when most severe case happened, 24 responses – Q4.2.4

In Figure 45, respondents indicated that the type of storage were severe fire started were located outdoor (18 responses), closely followed by the indoor option (13 responses). Heaps and bulk were more mentioned (7 times) than silos and bunkers (6 times); sacks, bags and cages (1 times) or tanks (1 time). Finally, maritime closed containers were not selected at all.

In the "Other" category, one respondent answered "*B. Outdoor, Feb and April 2017 severe fires in storage areas in-between shredding phases*".

A.1.4. Damages of the most severe fires

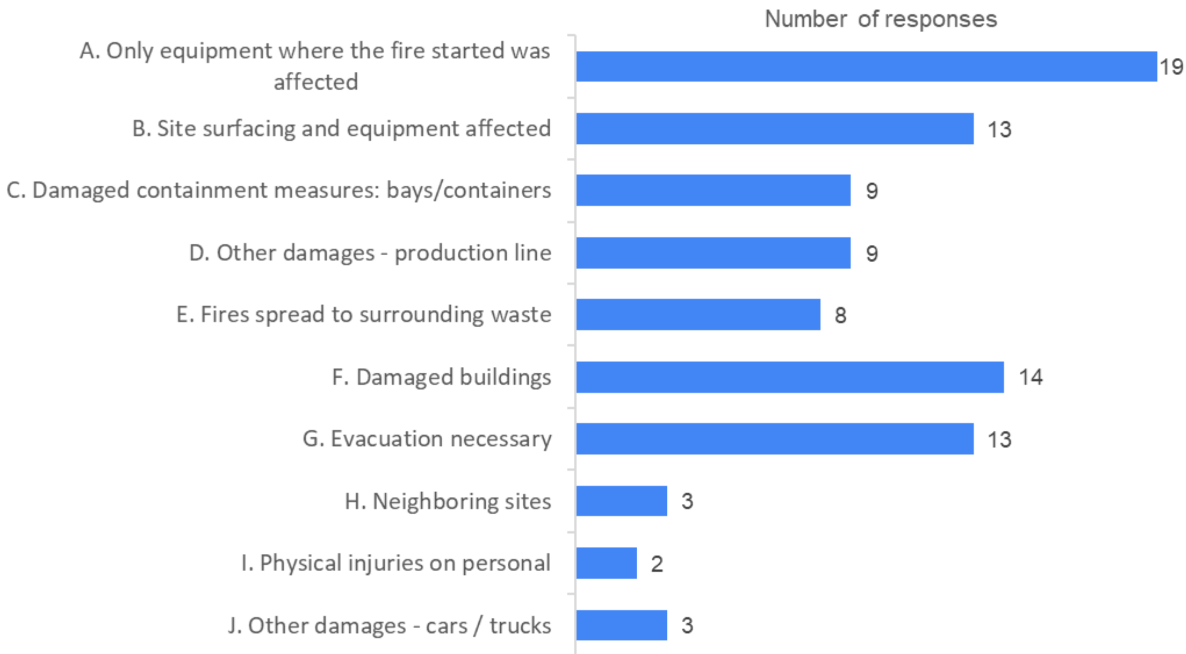

Figure 46. Characteristics of the most severe fire incident, 38 responses – Q4.3

The survey enquired about the severity of events occurred. The chart above provides an overview of the responses collected. **For half of the respondents (19 responses), the fire only affected the surrounding WEEE where the fire started.** This option is followed by the option in which fires affected buildings (14 responses), meaning that fires most likely affected the WEEE surrounding the ignition point, the storage areas and / or containers (if any) in which WEEE was placed and caused damages to the site building. In 13 cases, site surfacing and equipment were affected and in another 13 cases, evacuation was necessary. Only in two cases there were physical injuries to working staff.

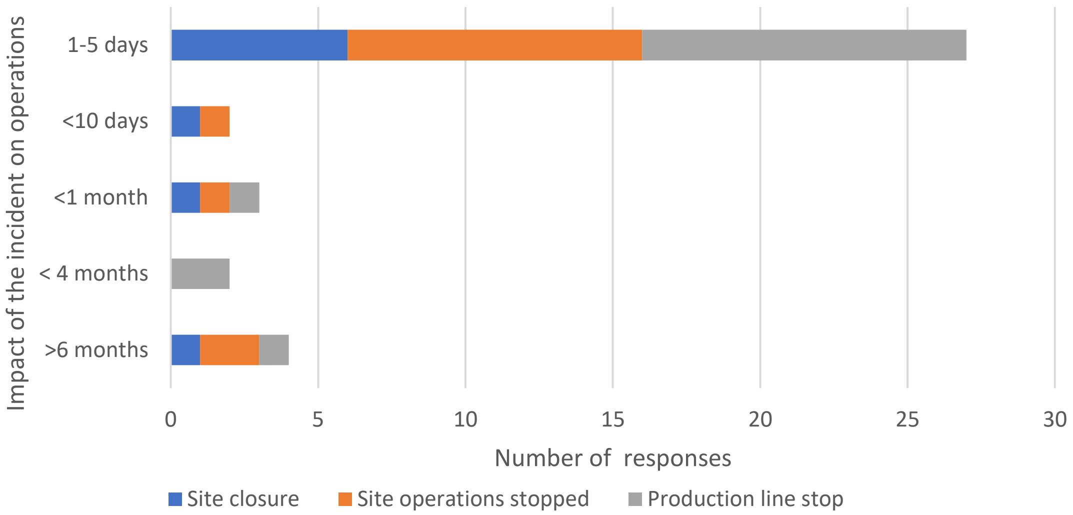

Figure 47. Consequence of the most severe cases – Q4.4

Figure 47 shows that the reported severe cases could lead to a site closure, the stop of a production line or of the whole site, for several days. However, those consequences lasted seldom more than a week. It should be noted that the number of respondents having either a site closure (9), production line (15) or site operations stopped (15) is well below the total number of respondents that reported a severe fire (39).

A.1.5. Cause of the ignition (if known) in the case of a severe incident

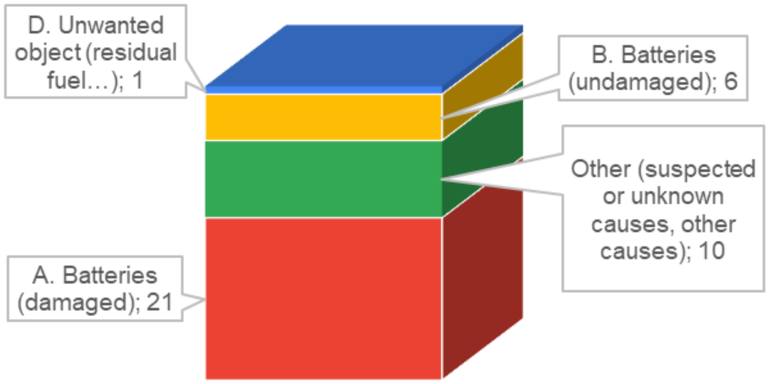

Figure 48. Cause of the ignition (if known) in the case of a severe incident, 38 responses – Q4.8

The cause of the ignition appears clearly represented in the chart above (Figure 48). 75% of the respondents identified the cause of the fires as damaged batteries. 10 out of the 38 responses fell under the "Other" category, and are reproduced in the following lines: In three cases, no evidence but batteries are suspected;

- In one case, battery in combination with an unwanted object
- In four cases, the cause of the incident is unknown
- In one case, a "spark cause ignition in vacuum unit"
- In one case, not sure if damaged or undamaged battery

The options on capacitors and mechanical heating were not selected by any respondent. Expert's feedback confirms this, reporting that a large share of incidents occurs either when the battery is in contact with other objects, or other batteries, or when the batteries is damaged, resulting in a short-circuit.

The responses on the causes of the most severe incident corresponds to what respondents answered for the majority of cases in 2018 (see part 2.2.5, Figure 28). Damaged batteries were identified as the main cause for the incidents.

A.1.6. Control of the most severe incident

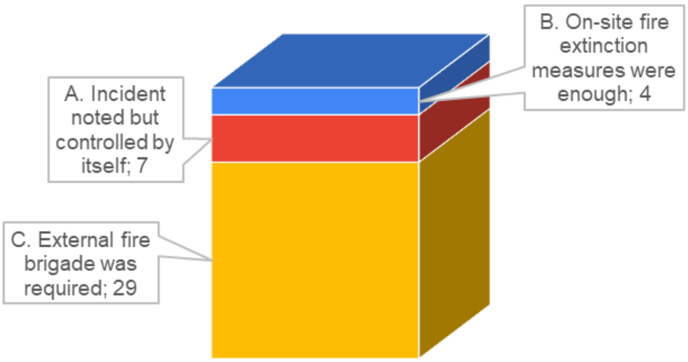

Figure 49. Control of the most severe incident, 40 responses – Q4.9.

The number of respondents here is larger than respondents who reported a severe case. This is due to the question 4.9 not being closed for respondents not declaring a severe fire case. Figure 49 shows that in most cases (73% out of the 40 respondents), the services of an external fire brigade was required for extinguishing the fires.

It can be noted that the way severe incidents were controlled does not correspond to the results of the questionnaire for most cases (see Figure 29). For the most severe cases, external fire brigade was required, whereas in most cases on-site fire extinction measures were enough.

A.1.7. Cost associated with the most severe incident and insurance coverage

Figure 50 provides a comparison of the cost of the most severe fire ever happened at the facilities, including costs of damaged waste, extinction measures, repair of affected areas, interruption of activities, etc. The breakdown of those costs depending on their cause was not detailed in the questionnaire, and has to be further investigated. Reported severe fires cost in average 1.3 M€, but varied a lot depending on the respondent[32]. Respondents were allowed to provide open cost figures, which have subsequently been grouped into ranges to easy further analysis and comparison of data.

[32] Standard deviation: 4.1 M€

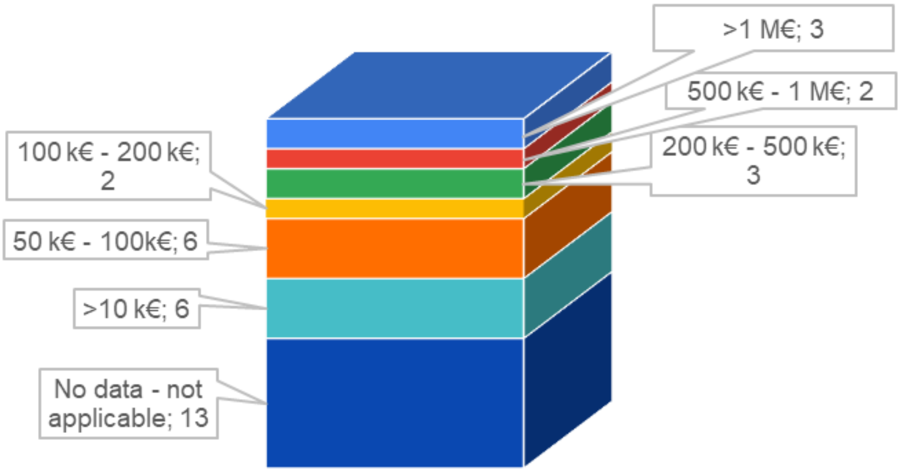

Figure 50. Estimated cost of the most severe case (€), 26 responses – Q4.6

As regards insurance coverage, out of the 36 responses received, 42% indicated that the insurance company provided partial coverage to the damages of the incident. This response is followed by 22% of respondents indicating that the insurance coverage was not required (Figure 51). These results differs to what was reported by the respondents for the majority of cases occurring in 2018 (see part 2.2.7, Figure 33), where insurance was not needed for a large part of the cases (41%). However, the share of incidents not covered by insurance is similar (19% here against 18% in 2.2.7).

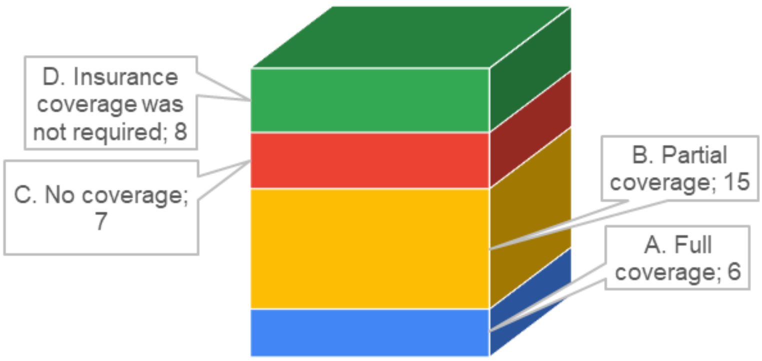

Figure 51. Insurance coverage of the incidents related to severe fire cases, 36 responses – Q4.6.1

Annex B - Questionnaire

Survey on fires caused by WEEE containing batteries and good practices implemented

The EEE industry, WEEE recycling industry, Eucobat and WEEE Forum gathered and set a round-table discussion to address the issue of fires caused by WEEE containing batteries.

The survey is divided into two parts aimed at:
-Part A. Characterising the incidents caused by WEEE batteries.
-Part B. Collecting good practices implemented for tackling such fires.

The final goal of this exercise is to produce training materials and a compilation of recommendations for fighting against fires in the whole WEEE management chain.

Please, note that:
-Part A on "Fires_characterization" is confidential and responses will be collected and anonymized by EuRIC only. EuRIC will remove data that may identify the respondent:
- Only anonymized data will be disclosed to the signatories of the survey (EuRIC/ WEEE Forum/WEEELabex/EERA);
- Only aggregated data will be disclosed to the roundtable.

-Part B on "Effective good practices" is not confidential (unless specified) as respondents with effective good practices might be contacted after the survey.
NOTE: data on parts A and B can be analyzed together in the questionnaire. However, only anonymized and aggregated data will be disclosed to the roundtable.

In compliance with the GDPR, we inform you that any contact data collected via the questionnaire will be strictly used for the purpose of this survey in case EuRIC (for part A) or the roundtable (for part B) may need to collect additional data or clarifications on your responses. You can contact us, for requesting the edition and cancellation of such contact data. If you agree to receive any updates on the outcomes of the roundtable, your contact details will also be used for this purpose.

Deadline for submitting responses: 31 October 2019, thank you very much!

*Required

Email address *

Please, submit only one questionnaire per site.

A company holding more than one site may submit one response for each site, please make sure only ONE response is submitted for a site. Please send any documents supporting your responses (pictures, reports, websites, news) to [dedicated mail address].

0 - Data from respondents (optional)

Contact data collected in this section will be used for the purpose of this survey in case EuRIC (for part A) or the roundtable (for part B) may need to collect additional data or clarifications on your responses. If you agree to receive any updates on the outcomes of the roundtable, your contact details will also be used for this purpose. When displaying the results of the survey of part A, all data collected will be grouped and anonymized.

0.1 Please indicate the name of your company

___

0.2 Please indicate the country your site is based in

___

0.3 If more than one site, please indicate the site you are referring to

___

0.4 Please provide the name of a contact person

___

0.5 Please provide the email address of the contact person so we can contact you for clarifications

___

1 - Type of respondent

1.1 Waste streams managed on-site (if applicable, select more than one) *

Tick all that apply.

- [ ] A. Municipal Solid Waste
- [ ] B. Mixed metal scrap
- [ ] C. Hazardous waste
- [ ] E. End-of-Life Vehicles
- [ ] Other: ___

1.2 Main type of activity performed for WEEE (select more than one if necessary) *

Tick all that apply.

- [ ] A. Public collection site (e.g. local civic amenity)
- [ ] B. Other collection facility (e.g. retail shop)
- [ ] C. Sorting and logistics site
- [ ] D. Treatment facility
- [ ] E. Storage facility
- [ ] F. Dismantling facility
- [ ] Other: ___

1.3 Activities on-site (if applicable, select more than one) *

Tick all that apply.

- [ ] A. Collection of WEEE
- [ ] B. Sorting of WEEE
- [ ] C. Pre-treatment of WEEE (dismantling, depolluting)
- [ ] E. Shredding (e.g. crushing, pressing, cutting)
- [ ] F. Post shredding treatment
- [ ] Other: ____________________

1.4 Annual capacity of the site (tons/year) for WEEE usually containing batteries (e.g. small WEEE, etc.)

Mark only one oval.

- ( ) A. 0-5,000
- ( ) B. 5,000 - 25,000
- ( ) C. 25,000 - 100,000
- ( ) D. 100,000 +
- ( ) E. I don't know
- ( ) Other: ____________________

Part A. 2 - Fires caused by WEEE containing batteries: general questions

Please whenever possible refer to episodes that happened in 2018.

2.0 Have there been any thermal incidents associated with batteries in your facilities in 2018? (e.g. sparks, hot spots, fires, explosions, etc.) *

Mark only one oval.

- ( ) Yes
- ( ) No *Skip to question 30.*

2.1 Definition of on-site thermal events caused by WEEE and frequency

Mark only one oval per row.

	Daily	Weekly	Monthly	2 - 6 times a year	7 -10 times a year	Yearly	Rarely	Never
Hot spot								
Smoke								
Sparks								
Slow burning (no flame)								
Slow burning fire (flame)								
Intense fire (rapid fire)								
Explosion								

2.2 Has the frequency of thermal events caused by WEEE containing batteries increased in the past 2 years? *

Mark only one oval.

- Yes
- No
- I don´t know
- Other: ____________________

2.3 Total number of intense fires and explosions caused by WEEE containing batteries in 2018 (fires/year)

____

2.4 Seasons when most thermal events caused by WEEE containing batteries occur (if applicable, select more than one)

Tick all that apply.

- D. Spring
- E. Summer
- F. Autumn
- G. Winter
- H. No specific season

2.5 Did annual insurance costs increased because your are managing WEEE containing batteries ?

Mark only one oval.

- Yes
- No
- Other: ____________________

2.6 If fires caused by WEEE containing batteries occurred, did insurance costs increase as a consequence?

Mark only one oval.

- Yes
- No
- Other: ____________________

2.7 If yes, to what extent? (%)

____

Part A. 3 - Overview of thermal events caused by batteries in 2018

In the following section, you will be asked to provide an overview of the several thermal events occurred at your facilities in 2018 and described in Q 2.1 (from hot spots to explosions). After this, you will be asked to provide information on the most severe case of fire that happened at your facilities.

3.1 Waste stream(s) where thermal events (from hot spots to explosions) happened in 2018 (if applicable, select more than one)

For this part, please provide extensive figures on the number of cases per option (not only majority for each option), if known.

Mark only one oval per row.

	<2	<5	<10	<15	>15
Municipal Solid Waste					
Mixed metal scrap					
Hazardous waste					
End-of-Life Vehicles					
Batteries and accumulators					
Mixed WEEE					
Large domestic appliances					
Small domestic appliances					
Other					

3.2 Stage in the process where the majority of thermal events (from hot spots to explosions) started in 2018 (if applicable, select more than one)

Tick all that apply.

- [ ] A. Collection point, container area
- [ ] B. Loading truck at collection point
- [ ] C. Transport from collecting point to the sorting center
- [ ] D. Reception of sorting/logistics centre, unloading
- [ ] E. Storage area of sorting/logistics centre
- [ ] F. Loading truck at sorting/logistics centre
- [ ] G. Transport from the sorting center to the (pre-) treatment site
- [ ] H. Acceptance / Reception area of (pre-) treatment site
- [ ] I. Transport to storage area after reception at (pre-) treatment site
- [ ] J. Unloading at storage area at (pre-) treatment site
- [ ] K. Storage area of (pre-) treatment site
- [ ] L. Pre Treatment - Manual Dismantling /depolluting
- [ ] M. Pre Treatment - Mechanical dismantling /depolluting
- [ ] N. Pre Treatment - Sorting/ Blending & mixing / grouping
- [ ] O. Transport to pre-shredder storage
- [ ] P. Pre-shredder storage
- [ ] Q. Transport to shredder
- [ ] R. Shredding (e.g. crushing, pressing, cutting)

- [ ] S. Transport after shredding
- [ ] T. Post-shredding storage

3.2.1 If during transport before delivery (C, G)--> how was WEEE transported when the majority of thermal events started?

Tick all that apply.

- [ ] A. Bulk/skip/roll-off containers (20-44 cubic meters)
- [ ] B. Small containers and/or cages (< 3 cubic meters)
- [ ] C. Big bags
- [ ] Other: ____________________

3.2.2 If during transport before delivery (C, G) --> application of ADR rules (select the options describing the majority of thermal events)

Tick all that apply.

- [ ] A. Last applicable ADR rules have been applied
- [ ] B. Last applicable ADR rules have been helpful to circumvent the fires
- [ ] C. I don´t know
- [ ] Other: ____________________

3.2.3 If during transport on-site (I, O, Q, S) --> transport type where the majority of thermal events started

Tick all that apply.

- [ ] A. Conveyor belts
- [ ] B. Forklift trucks
- [ ] C. Trucks
- [ ] D. Pneumatic conveyors
- [ ] E. Loading shovels
- [ ] F. Unloading (tipping, sliding, scrap handler, bulldozer, forklift trucks for containers)
- [ ] G. Cranes
- [ ] H. Walking floor trailers
- [ ] Other: ____________________

3.2.4 If during storage (A, E, K, P, T)--> storage type where the majority of thermal events started (if applicable, select more than one)

Tick all that apply.

- [ ] A. Indoor
- [ ] B. Outdoor
- [ ] C. Heaps / bulk
- [ ] D. Sacks / bags/cages
- [ ] E. Closed maritime container
- [ ] F. Silos / bunker

- [ ] G. Tanks
- [ ] Other ______________________

3.3 Severity of the majority of thermal events occurred in 2018 (if applicable, select more than one)

Mark only one oval per row.

	Most cases	Often	Half of the cases	Sometimes	Rarely	Never
Only equipment where the fire started was affected	◯	◯	◯	◯	◯	◯
Site surfacing and equipment affected	◯	◯	◯	◯	◯	◯
Damaged containment measures:	◯	◯	◯	◯	◯	◯
bays/containers Other damages - production line	◯	◯	◯	◯	◯	◯
Fires spread to surrounding waste	◯	◯	◯	◯	◯	◯
Building was damaged	◯	◯	◯	◯	◯	◯
Neighboring sites were affected	◯	◯	◯	◯	◯	◯
Evacuation necessary	◯	◯	◯	◯	◯	◯
Physical injuries on personal	◯	◯	◯	◯	◯	◯
Other damages - cars / trucks	◯	◯	◯	◯	◯	◯

3.4 Duration of fires

Mark only one oval per row.

	Most cases	Often	Half of the cases	Sometimes	Rarely	Never
<1 hour	◯	◯	◯	◯	◯	◯
1 hour to 1 day	◯	◯	◯	◯	◯	◯
>1 day	◯	◯	◯	◯	◯	◯

3.5 Estimated cost of incidents in 2018 (€) (costs include - waste damaged, extinction measures, repair of affected areas, interruption of activities, etc.)

____

3.6.1 Did the insurance cover the incidents in 2018?

Mark only one oval.

◯ A. Full coverage in most cases

◯ B. Partial coverage in most cases

◯ C. No coverage in most cases

◯ D. Insurance intervention not required in most cases

◯ Other: ______________________

3.8 Cause of the ignitions (if known)

Mark only one oval per row.

	Most cases	Often	Half of the cases	Sometimes	Rarely	Never
Batteries (damaged)	⬭	⬭	⬭	⬭	⬭	⬭
Batteries (undamaged)	⬭	⬭	⬭	⬭	⬭	⬭
Capacitors	⬭	⬭	⬭	⬭	⬭	⬭
Mechanical heating	⬭	⬭	⬭	⬭	⬭	⬭
Unwanted object (residual fuel…)	⬭	⬭	⬭	⬭	⬭	⬭
Others	⬭	⬭	⬭	⬭	⬭	⬭

3.9 Control of the majority of thermal incidents happened in 2018

Mark only one oval.

- ⬭ A. Incident noted but controlled by itself in most cases
- ⬭ B. On site fire extinction measures were enough in most cases
- ⬭ C. External fire brigade was required in most cases

Part A. 4 - Batteries fires: Most severe case

This section requests information about the most severe case occurred in the facilities in recent years (covering 2016, 2017, 2018 and 2019)

4.0 Has there been any severe incident associated with batteries in your facilities in recent years?

Mark only one oval.

- ⬭ Yes
- ⬭ No *Skip to question 45.*
- ⬭ I don´t know *Skip to question 45.*

4.1 Waste stream where fire event happened

Mark only one oval.

- ⬭ A. Municipal Solid Waste
- ⬭ B. Mixed metal scrap
- ⬭ C. Hazardous waste
- ⬭ E. End-of-Life Vehicles
- ⬭ F. Batteries and accumulators
- ⬭ G. Mixed WEEE
- ⬭ H. Large domestic appliances
- ⬭ I. Small domestic appliances
- ⬭ Other: ______________

4.2 Stage in the process where the most severe case of fire started in 2018

Tick all that apply.

- [ ] A. Collection point, container area
- [ ] B. Loading truck at collection point
- [ ] C. Transport from collecting point to the sorting center
- [ ] D. Reception of sorting/logistics centre, unloading
- [ ] E. Storage area of sorting/logistics centre
- [ ] F. Loading truck at sorting/logistics centre
- [ ] G. Transport from the sorting center to the (pre-) treatment site
- [ ] H. Acceptance / Reception area of (pre-) treatment site
- [ ] I. Transport to storage area after reception at (pre-) treatment site
- [ ] J. Unloading at storage area at (pre-) treatment site
- [ ] K. Storage area of (pre-) treatment site
- [ ] L. Pre Treatment - Manual Dismantling /depolluting
- [ ] M. Pre Treatment - Mechanical dismantling /depolluting
- [ ] N. Pre Treatment - Sorting/ Blending & mixing / grouping
- [ ] O. Transport to pre-shredder storage
- [ ] P. Pre-shredder storage
- [ ] Q. Transport to shredder
- [ ] R. Shredding (e.g. crushing, pressing, cutting)
- [ ] S. Transport after shredding
- [ ] T. Post-shredding storage

4.2.1 If during transport before delivery (C, G) --> how was WEEE transported?

Tick all that apply.

- [ ] A. Bulk/skip/roll-off containers (20-44 cubic meters)
- [ ] B. Small containers and/or cages (< 3 cubic meters)
- [ ] C. Big bags
- [ ] Other: ____________________

4.2.2 If during transport before delivery (C, G) --> application of ADR rules (select the options describing the incidents)

Tick all that apply.

- [ ] A. Last applicable ADR rules have been applied
- [ ] B. Last applicable ADR rules were helpful to circumvent the fires
- [ ] C. I don´t know
- [ ] Other: ____________________

4.2.3 If during transport on-site (I, O, Q, S) --> transport type when the fire happened

Mark only one oval.

- A. Conveyor belts
- B. Forklift trucks
- C. Trucks
- D. Pneumatic conveyors
- E. Loading shovels
- F. Unloading (tipping, sliding, scrap handler, bulldozer, forklift trucks for containers)
- G. Cranes
- H. Walking floor trailers
- Other:

4.2.4 If during storage (A, E, K, P, T)--> storage type when the fire started (if applicable, select more than one)

Tick all that apply.

- A. Indoor
- B. Outdoor
- C. Heaps / bulk
- D. Sacks / bags/cages
- E. Closed maritime container
- F. Silos / bunker
- G. Tanks
- Other:

4.3 Severity of the most severe fire (if applicable, select more than one)

Tick all that apply.

- A. Only equipment where the fire started was affected
- B. Site surfacing and equipment affected
- C. Damaged containment measures: bays/containers
- D. Other damages - production line
- E. Fires spread to surrounding waste
- F. Damaged buildings
- G. Evacuation necessary
- H. Neighboring sites
- I. Physical injuries on personal
- J. Other damages - cars / trucks

4.4 Consequences of the most severe fire

Mark only one oval per row.

	1-5 days	<10 days	< 15 days	<1 month	< 4 months	>6 months	Not applicable
Site closure							
Site operations stopped							
Production line stop							

4.5 Duration of the most severe fire

Mark only one oval.

- ◯ <1 hour
- ◯ 1-6 hours
- ◯ 1 day
- ◯ 2 - 3 days
- ◯ > 3 days
- ◯ Other: ____________

4.6 Estimated cost of the most severe case (€)(costs include - waste damaged, extinction measures, repair of affected areas, interruption of activities, etc.)

____

4.6.1 Did the insurance cover the incident?

Mark only one oval.

- ◯ A. Full coverage
- ◯ B. Partial coverage
- ◯ C. No coverage
- ◯ D. Insurance coverage was not required

4.7 Characteristics of the most severe fire incident (if applicable, select more than one)

Tick all that apply.

- ☐ A. Hot spot
- ☐ B. Smoke
- ☐ C. Sparks
- ☐ D. Slow burning (no flame)
- ☐ E. Slow burning (flame)
- ☐ F. Intense fire
- ☐ G. Explosion

4.8 Cause of the ignition (if known)

Mark only one oval.

- ◯ A. Batteries (damaged)
- ◯ B. Batteries (undamaged)
- ◯ C. Capacitors
- ◯ D. Unwanted object (residual fuel…)
- ◯ E. Mechanical heating
- ◯ Other: ____________

4.9 Control of the most severe incident

Mark only one oval.

- A. Incident noted but controlled by itself
- B. On-site fire extinction measures were enough
- C. External fire brigade was required
- Other: ______