Safe collection of portable consumer lithium-ion batteries

Development needs for collection equipment

GAIA CONSULTING, 28 NOVEMBER 2023
OLLI SAHIMAA AND TUOMAS RAIVIO

Content

1. Introduction and goals of the analysis

Current situation of the collection of consumer batteries

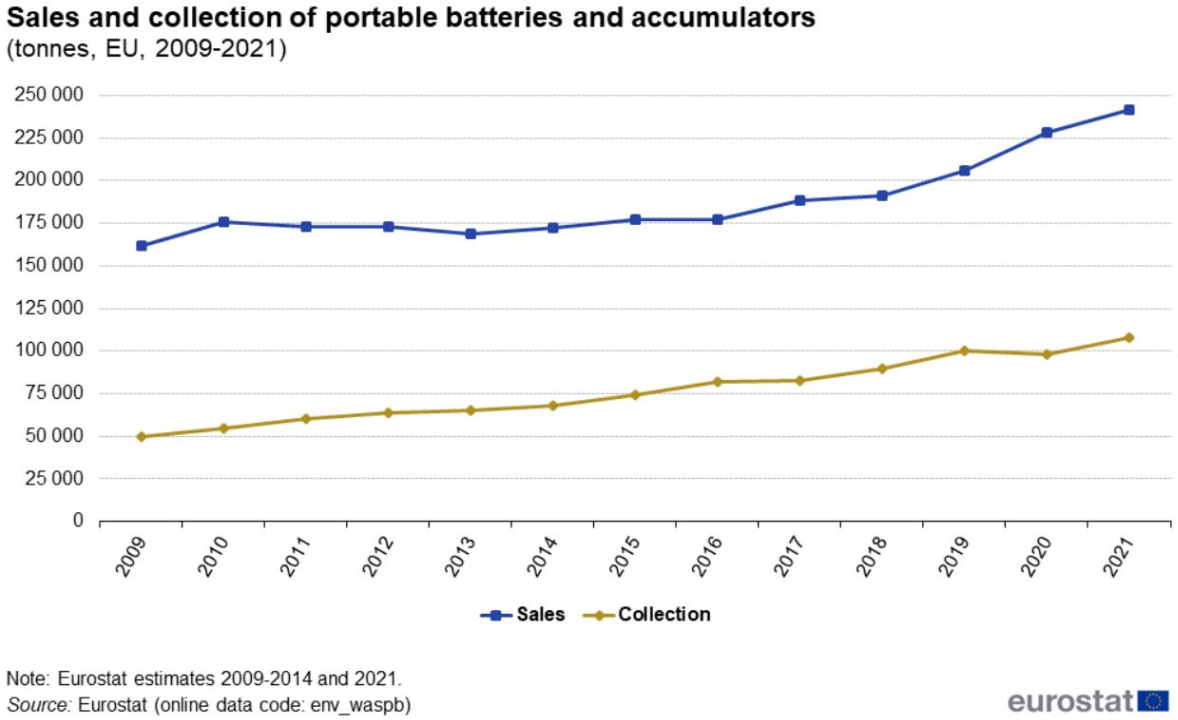
Producer responsibility

- Producers, i.e. **importers and manufacturers**, of batteries are obliged to arrange the waste management of their products at their own expense when the products are discarded. Producers are operators who, regardless of the method of sale, professional bring to the Finnish market batteries for the first time or distance sell them directly to users.
- In practice, arranging the waste management of portable batteries means arranging their pick-up from all store locations that sell batteries, as well as other collection points in Finland, and their processing thereafter, the goal of which is to recycle the materials.
- The distributors of batteries are responsible for the costs of the receipt arrangements they organise, and they are obliged to package the received batteries into batches that are suitable for transport.

Collection network

- The battery collection network in Finland is managed by the producer organisation Recser Oy, a representative of producers placing batteries on the market.
- Recser Oy's collection network includes all batteries that weigh less than 25 kg. The collection of small batteries is largely carried out in shops and other outlets that sell them, which are also obliged to accept them for no charge and without requiring purchase a new product.
- The batteries of electric means of transport and other larger industrial and vehicle batteries are collected through the regional collection network formed by municipal waste processing plants, for example (the collection points are listed here: www.kierratys.info).

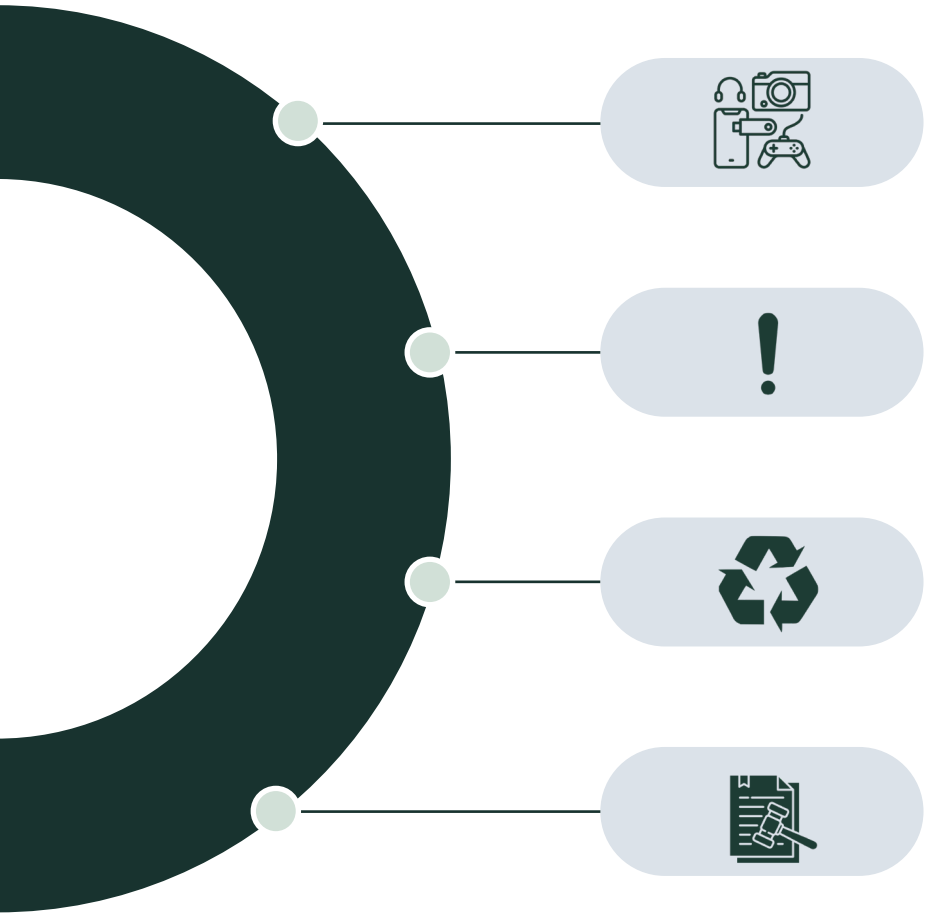
The sales and collection quantities of portable consumer batteries have increased in recent years



- The increase in collection from 2010 to 2021 was about 100%.
- Sales and collection quantities are expected to increase significantly in future.

Source: https://ec.europa.eu/eurostat/statistics-explained/SEPDF/cache/66807.pdf

Popularisation of lithium-ion batteries and other changes in the operating environment



The electrification of society has a long history. **Life has become more battery-reliant** and small **lithium-ion batteries** have become commonplace with the popularisation of consumer devices, such as mobile phones, laptops and power tools. They are used widely in various devices and vehicles.

The **risk factors** of lithium-ion batteries are related to their high energy, possible damage and factors leading to an internal short circuit, such as damage, misuse and manufacturing defects. These factors can cause heat dissipation and fires.

The higher numbers of batteries and the **EU's tightening recycling goals** are expected increase the collection quantities of batteries in shops and other collection points in the future.

The changes in the operating environment have resulted in a need to determine how well the collection chain currently functions and what kinds of requirements the **EU's new Batteries Regulation** imposes on the development of collection equipment.

Goal and delineation of the analysis

The goal of the analysis is to form a view of the current state of the collection of portable lithium-ion batteries (<25 kg) and the changes in the operating environment, and to assess how batteries can be collected and transported smoothly, cost efficiently and safely in the future, in terms of the right kinds of collection tools. The main focus of the analysis is on batteries returned by consumers.

Battery collection chain

Charting the current state of shop collection points and the collection equipment.

Needs and perspectives of stakeholders

The current state and development needs from the perspective of safety, fluency and cost efficiency.

International points of comparison

Examining the collection arrangements of two reference countries.

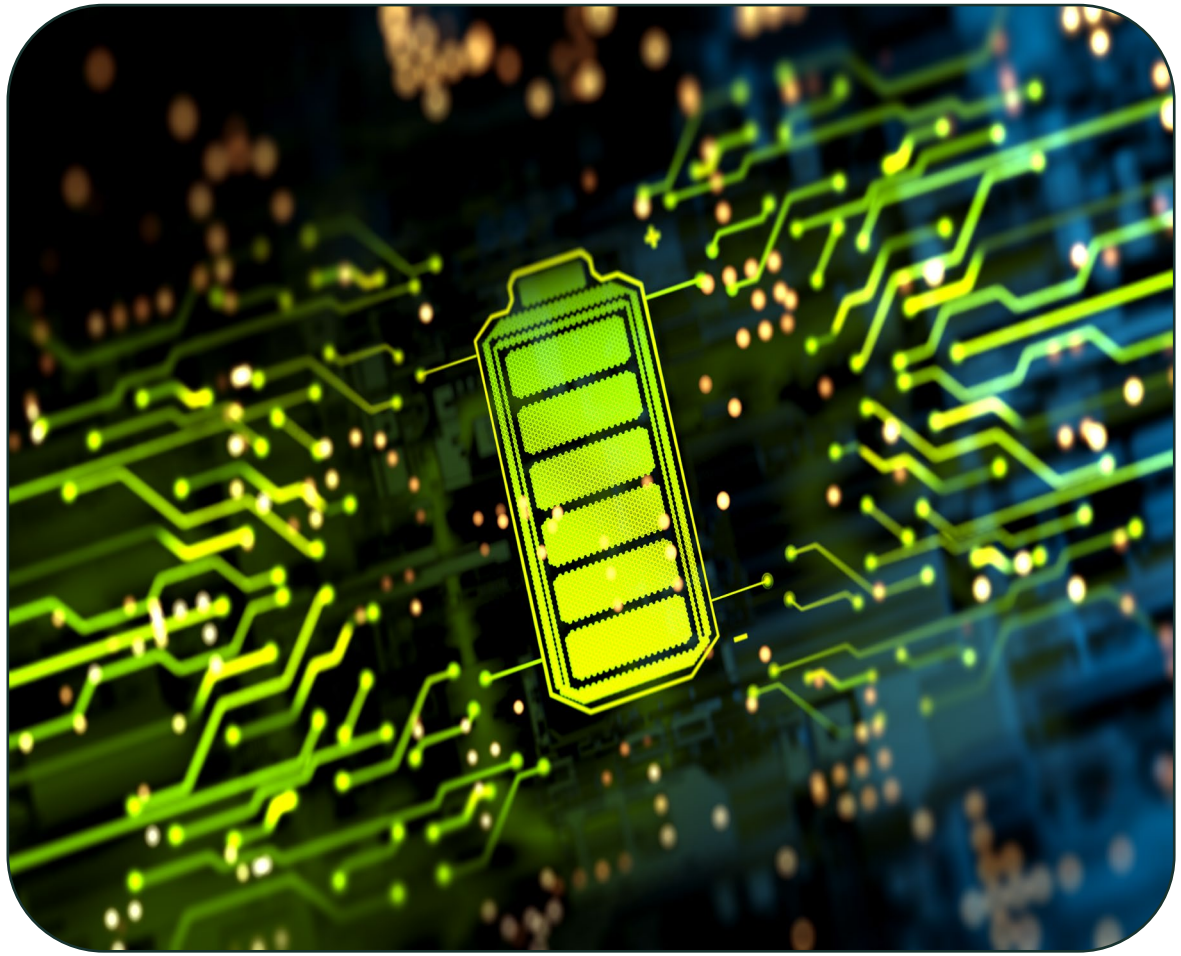
Analysis and conclusions

Suggested measures in cooperation with stakeholders and the reporting and communication of the results.

2. Significance of the EU Batteries Regulation for the collection chain

The EU's new Batteries Regulation

- The European Union's new Batteries Regulation will replace the directive of 2006, which is based on producer responsibility, i.e. the responsibility of the importers of batteries to arrange the waste management and recycling of their products.
- The EU's new Batteries Regulation is part of the European Green Deal. Its key focus in creating a circular economy for battery minerals in Europe.
- The aim of the new regulation is to ensure that the battery industry pays more attention to the environmental effects of batteries throughout their life cycles as well as sustainable production from the mining of raw materials to manufacturing, recycling and re-using.
- The Regulation took effect in August 2023, after which most of the pertinent requirements are subject to transition periods of 12–36 months.



The EU's new Batteries Regulation changes the producer-responsibility-based battery collection chain to a degree

- Battery categories have been changed correspond better to the batteries on the market.
- Categories retained:
  - portable batteries (batteries weighing 5 kg or less)
  - vehicle batteries (starter batteries, lighting, ignition)
  - industrial batteries
- New categories:
  - EV batteries
  - batteries of light electric means of transport (electric bicycles, mopeds and scooters)
- The definition of a producer subject to producer responsibility has been specified to refer to the manufacturer, importer, distributor or distance seller of batteries.
- As a new **requirement, producers are obliged to provide collection points and operators preparing or carrying out reuse with information on important safety and protection matters related to the receipt, processing and storage of batteries*.**

- **The Regulation will significantly intensify the collection goals for batteries in increments from the current 45%**
  - to 63% by the end of 2027
  - to 73% (by the end of 2030).
  - → Preparations must be made for receiving increasingly larger batteries and larger quantities of them.
- **According to the regulation, producers must provide collection points with the required collection and transport equipment in addition to the pick-up service. In the current division of responsibilities, producers are responsible for the process beginning from the back doors of distributors.**
- In the future, the requirements for the collection of LMT (light means of transport) batteries will be largely in line with the collection of portable batteries specified above. **Producers must provide the collection points with suitable collection infrastructure for the separate collection of waste volumes in compliance with the applicable safety requirements.**

*Article 60

3. Risk factors of lithium-ion batteries

Lithium-ion batteries

- A lithium-ion battery is a chargeable power storage solution, the functionality of which is based on the motion of lithium ions between the negative and positive poles. Li-ion batteries do not normally contain metallic lithium.
- The battery usually consists of multiple cells, an electronic battery management system (BMS*), a protective enclosure and connectors. The cells can be cylindrical or prismatic and have either a steel or plastic enclosure.
- An important task of the battery management system is to ensure the safety of the battery. It monitors the current, voltage and temperature of the cells and often communicates with the charger, for example.
- If the safe operating range of the cells is about to be exceeded, the BMS cuts power (supply) to the cells and issues an alarm. On a battery-specific basis, the BMS can also include other extra functions.
- Li-ion batteries feature high energy density, no memory effects and a low self-discharge rate.

Examples of the upsides of lithium batteries:
- High energy density
- Low need for maintenance
- Fast charging

Examples of the downsides of lithium batteries:
- Require protection mechanisms to reduce hazards
- Function poorly in freezing temperatures
- Safety perspectives (e.g. regulation necessitates investments in transport safety)

* Smaller batteries may have a simpler protection circuit

There are risks related to the collection of used lithium-ion batteries

Collection network

- The risks must be considered in the context of decommissioned lithium-ion batteries for the following reasons:
  - They may still have remaining charge. Their operation may even have been tested by charging them fully before bringing them to a collection point for decommissioned batteries.
  - They may be damaged or less safe than normal due to their **ageing**.

- **Along the chain, the risks are focused where batteries are collected.**

- Currently, 90% of the batteries collected in shops are alkaline batteries. Lithium-ion batteries constitute a very small proportion of what is collected in shops, which is why the fire risk is mostly formed by untaped primary lithium batteries.

Fire risk

Generally speaking, all batteries can start a fire. Lithium-ion batteries contain a great deal of energy and they are combustible. New lithium-ion batteries are rarely dangerous.

The fire hazard is caused by the **thermal runaway phenomenon**. In this situation, the battery has suffered an external or internal short circuit, for example, which has caused the battery to heat up and eventually combust. The following factors may cause thermal runaway or increase its risk in lithium-ion batteries:

- Impacts, penetration, vibration, being dropped or other physical damage to the battery – the damage may cause an internal short circuit
- External short circuit
- Misuse of the batteries: charging the battery in freezing temperatures, allowing the battery to discharge fully and charging the battery with excessive voltage
- Storing or using the battery at an excessively hot or cold temperature
- Manufacturing defects that increase the risk of internal short circuit
- Careless handling of old batteries

The risks increase in the context of concentrated battery power and larger battery size.

Probability / Repercussion	Low probability	Moderate probability probability	High probability
Major repercussion	• Large units • Low number • New • No measures • Many untrained people • Fire load in the same space / no extinguishing capacity		• Large units, large number • Used • Measures • High vulnerability • Many untrained people • Fire load in the same space / no extinguishing capacity
Moderate probability			
Minor repercussion	• Small units • Low number • New • No measures • Low number of trained people • No fire load nearby / fast extinguishing capacity		• Small units • High number • Used • Measures • Low number of trained people • No fire load nearby / fast extinguishing capacity

Collection points often here

4. Collection system for lithium-ion batteries

In current legislation, batteries are divided into three classes according to their intended purpose*

gaia PART OF SWECO

1

Portable batteries

Portable batteries that are enclosed and are not industrial batteries.

2

Industrial batteries

Batteries designed exclusively for industrial or professional use or used in electric vehicles.

- For example, e-bike batteries are categorised as industrial batteries because they are “batteries used in electric vehicles” according to the definition provided above.
- For example, consumer batteries that weight more than 5 kg and are used for energy storage or leisure purposes.

→ The law can regard even the batteries of consumer products as industrial batteries.

3

Automotive batteries

Batteries used for starting, lighting or firing

vehicles.

*The classification of batteries: Government Decree on Batteries (520/2014)

3. RECEIPT AND COLLECTION CHAIN FOR LITHIUM-ION BATTERIES

Current state of the collection of portable batteries

Battery imports

Consumers deliver spent batteries to shop collection points.

Portable batteries can be returned free of charge and without the obligation to buy a new product to any distributor outlet that sells them. The current regulation does not specify weight limits, which means that portable batteries must be accepted by any distributor outlet that sells any portable battery.

In addition to this, consumers return batteries of equipment such as LMTs, vehicles and boats to outlets that sell them and to waste disposal sites, but there is no obligation to accept these batteries.

Shop collection points

The batteries are typically collected in cardboard boxes or plastic barrels supplied by the producer organisation. The container is often located behind a collection wall. In addition to a cardboard box, some operators also use a metal, fireproof container.

A separate location should be arranged for the storage of received batteries before they are delivered on to the next stage.

The collection practices of distributors vary with regard to staff training, monitoring and fire safety, for example.

Packaging and transport

Portable batteries are primarily transported from distributor points in Recser's boxes or barrels. Distributors may not hand collected batteries over to parties other than producers or the transport companies specified by them.

Recser Oy's contracted driver picks the batteries up by order and delivers them to the recycling plant (Akkuser, Nivala). In transit, the relevant safety requirements must be observed because the transport arrangements are covered by the regulation on the transport of dangerous goods.

Recycling and final processing

At the recycling plant, the batteries are dismantled and processed appropriately. At this stage, battery materials are separated. Lithium-ion batteries contain valuable metals, such as lithium, cobalt and nickel, which can be reused.

Results of stakeholder interviews

Identified challenges with the collection chain

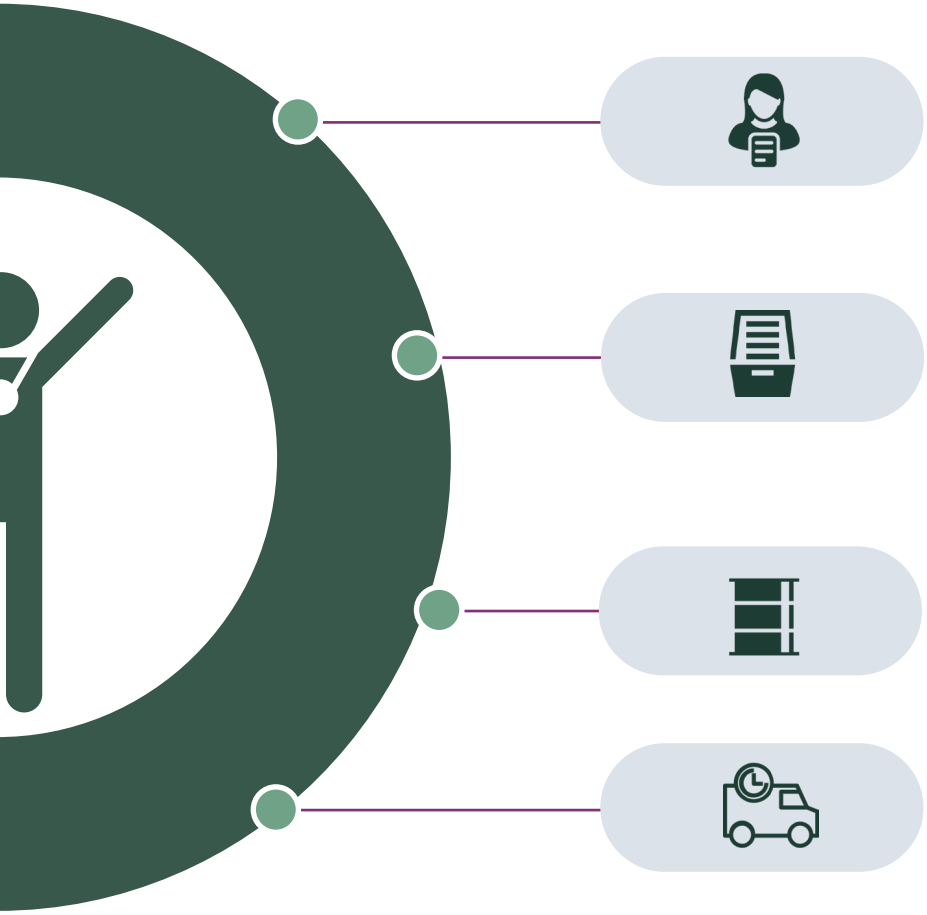
- According to **Traficom**, transport-related regulation is currently clear. From Traficom's perspective, the updates brought about by the EU Batteries Regulation do not substantially change the field of operations. Larger transport quantities naturally increase risks. Recser's current transport packaging adheres to the transport regulation.
- **In the grocery trade**, there are shortcomings in the organisation of battery collection. The practices may not be as advanced as those of outlets that sell/receive more batteries. The most significant shortcomings are related to the processing of batteries: the people processing the batteries may not realise that dropping or otherwise damaging a battery increases the risk of fire.
- **Storage spaces** for warranty returns, recalled produces and batteries due for maintenance may not have been specified. There may not be a fire safe space for quarantine.
- In shops, **battery safety** is also linked to other operations besides the collection of spent batteries. Package shipments, staff walkie-talkies, complaints, WEEE collection, and so on. The operating locations may have instructions on the charging practices of battery-operated devices, but the staff may not know enough to consider the risks related to batteries (dropping, for example).

Identified challenges with current transport arrangements

- **The collection container** for small batteries can be a cardboard box or traditional 200 l plastic waste container (hole in the wall). Cardboard boxes in particular are not regarded as safe collection containers. **Cardboard and plastic transport containers** mean that there is an **immediate fire load** around the batteries.
- **The transport equipment offered by Recser is now also used widely as collection equipment.** Very few shops have adopted metal, fireproof boxes or fireproof cabinets to increase safety in the collection of spent batteries.
- The specific **risks** should be understood along with the ways in which they can be reduced through various collection solutions.
- There may also be a need for harmonised signs, phrasings and branding.
- This would require **cooperation** between recycling operators and the packaging industry in discussions around packaging needs.
- There currently are few **packaging solutions** for transporting damaged batteries on the market.

3. RECEIPT AND COLLECTION CHAIN FOR LITHIUM-ION BATTERIES

Good battery collection chain practices identified through the interviews



Batteries are handled by designated people who are aware of safety matters (e.g. warehouse workers accept batteries and take care of shipping, and the same methods apply to complaints). Those responsible for warehouse operations are trained on batteries and dangerous substances.

Cardboard transport boxes are placed in metal, fireproof boxes.

Lithium-ion batteries are collected in enclosed metal barrels in the storage spaces. Vermiculite is used as the filler.

The aim is to ship full collection containers immediately for further processing. Collection containers are positioned near doors through which goods are brought in so that they can be moved outside quickly. A fireproof cabinet for full containers provides effective extra protection in backrooms.

4. Comparison of collection and transport equipment solutions

Packaging requirements for recyclable lithium-ion batteries, ADR

- The ADR Agreement and legislation on the transport of dangerous goods place the following requirements on the packaging of lithium-ion batteries:
- Undamaged small batteries (<100 Wh): packaging method P909
  - Max. 30 kg, strong exterior packaging, short circuit prevention
- Undamaged large batteries: packaging method P909
  - Separate packaging, short circuit prevention
- Damaged large batteries: packaging method P908
  - Leak-resistant interior packaging, short circuit prevention
  - Heat insulation and sufficient vibration resistance
- (Metal packaging must feature a non-conductive interior lining)

Collection and transport equipment currently used by Recser

Material	Cardboard	Plastic
Capacity (l)	22 l	110 l
Dimensions	380 mm x 240 mm x 240 mm	Diameter 455 mm, height 788 mm
Manufacturer	DS Smith Packaging	CurTec
Safety perspectives	Risk of fire load in the event of a fire and the possibility of the fire spreading to surrounding structures	Risk of fire load in the event of a fire and the possibility of the fire spreading to surrounding structures

Boxes suited to the transport of damaged batteries have been acquired for testing

Cardboard boxes ensures packaging method P909 for small batteries

Plastic barrels with packaging instructions ensure compliance with packaging method P909 (plastic bag as interior packaging and short circuit prevention) or P908 (plastic bag, cushioning material) for batteries that require use of these methods

Generally speaking, a cardboard box and plastic barrel can contribute to a possible battery fire and its propagation in the collection location and in transit.

Reference countries

Belgium – Bebat

- Bebat was established in 1995 and covers about 4,000 producers.
- The collection network includes about 24,500 collection points in grocery shops, schools and municipal collection areas.
- Long-term development to improve the safety of collection equipment and eliminate the risks of lithium-ion batteries.
    - For example, the potential pressure events of e-bike batteries in containers have been considered.
    - Various cover solutions have also been developed, such as the automatic monitoring of filling.
- The high concentrations of lithium-ion button cells have been identified as an increasing concern.
- These days, the sale of collection equipment has been decentralised to the company Bebat Pro.

Czech Republic – Ecobat

- Ecobat has operated since 2002, taking care of the recycling of batteries across a wide spectrum.
- Includes about 1,500 producers.
- Ecobat has about 25,000 collection points: about one-third in grocery shops, about one-third in municipal collection areas, and about one-third in electronics shops and other companies in the sector.
- The Czech Republic has recognised the risks increased by lithium-ion batteries. Issues, such as numerous fires, began to emerge about five years ago.
- Since then, there have been development efforts to identify the collection points with the highest risk.
    - Consolidation and comparison of historic data regarding certain types of collection points.
    - Classifying the types of batteries collected/collection points.
- The development efforts have reduced the realised risks over the past three years.

Examples of Bebat's collection equipment

Material	Steel barrel (0.7 mm), galvanised steel base	Steel barrel (0.7 mm), galvanised steel base	Galvanised steel	Galvanised steel
Capacity (l)	53 l	62 l	260 l	520 l
Dimensions	Diameter 346 mm, height 650 mm	Diameter 346 mm, height 750 mm	Exterior measurements 741 mm x 801 mm x 1,098 mm	Exterior measurements 1,200 mm x 1,000 mm x 1,085 mm
Manufacturer	Bebat Pro	Bebat Pro	Bebat Pro	Bebat Pro
Safety perspectives	Heat and flame resistant with the transport cover	Reinforced cover compared to the 53-litre barrel. Designed especially for storing and transporting large lithium-ion batteries, such as e-bike batteries. Can withstand sudden pressure discharges.	Heat and pressure resistant. Option to supply extinguishing water without opening the cover.	Heat and pressure resistant. Option to supply extinguishing water without opening the cover.

Examples of Ecobat collection equipment

Material	Cardboard	Steel	Steel	Steel
Capacity (l)	22 l	30 l	60 l	530 l
Dimensions	250 mm x 390 mm x 240 mm	Diameter 398 mm, height 315 mm	Diameter 398 mm, height 315 mm	1200 x 1000 x 832 mm
Manufacturer	Podorlická kartonážní spol. s r.o.	MEVA-TEC	MEVA-TEC	STS Kamenice nad Lipou
Safety perspectives	Risk of fire load in the event of a fire and the possibility of the fire spreading to surrounding structures	Storage and transport barrel for lithium-ion batteries. Unknown heat and pressure resistance compared to Bebat barrels.	Storage and transport barrel for lithium-ion batteries. Unknown heat and pressure resistance compared to Bebat barrels.	Also suitable for transporting damaged batteries.

The metal containers used in the reference countries reduce the fire risk but do not eliminate all hazards.

- Metal containers provide significant extra protection in terms of fire risk, because they prevent battery fires from igniting the container and surroundings.
    - However, a plastic membrane or non-conductive bag must be placed inside the container to prevent short circuits.
- The properties of the collection covers are weaker than the transport covers. The advanced features of Bebat's transport covers include fire and heat resistance and the ability to relieve pressure.
- Despite the metal containers, aspects such as toxic flue gases (that the containers do not stop) and the heating of the container remain as risk factors.

Comparison to the current situation in Finland

Recser was established in 2008 and covers about 1,000 producers. There are about 11,000 active collection points.

Compared to the current situation in Finland, **the Belgian solution is very advanced**, but it should be noted that the funding model for recycling is very different in Belgium to that in Finland. The Czech solution is risk based.

The Czech Republic and Belgium use a **more diverse range of collection equipment**. Generally speaking, all collection equipment is compliant with the requisite packaging methods, but **steel containers are used to improve the safety of collection and/or transport**, at least in terms of fire propagation. Bebat has made a full transition to **steel container solutions** and implemented **smart solutions** (monitoring of filling, fire alarms) in the covers of the collection containers.

Ecobat has applied a more cost-efficient 'hybrid model' that aims to **identify the riskiest collection points** in the field and maintained a diverse range of collection equipment, including cardboard boxes.

By virtue of the EU Batteries Regulation, **producers must provide the collection points with suitable collection infrastructure for the separate collection of waste volumes handed over, that meet the applicable safety requirements.**

In terms of developing the safety of collection equipment, reducing fire risks is important particularly in areas where the quantities/concentrations of lithium-ion batteries or primary lithium batteries are significant now or they will be in the future. As a pioneer, Bebat has developed the safety of its collection equipment persistently, and their collection solutions set the benchmark for other collection equipment on the market. In Finland, too, various parties are developing and selling various partial solutions that improve safety, such as metal protection boxes for cardboard collection boxes, fireproof interior bags and metal fireproof cabinets.

As such, there is demand for improvements in safety. There is currently no clear **history-based** evidence on the significance of collection equipment in terms of the starting and propagation of fires. However, historic data does not account for the ever-increasing number of lithium-ion batteries.

Cost comparison

Collection equipment investments

A transition to a system based on metal barrels and boxes is estimated to require **millions invested in collection equipment**, in the event that cardboard boxes and plastic barrels are replaced with metal barrels (and metal boxes). This multiplies the producer organisation's equipment expenses dozens of times over. The costs

are currently formed by single-use cardboard boxes for transport and the replacement of some of the plastic barrels.

Other costs

There are also other financial factors related to updating the collection system:

- As regards barrels and metal boxes, the **delivery of empty equipment** to collection points will became an issue compared to cardboard box recycling. On the other hand, the logistical arrangements will change if empty metal barrels are delivered to the points instead of cardboard boxes to be assembled on site.
- The **administration and communications efforts** resulting from work to develop and update the system must also be taken into account.

5. Conclusions

Conclusions

This analysis produced perspectives on the current state of safety in terms of the collection of portable batteries and presented the collection and transport equipment solutions of two reference countries, including estimated cost impacts.

The changes necessitated by the Batteries Regulation and our increasingly battery-reliant society require producers to assess safety and vulnerabilities across the collection chain.

01

The Batteries Regulation expands producer responsibility to cover collection equipment. In 2025, the responsibility for arranging and covering the costs of collection equipment will be transferred to the producers, i.e. the importers and Finnish manufacturers of batteries. In practice, the producer organisation will procure the equipment and transfer the increased costs to the recycling fees of batteries, according to the causation principle. The producers and producer organisations in Finland and elsewhere in Europe will need to assess the current level of safety and consider how to develop it.

02

In the future, the recycling volumes of lithium-ion batteries are predicted to increase significantly, and the cardboard boxes currently in use are not suitable for transporting lithium-ion batteries that weigh more than 0.5 kg or are damaged. At the moment, only some shops have procured or are about to procure collection equipment or extra equipment to limit possible fires.

03

Safety must be considered in the context of collection equipment but also in relation to transport and battery handling, even though there is currently knowledge of very few realised risks. Collection solutions cannot eliminate all risks, meaning that it is important for the parties maintaining collection points to account for toxic flue gases in their rescue plans, for example. Collection is usually the most vulnerable point of the recycling chain. Fires are most likely in the context of transport and final processing, but the vulnerability is lower and preparedness arrangement are better.

Appendices

Battery safety guide for shop employees

Created by Gaia Consulting Oy and Ideavirta Oy
Commissioned by Recser Oy, the Finnish Commerce Federation and Tukes; STEK involved as a financier

AKKUOPAS.FI

Guide for mobile devices, which includes videos and instructional materials that progress through questions.

- Accessible by everyone on their personal phones
- No concerns about the print materials being lost
- Easy to update
- Language versions are easier to implement than for printed guides
- Easy to link to important websites
- Can also be accessed by means of a browser

ASIAKKAAMME TEKEVÄT MAAILMASTA PUHTAAMMAN JA TURVALLISEMMAN

gaia
PART OF SWECO