Wastes from recycling of spent batteries

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OUTLINE

- Introduction
  - Batteries
  - Legal requirements regarding waste batteries
- Methods
- Results and Discussion
  - Determination of process wastes and responsible processes for waste generation
  - Classification of wastes in accordance with the European Waste Codes
  - Identification of management strategies for each waste
- Conclusion

INTRODUCTION

Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators (Batteries Directive) defines ‘battery’ or ‘accumulator’ as

- any source of electrical energy generated by direct conversion of chemical energy and consisting of one or more primary battery cells (non-rechargeable) or consisting of one or more secondary battery cells (rechargeable)

BATTERIES

All the electrochemical cells and batteries are classified into two types:

- Primary (non-rechargeable)
- Secondary (rechargeable)

Primary batteries (non-rechargeable)

Source: https://industry.panasonic.eu/products/energy-building/batteries/battery-cells/primary-batteries

Secondary batteries (rechargeable)

Source: https://amazon.com

Source: https://amazon.com

Source: https://industry.panasonic.eu/products/energy-building/batteries/battery-cells/secondary-batteries-rechargeable-batteries

BATTERIES

Batteries, according to their types, include:

- Zinc
- Iron
- Manganese
- Nickel
- Lithium
- Cobalt
- Cadmium
- Copper
- Aluminum

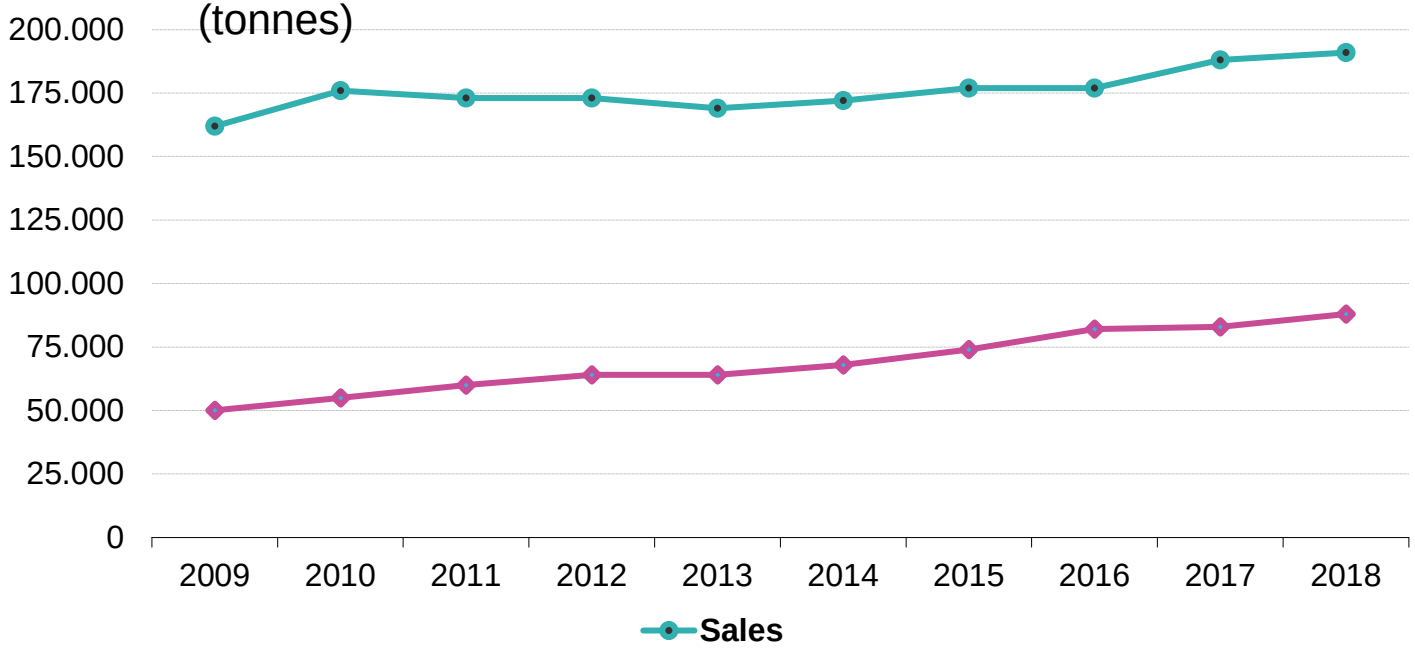
In addition to metals, they include various chemical solutions, materials such as plastics and paper/cardboard.

BATTERIES

- Batteries play an essential role to ensure that many daily-used products, appliances and services work properly, constituting an indispensable energy source in our society.
- Every year, approximately 800.000 tons of automotive batteries, 190.000 tons of industrial batteries, and 160.000 tons of consumer batteries enter the European Union.
- Not all these batteries are properly collected and recycled at the end of their life, which increases the risk of releasing hazardous substances and constitutes a waste of resources.
- Many of the components of these batteries could be recycled, avoiding the release of hazardous substances to the environment and, in addition, providing valuable materials to important products and production processes in Europe.

BATTERIES

Sales and collection of portable batteries and accumulators, EU-27, 2009–2018
(tonnes)



Note: Rounded estimates

Source: Eurostat

In 2018, **191 000 tonnes** of portable batteries were sold in the EU; **88 000 tonnes** of used portable batteries were collected as waste to be recycled.

In 2018, close to **48 %** of portable batteries sold in the EU were collected for recycling.

LEGAL REQUIREMENTS

- Batteries Directive (Directive 2006/66/EC) intends to contribute to the protection, preservation and improvement of the quality of the environment by minimizing the negative impact of batteries and accumulators and waste batteries and accumulators.
- Annex III of the Directive specifies recycling requirements.

ANNEX III

DETAILED TREATMENT AND RECYCLING REQUIREMENTS

PART B: RECYCLING

3. Recycling processes shall achieve the following minimum recycling efficiencies:

(a) recycling of 65 % by average weight of lead-acid batteries and accumulators, including recycling of the lead content to the highest degree that is technically feasible while avoiding excessive costs;

(b) recycling of 75 % by average weight of nickel-cadmium batteries and accumulators, including recycling of the cadmium content to the highest degree that is technically feasible while avoiding excessive costs; and

(c) recycling of 50 % by average weight of other waste batteries and accumulators.

ANNEX XII

Treatment and recycling requirements

Part B

Recycling efficiencies

1. No later than 1 January 2025, recycling processes shall achieve the following minimum recycling efficiencies:

   (a) recycling of 75 % by average weight of lead-acid batteries;

   (b) recycling of 65 % by average weight of lithium-based batteries;

   (c) recycling of 50 % by average weight of other waste batteries.

2. No later than 1 January 2030, recycling processes shall achieve the following minimum recycling efficiencies:

   (a) recycling of 80 % by average weight of lead-acid batteries;

   (b) recycling of 70 % by average weight of lithium-based batteries.

Part C

Levels of recovered materials

1. No later than 1 January 2026, all recycling processes shall achieve the following levels of materials recovery:

   (a) 90 % for cobalt;

   (b) 90 % for copper;

   (c) 90 % for lead;

   (d) 35 % for lithium;

   (e) 90 % for nickel.

2. No later than 1 January 2030, all recycling processes shall achieve the following levels of materials recovery:

   (a) 95 % for cobalt;

   (b) 95 % for copper;

   (c) 95 % for lead;

   (d) 70 % for lithium;

   (e) 95 % for nickel.

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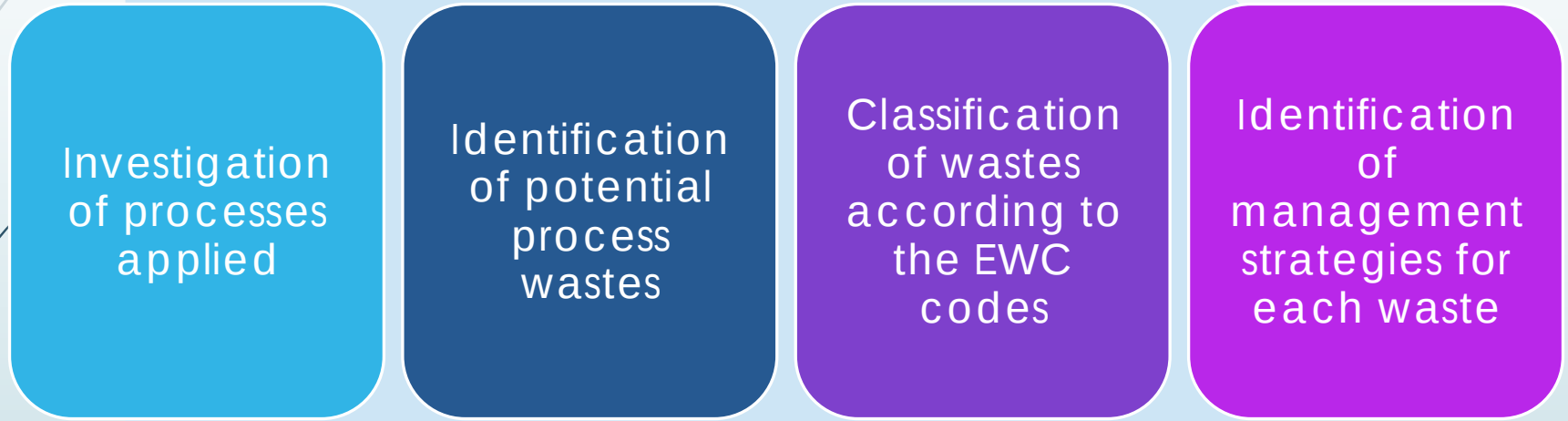
AIM

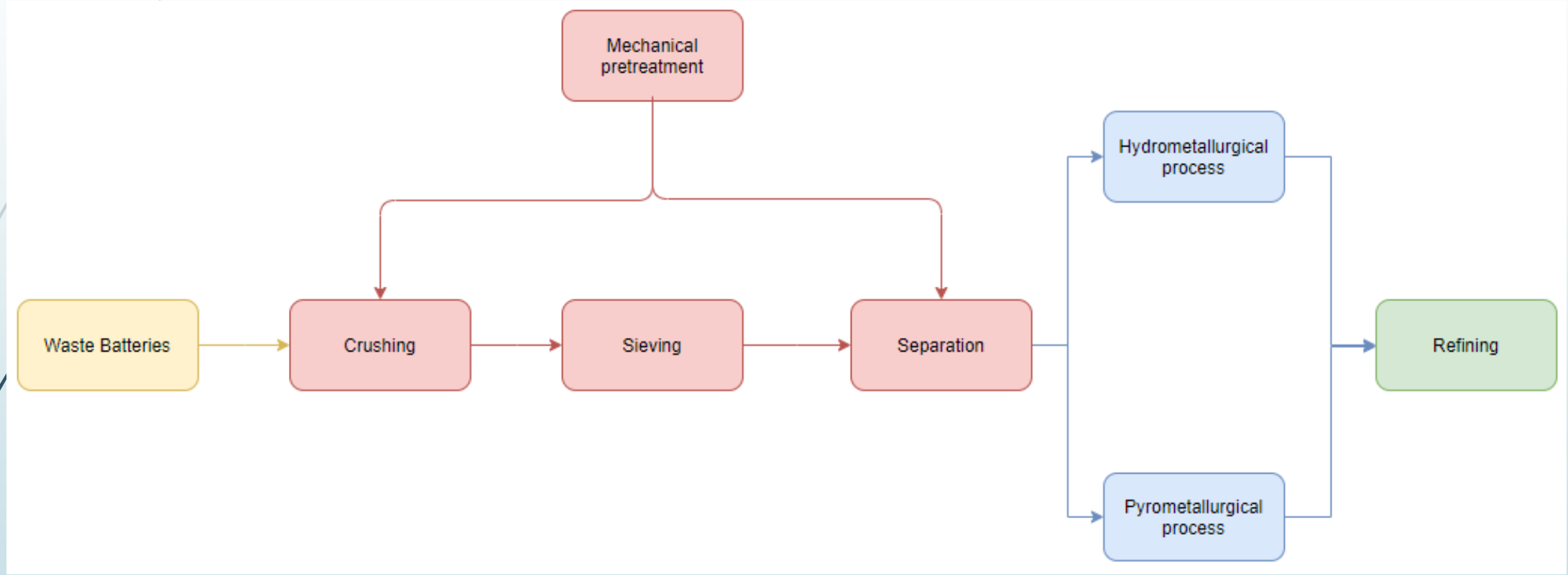
- To investigate the processes applied in recycling of waste batteries
- To determine process wastes and responsible processes for waste generation
- To classify wastes in accordance with the European Waste Codes
- To identify management strategies for each waste

METHODS


Investigation of processes applied
Identification of potential process wastes
Classification of wastes according to the EWC codes
Identification of management strategies for each waste

RESULTS AND DISCUSSION

Processes applied in recycling of waste batteries



RESULTS AND DISCUSSION

- The goal of recycling processes is to separate the components of spent batteries into different fractions that can be reintroduced into the production of useful materials.

- Current recycling technologies can be classified into two main categories: pyrometallurgy based on high-temperature pyrolysis and hydrometallurgy based on low-temperature solution.

PROCESSES APPLIED IN RECYCLING OF WASTE BATTERIES

- Crushing: To decrease the volume of spent batteries and to concentrate the valuable components, a large number of small cells or modules obtained after sorting and dismantling are subjected to a crushing process.
- Sieving: is usually used as a preliminary process to separate and concentrate the metallic fraction of spent batteries. Sieving provides a basic overview of the valuable metal distribution among the various particle sizes in a crushed sample.

PROCESSES APPLIED IN RECYCLING OF WASTE BATTERIES

- Separation: After crushing and sieving, the different components of waste batteries have been separated and concentrated preliminarily. Then, based on their different physical characteristics, including thermal properties, density, magnetic characteristics, wettability, and electromagnetic behavior, a separation process is performed to further remove impurities.

PROCESSES APPLIED IN RECYCLING OF WASTE BATTERIES

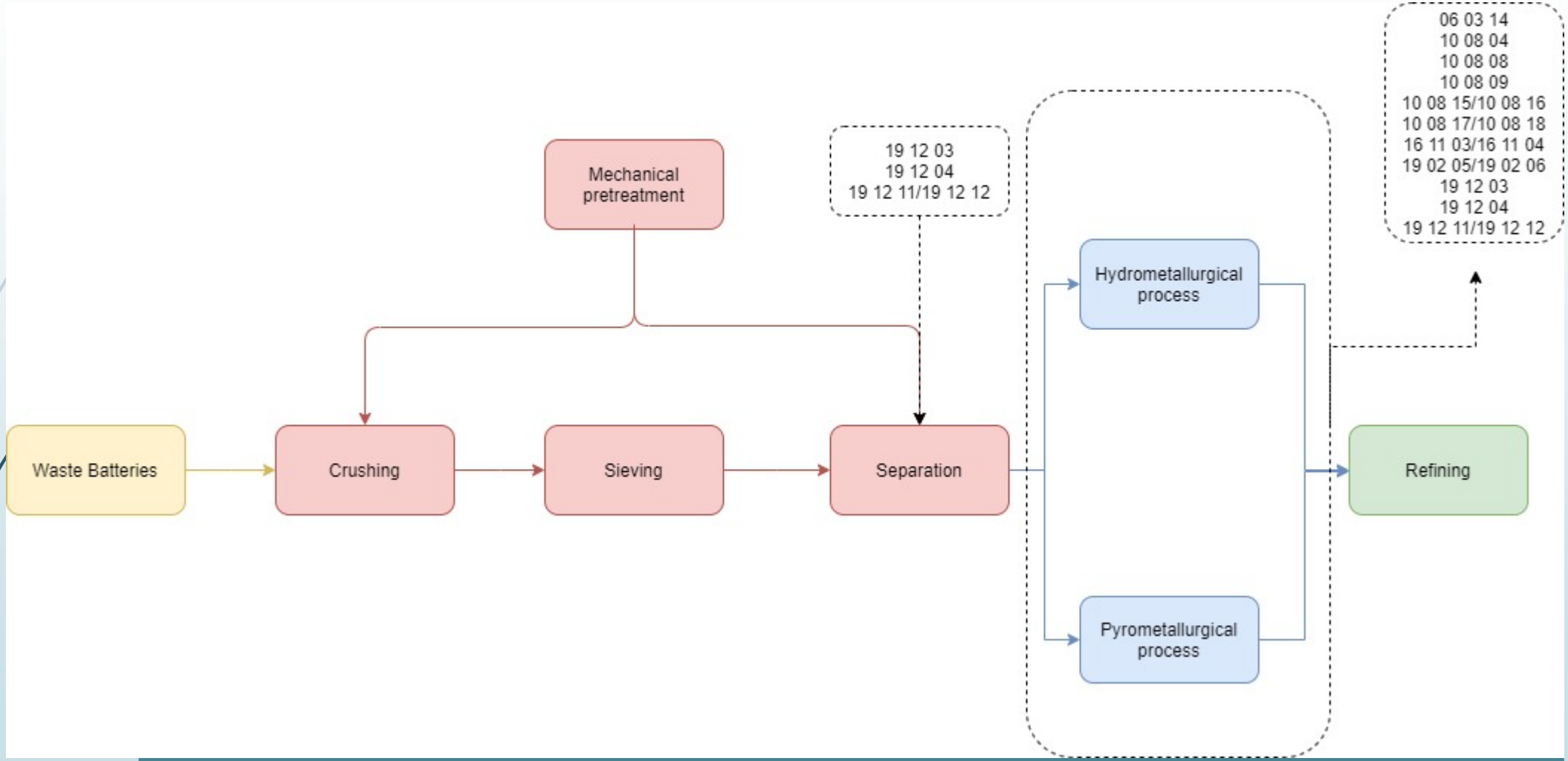
- Pyrometallurgical processes: The pyrometallurgical process here refers to a single pyrolysis treatment of spent battery components. The products after pyrolysis fall into two main categories: electrode materials and alloys.
- High-temperature treatment
- High energy consumption and emission of hazardous gases
- Simple and high productivity

PROCESSES APPLIED IN RECYCLING OF WASTE BATTERIES

- Hydrometallurgical processes: are chemical processes with aqueous solutions
- The degree of purity of the recovered substances is high.
- The refining process may not be needed after hydrometallurgical applications.
- Refining: The substance to be recovered is purified.

EWC Codes	Definition	EWC Codes	Definition
06 03 14	Solid salts and solution other than those mentioned in 06 03 11 and 06 03 13	16 11 03*	Other linings and refractories from metallurgical processes containing dangerous substances
10 08 04	Particulates and dust	16 11 04*	Other linings and refractories from metallurgical processes other than those mentioned in 16 11 03
10 08 08	Salt slag from primary and secondary production	19 02 05*	Sludges from physico/chemical treatment containing dangerous substances
10 08 09	Other slags	19 02 06*	Sludges from physico/chemical treatment other than those mentioned in 19 02 05
10 08 15*	Flue-gas dust containing dangerous substances	19 12 03	Non-ferrous metal
10 08 16*	Flue-gas dust other than those mentioned in 10 08 15	19 12 04	Plastic and rubber
10 08 17*	Sludges and filter cakes from flue-gas treatment containing dangerous substances	19 12 11*	Other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances
10 08 18*	Sludges and filter cakes from flue-gas treatment other than those mentioned in 10 08 17	19 12 12*	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11

RESPONSIBLE PROCESSES FOR WASTE GENERATION



RECOVERY AND DISPOSAL OPTIONS

Disposal	Recovery
D1: Deposit into or on to land	R1: Use principally as a fuel or other means to generate energy
D4: Surface impoundment	R3: Recycling/reclamation of organic substances which are not used as solvents
D5: Specially engineered landfill	R4: Recycling/reclamation of metals and metal compounds
D9: Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12	R5: Recycling/reclamation of other inorganic materials
D10: Incineration on land	R12: Exchange of waste for submission to any of the operations numbered R 1 to R 11
D15: Storage pending any of the operations numbered D 1 to D 14	R13: Storage of waste pending any of the operations numbered R 1 to R 12

RECOVERY AND DISPOSAL OPTIONS

Disposal	Recovery
D1: 10 08 15/10 08 16, 10 08 17/10 08 18, 19 12 03,	R1: 19 12 04, 19 12 11/19 12 12
D4: 10 08 15, 10 08 17	R3: 10 08 17, 19 12 04, 19 12 12
D5: 06 03 14, 10 08 15/10 08 16, 10 08 17/10 08 18, 16 11 03/16 11 04, 19 02 05/19 02 06, 19 12 04, 19 12 11/19 12 12	R4: 06 03 14, 10 08 17, 19 02 05/19 02 06, 19 12 03
D9: 19 12 11/19 12 12	R5: 10 08 15, 10 08 17, 16 11 03/16 11 04
D10: 19 12 04, 19 12 11/19 12 12	R12: 16 11 03/16 11 04, 19 12 11/19 12 12
D15: 06 03 14	R13: 06 03 14, 10 08 15/10 08 16, 10 08 17/10 08 18, 19 02 05/19 02 06, 19 12 11/19 12 12

CONCLUSION

This study

- revealed the situation of recycling of waste batteries providing a summary for their production processes and generated wastes from each process.
- classified process wastes in accordance with the European Waste Codes.
- listed recovery and disposal options for the wastes.

Thank you…

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