

Technical recommendations for the targeted amendment of the EU List of Waste entries relevant to batteries

Waste Expert Group meeting

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Policy context

- The JRC is providing technical support to the preparation, implementation and accompanying measures related to new **Batteries Regulation** (EU) 2023/1542.
- Particularly, Recital 116 “[*Commission Decision 2000/532/EC*] should be revised to reflect all battery chemistries, in particular the codes for lithium-based waste batteries, in order to enable proper sorting and reporting of such waste batteries”.
- JRC supports the development of targeted amendments of the European List of Waste entries relevant to batteries.

LoW update: rationale and challenges

- European List of Waste
 - Decision 2000/532/EC and subsequent amendments
 - Categorisation of waste types + classification as hazardous / non-hazardous
- Battery-relevant entries
 - Not reflecting some chemistries with current commercial relevance (notably **Li, Ni**)
 - No straightforward classification for current / emerging waste flows
 - Battery manufacturing waste; **black mass**; other intermediate fractions
- Risk of fragmentation
 - EU countries have already introduced their own waste codes
 - Not harmonised and potentially hindering cross-border flows
 - Uneven classification of similar wastes in different jurisdictions

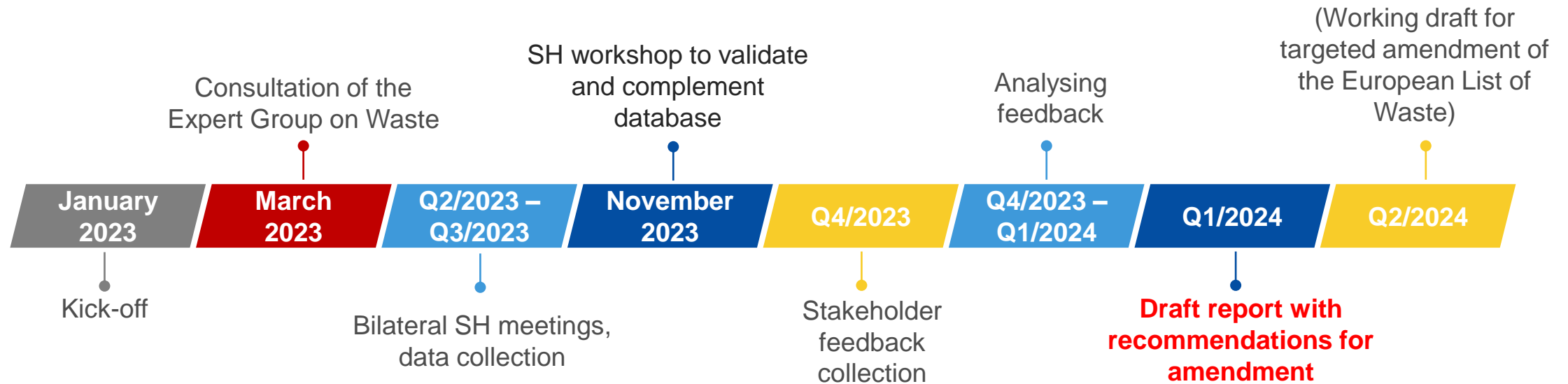
Legislative framework (concepts / definitions)

- Legal definitions of waste and waste batteries stem from the EU waste legislation:
- Definition of waste in the WFD (Article 3 (1)):
 - *“any substance or object which the holder discards or intends or is required to discard”.*
- Waste battery:
 - any battery (defined in the Batteries and Waste Batteries Regulation) that has become waste
- Battery manufacturing waste:
 - *“the materials or objects rejected during the battery manufacturing process, which cannot be re-used as an integral part in the same process and need to be recycled”.*
- NB: Article 7 (1) of the WFD on the List of Waste:
 - *“the inclusion of a substance or object in the list shall not mean that it is waste in all circumstances. A substance or object shall be considered to be waste only where the definition in point (1) of Article 3 is met”.*
 - The focus of the List of Waste is on waste (!)

Objectives and scope of the JRC project

- To deliver a technical report providing evidence to back up a potential targeted amendment of the List of Waste for entries relevant to batteries
- This JRC report will inform the preparation of an amendment of the List of Waste
- Current status
 - JRC Draft final report distributed to the Waste Expert Group ahead of the present WEG meeting
 - (Based on JRC research and input received from MSs following WEG 31.03.2023 and from stakeholders following workshop of 21.11.2023)

Timeline and status of the project



EU List of Waste on batteries – current entries

- 16 06 01* Lead batteries
- 16 06 02* Ni-Cd batteries
- 16 06 03* mercury-containing batteries
- 16 06 04 alkaline batteries (except 16 06 03)
- 16 06 05 other batteries and accumulators
- 16 06 06* separately collected electrolyte from batteries and accumulators
 - + additional national entries

- includes all recent chemistries e.g. Li-ion, NiMH
- non-hazardous

- 20 01 33* batteries and accumulators including 16 06 03 and unsorted batteries and accumulators
- 20 01 34 batteries and accumulators other than 20 01 33
 - + additional national entries

- 4 MSs (AT, ES, NL, PT) have already implemented new WCs for lithium and nickel containing batteries.
- **12 other MS** will implement new WCs
- No member state have implemented new WCs for battery manufacturing waste
- 2 MSs have WCs for intermediate fractions of batteries recycling processes

*hazardous

Other waste codes used for battery materials

- Operators have used e.g. the following waste codes to accept Li batteries:
 - 16 01 21* hazardous components with the exception of those falling under 16 01 07 to 16 01 11, 16 01 13 and 16 01 14) → *LIB from ELV*
 - 16 02 15 * hazardous components removed from discarded equipment → *LIB from WEEE*
- Waste codes for intermediate materials from recycling processes:
 - 19 01 11* bottom ash and slag containing hazardous substances
 - 19 01 17* pyrolysis wastes containing hazardous substances
- No specific waste code for Li-ion black mass. Currently black mass is often handled using the following waste codes:
 - 19 10 03*: fluff-light fraction and dust containing dangerous substances
 - 19 10 05*: other fractions containing dangerous substances
 - 19 12 11*: other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances
- NB alkaline black mass often handled using the following waste codes:
 - 19 12 03 non-ferrous metal
 - 19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11

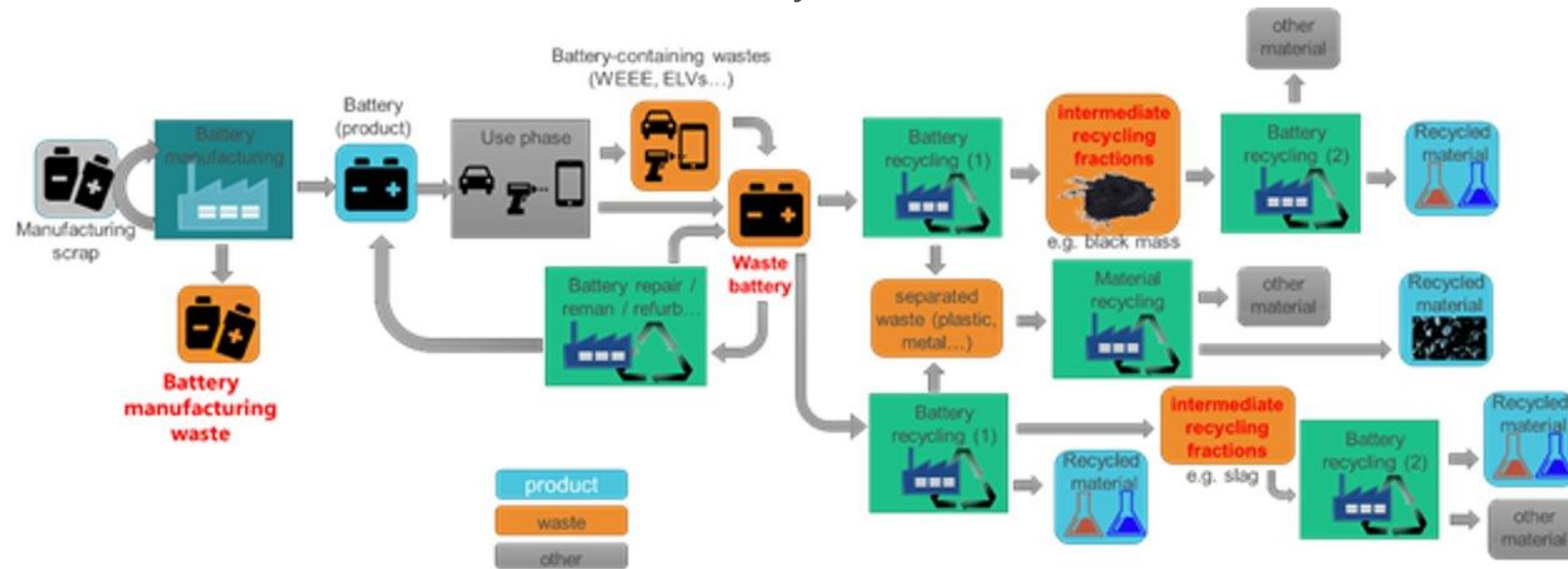


Scope – Waste batteries (types and chemistries)

- **Pb-, Ni-Cd and Hg-** based batteries are currently classified as hazardous. No evidence on the necessity to change this status. Hence, they are considered but **not addressed in depth**.
- All **lithium-based batteries** types are **in scope**. Specific focus on **LCO, LMO, NMC, NCA, LFP**, as well as **LTO and LiSOCl**.
- **Nickel-Metal-Hydride (NiMH)** and **Sodium-Nickel-Chloride (Na-NiCl₂)** batteries are **under scope** to cover the nickel-based batteries.
- **Alkaline batteries** are already listed in the LoW, however, these batteries could contain chemical compounds with hazardous properties and are therefore **under the scope**.
- **Zinc-based batteries** (e.g. Zn-C, Zn-Cl, Zn-air, Ag-Zn, and Ag-oxide) could contain chemical compounds with hazardous properties and are therefore **under scope**.
- **Sodium-based batteries** are similar in design and construction to lithium batteries, but rely on sodium compounds. These batteries could come onto the market in large quantities in the coming years and are therefore also **under scope**.

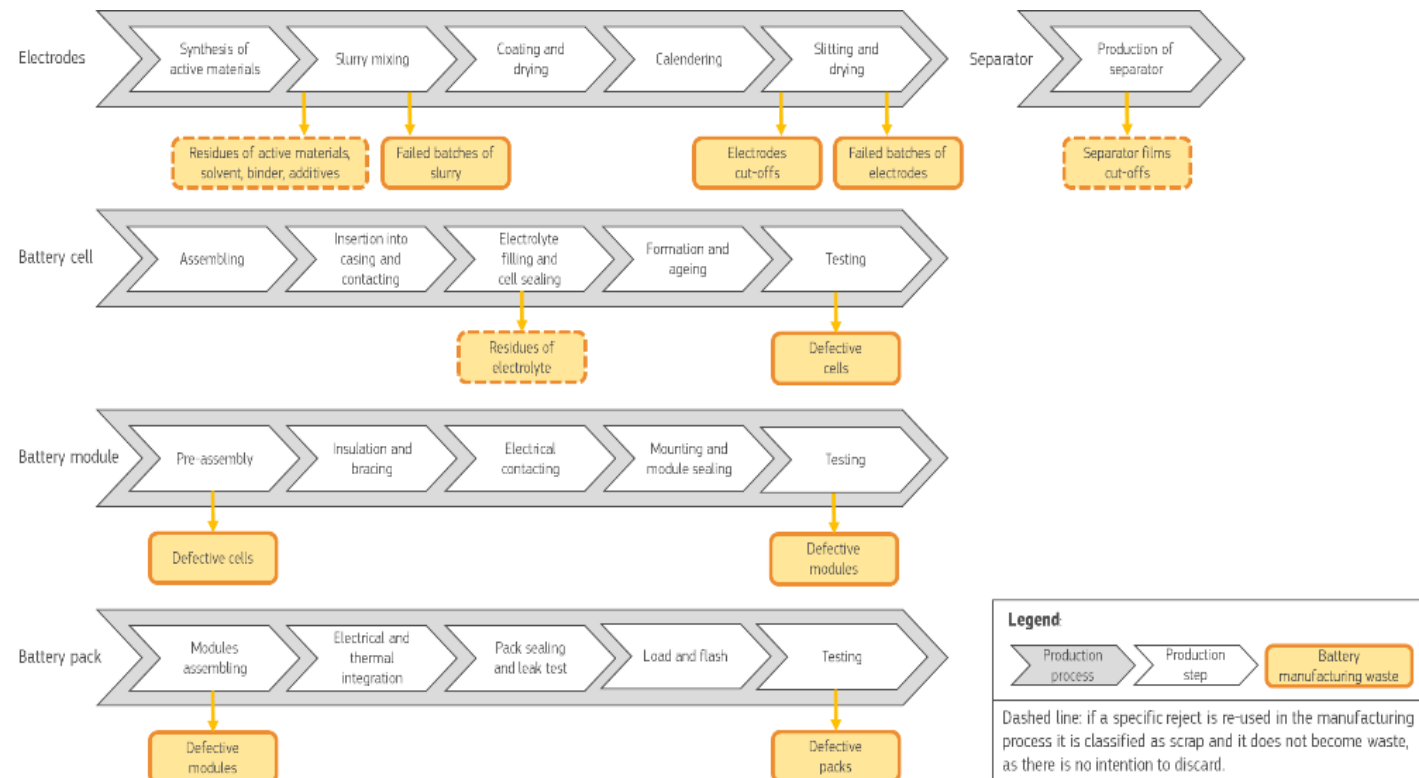
Scope – Battery related waste streams

- The following **battery related waste streams** are considered in the scope:
 - Waste batteries;
 - Battery manufacturing waste;
 - Intermediate material flows of battery waste treatment.



Scope – Battery manufacturing waste

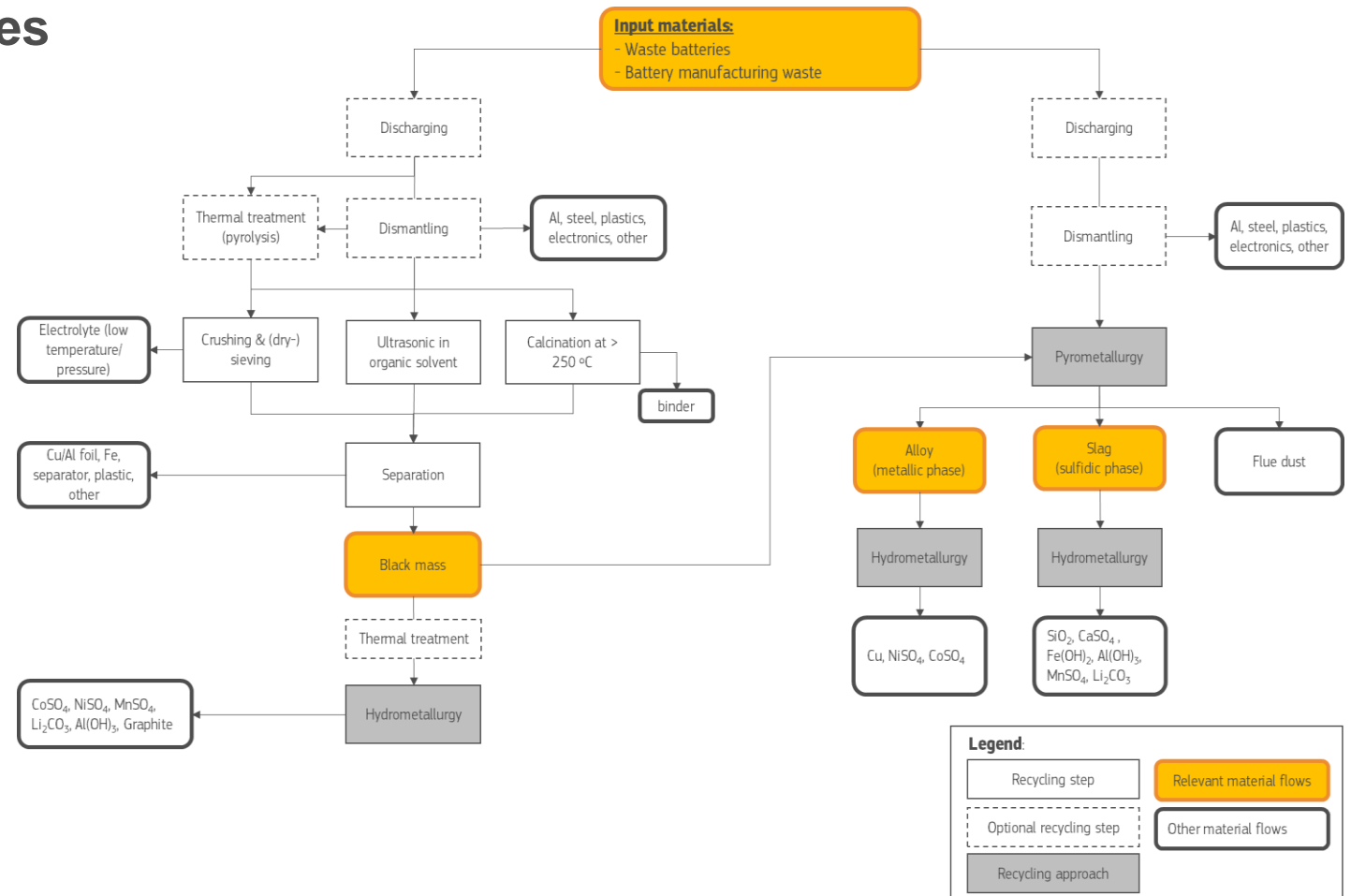
- Definition of **battery manufacturing waste** in Article 3 (51) of the Battery Regulation: *“the materials or objects rejected during the battery manufacturing process, which cannot be re-used as an integral part in the same process and need to be recycled”*.
- Waste streams from battery manufacturing considered in the scope include:
 - Residues of active materials, solvent, binder, additives and failed batches of slurry;
 - Electrode cut-offs and failed batches of electrodes;
 - Separator film cut-offs;
 - Residues of electrolyte;
 - Defective cells, modules and packs.



Scope – Intermediate material flows from battery waste treatment

Example - Lithium-based batteries

- **Black mass** from mechanical recycling
- **Alloy** and **slag** from pyrometallurgical recycling



Methodology

- Since the latest LoW revision, novel battery types are being produced, enter the market, end up as waste, and are already recycled in some cases.
- Battery related wastes that do not have a specific waste code need to be assigned to existing waste codes from the EU LoW.
- **Problem:** Current EU LoW may not reflect the characteristics (especially, hazardous) of the battery waste stream under scope.
- Consultation of the Expert Group on Waste on lithium- and nickel- based batteries was carried out.

Methodology - EU LoW adaptations in Member States and current classification

- Union legislation does not specifically require the national adaptation of the List-of-Waste (but carried out in practice when seen as necessary by MS).
- As part of the consultation of the Expert Group on Waste, Member States were asked among other things
 - how battery related wastes are **currently classified** and
 - whether the List-of-Waste **has already been adapted** or **will be adapted** in the near future.
- Provision of information for the **classification** but also **adoption of the LoW** of the battery related waste streams under scope.

Li-waste batteries – Classification in MS

- Consultation of the Expert Group on Waste revealed an **inhomogeneous picture in the EU**.
- **Five different** waste codes (hazardous and non-hazardous) are assigned to LIB, in case the LoW is not already extended for this type of batteries.
- Some MS **distinguish between the sources** of the LIB (e.g. separate collected, from WEEE or ELV).

Member State	Type of waste battery	16 01 21*	16 02 15*	16 06 05	20 01 33*	20 01 34
AT	LIB from WEEE		x			
	LIB from ELV	x				
	Mix of LIB and NiMH batteries				x	
BE (Br)	LIB from WEEE	x				
	LIB from ELV		x			
	LIB unknown				x	
BE (Fl/Wa)	LIB			x		
CZ	LIB (general)	x	x	x		
DE	LIB from WEEE		x			
				x		
	LIB from ELV	x				
DK	LIB			x		
FI	LIB			x		
IR	LIB (general)	x	x	x	x	x
IT	LIB from municipal waste collection			x	x	
LT	LIB		x			
LU	LIB of light means of transport and ELV			x		
	Mix batteries from WEEE: Li, Ni metal hydride, Ni-Cd				x	
NL	LIB				x	
SK	LIB	x		x		

Li-waste batteries – National LoW adaptations

Consultation of the WEG revealed **different approaches in the EU.**

Austria	
35337*	Lithium batteries
Czech Republic (from 2025)	
16 06 05 01	Batteries and accumulators containing lithium
Estonia	
16 06 05 04	Lithium-ion batteries
16 06 05 06	Lithium batteries, non-rechargeable portable batteries
France¹	
16 06 05*	Other batteries and accumulators
Spain	
16 06 07*	Accumulators, cells or batteries in whose composition lithium is present in any form, such as lithium cells or lithium-ion accumulators
20 01 42*	Accumulators, cells or batteries in whose composition lithium is present in any form, such as lithium cells or lithium-ion accumulators

Li-battery recycling – Classification of black mass

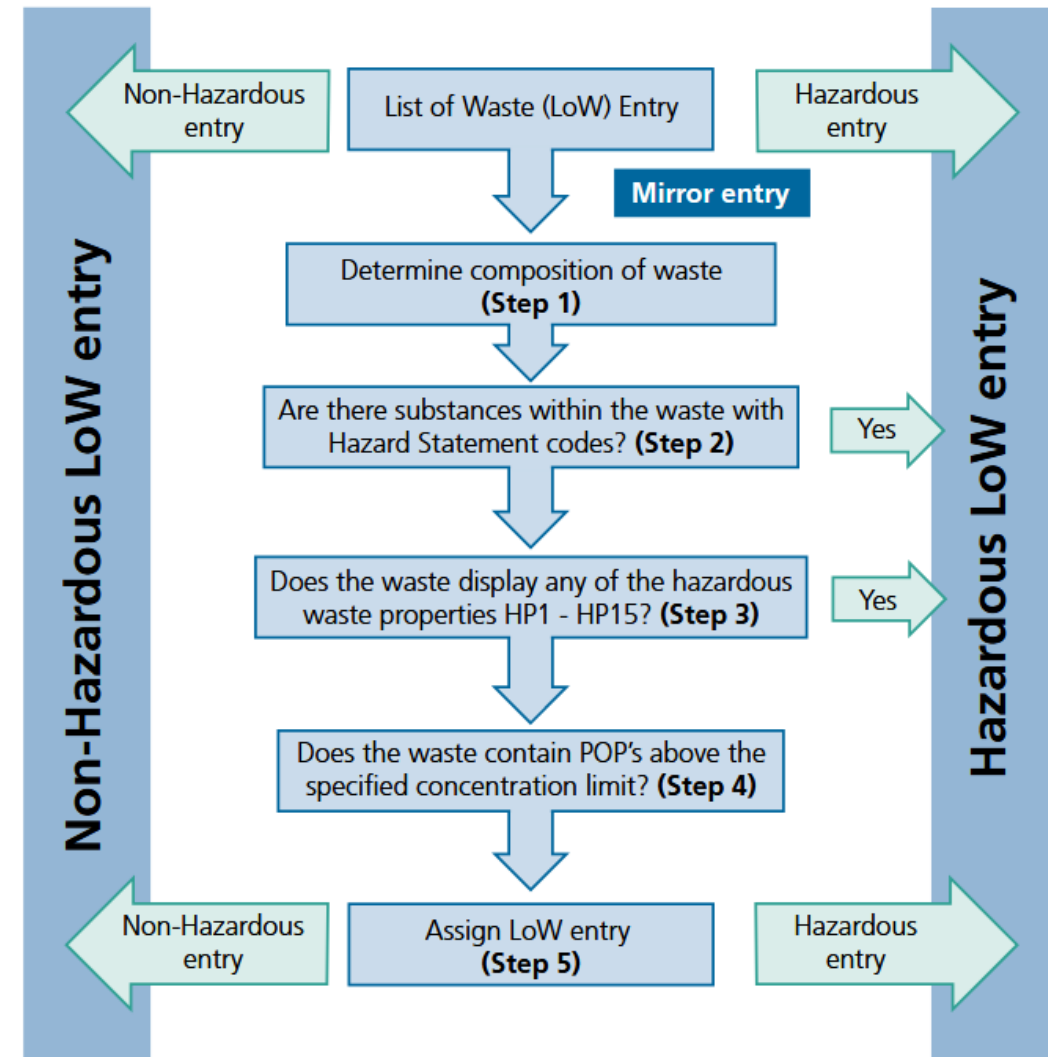
Currently associated waste codes for lithium black mass:

- 19 12 11* (other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances)
- 19 10 05* (other fractions containing dangerous substances)
- 06 03 15* (metallic oxides containing heavy metals)

Waste codes applied for black mass from lithium batteries are classified as hazardous.

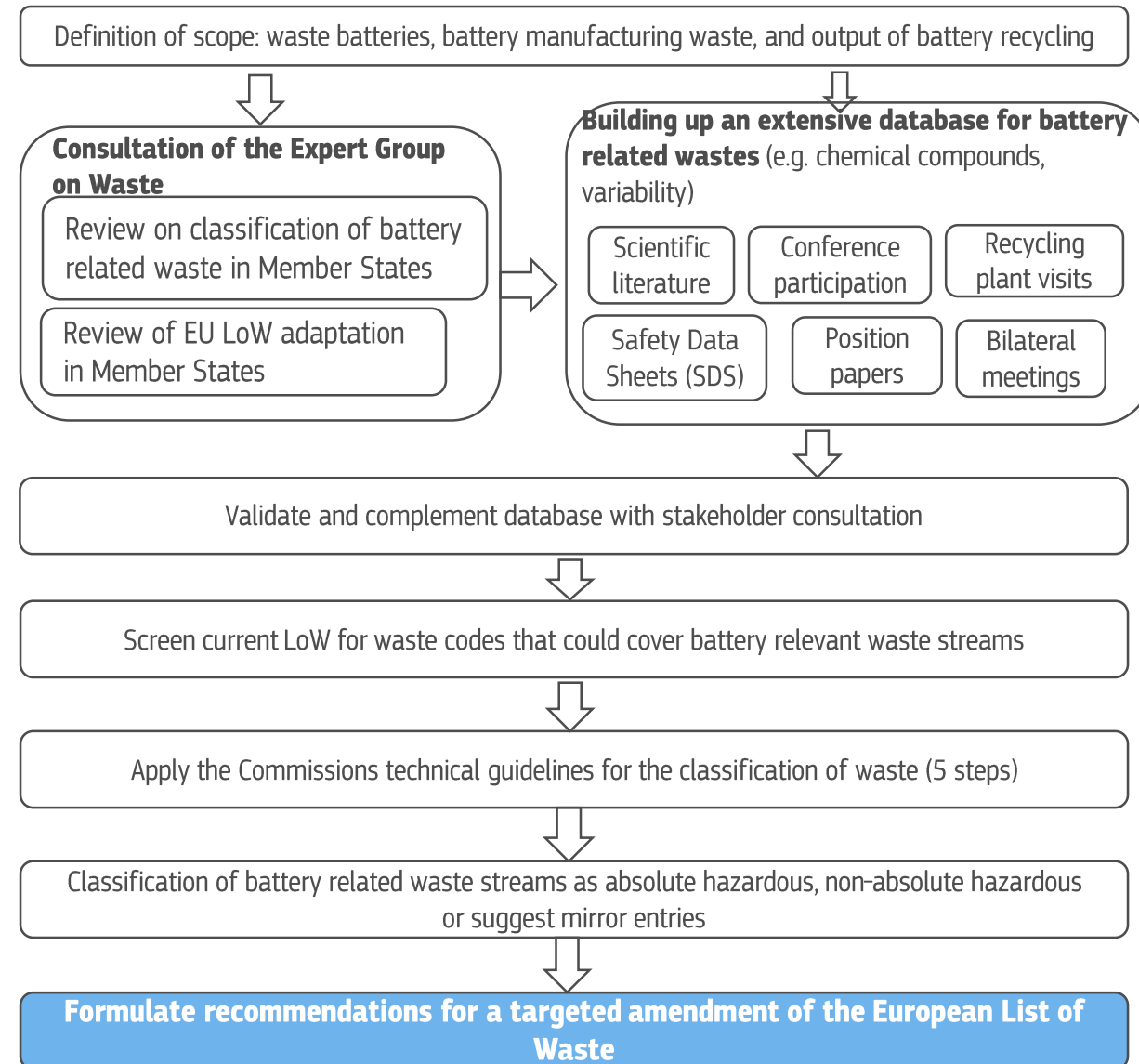
Methodology – Hazard determination (I)

- Commission provides technical guidelines on the classification of waste¹.
- Guidelines are the basis for the determination of hazardousness.
- JRC follows **the 5 steps to classify a waste.**



Methodology – Proposal for a potential amendment of the EU LoW

- To prepare a potential amendment of the EU LoW, the **current EU** (and national) **LoW entries** are analysed.
- After the identification of the different battery waste relevant streams and their classification, the **missing LoW entries for these waste are identified**.
- Based on the classification of the battery waste, the **JRC has issued recommendations for a potential amendment of the EU LoW in its draft final report**.



Li-waste batteries – Scope

- Seven different **lithium battery chemistries** are under scope to cover the broad variety of lithium-based batteries.
- Typically, the **mineral composition of the cathode** makes the difference between battery chemistries.
- Even within a battery chemistry, the **chemical composition can vary significantly (e.g. NMC)**



Battery type	Battery chemistry
Lithium based	<div>LCO: Lithium-Cobalt-Oxide LMO: Lithium-Manganese-Oxide NMC: Lithium-Nickel-Manganese-Cobalt-Oxide NCA: Lithium-Nickel-Cobalt-Aluminium-Oxide LTO: Lithium-Titanium-Oxide (anode) LFP: Lithium-Iron-Phosphate LiSOCl: Lithium-Thionyl-Chloride (primary)</div>

The basic formula of NMC consists of 33 % Ni, 33 % Mn, and 33 % Co ($\text{LiNi}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$, NMC 111):

Share of the metals can vary in different NMC. Typical blends are:

- $\text{LiNi}_{0.4}\text{Co}_{0.2}\text{Mn}_{0.4}\text{O}_2$ (NCM 424)
- $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$ (NCM 523)
- $\text{LiNi}_{0.5}\text{Co}_{0.3}\text{Mn}_{0.2}\text{O}_2$ (NCM 532)
- $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ (NCM 622)
- $\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$ (NCM 811)

Li-waste batteries – Characterisation

Battery components	Chemistries of lithium batteries and materials										
	LCO	LMO	NMC	NCA	% total battery	LTO	% total battery	LFP	% total battery	LiSOCl	% total battery
Cathode material	LiCoO ₂	Li ₂ Mn ₂ O ₄	LiNi _{0.8} Mn _{0.1} Co _{0.1} O ₂	LiNi _{0.5} Co _{0.3} Al _{0.2} O ₂	20-50 %	LiMO ₂ , others	20-50 %	LiFePO ₄	25-50 %	Metal Lithium	3.5-5 %
Cathode collector	Aluminium foil				8-15 %	Aluminium foil	6-8 %	Aluminium foil	6-8 %	Aluminium foil	no data
Anode material	Typically: Graphite SiO ₂ (Silicon dioxide) Carbon black				10-30 % no data 1-3 %	Li ₄ Ti ₅ O ₁₂ (lithium-titanate nanocrystals)	unknown	Graphite	10-30 %	Graphite	3-5 %
Anode collector	Copper foil				4-7 %	Copper foil	10-12 %	Copper foil	10-12 %	Copper foil	no data
Electrolyte	Lithium salts				10-20 %	Lithium salts		Lithium salts		SOCl ₂ LiGaCl ₄ AlCl ₃	25-45 % no data 1-5 %
	LiPF ₆ (Lithium Hexafluorophosphate) LiBF ₄ (Lithium Tetrafluoroborate) LiClO ₄ (Lithium Perchlorate)					LiPF ₆ LiBF ₄ LiFSI		LiPF ₆ LiBF ₄ LiFSI			
	Organic solvents					Organic solvents		Organic solvents			
	C ₃ H ₄ O ₃ (Ethylene carbonate) C ₄ H ₆ O ₃ (Propylene carbonate) (CH ₃ O) ₂ CO (Dimethyl carbonate) C ₃ H ₂ O ₃ (Vinylene Carbonate) C ₆ H ₅ F (Fluorobenzene) LiF ₂ PO ₂ (Lithium difluorophosphate) F ₂ LINO ₄ S ₂ (Lithium bis(fluorosulfonyl)imide) C ₃ H ₆ O ₃ S (1,3-Propanesultone) C ₈ H ₁₂ Si (Tetravinylsilane) C ₂ H ₄ O ₄ S (1,3,2-Dioxathiolane 2,2-dioxide)					C ₃ H ₄ O ₃ C ₄ H ₆ O ₃ (CH ₃ O) ₂ CO) C ₃ H ₂ O ₃ C ₆ H ₅ F LiF ₂ PO ₂ F ₂ LINO ₄ S ₂ C ₃ H ₆ O ₃ S C ₈ H ₁₂ Si C ₂ H ₄ O ₄ S		C ₃ H ₄ O ₃ C ₄ H ₆ O ₃ (CH ₃ O) ₂ CO) C ₃ H ₂ O ₃ C ₆ H ₅ F LiF ₂ PO ₂ F ₂ LINO ₄ S ₂ C ₃ H ₆ O ₃ S C ₈ H ₁₂ Si C ₂ H ₄ O ₄ S			
Binder	PVDF (polyvinylidene fluoride) dissolved in N-methyl-2-pyrrolidone (NMP) PTFE (Polytetrafluoroethylene) in unknown solvent CMC (Carboxy methyl cellulose) in aqueous solvent Na-alginate in aqueous solvent LA132 (Polyacrylic latex) in aqueous solvent PPA (Poly(acrylic acid)) in aqueous solvent PDADMA (Poly(diallyldimethylammonium) in aqueous solvent Carbon black				1-8 %	PVDF PTFE CMC Na-alginate LA132 PPA PDADMA Carbon black		PVDF CMC		0.30 % 0.30 %	no data no data
Separator	Polymeric membranes (e.g. PE or PP) Non-woven fabric mats				3-5 %	Polymeric membranes Non-woven fabric mats		Polyethylene Nylon Styrene Butadiene Rubber (SBR)		3-4 % 4 % 0.05 %	Polymeric membranes 3-5 %
Case and tab	Steel, plastic				15-30 %	Steel, plastic		Steel, plastic		25-30 %	Steel, plastic 15-30 %

Li-battery recycling – Characterisation black mass

Black mass compounds	Hazard properties	BM1-LIB	BM2-LIB	BM3-LIB	BM4-LIB	BM5-LIB	BM6-LFP	BM7-LFP
		Weight (% total battery)						
Mixed metal oxides	see Table 5	10-75 %	-	-	-	-	-	-
Li-oxide		<10 %	-	-	<70%*	-	-	-
Li-, Ni-oxides		-	-	-		-	-	-
Li-, Co-oxides		-	1-50 %	-		-	-	-
Li-, Ni-, Co-, Al-oxides		-	1-50 %	-		-	-	-
Li-, Ni-, Co-, Mn-oxides		-	1-50 %	30-50 %		≥60 %	-	-
Li-, Fe-phosphate		-	-	-	-	-	≥60 %	60-70 %
Aluminium	not hazard	<10 %	-	<10 %	<10 %	<5 %	<5 %	<5 %
Copper	CAS No. 231-159-6 H411, Aquatic Chronic 2	<10 %	-	<5 %	<10 %	<5 %	<5 %	<2.5 %
Graphite	see Table 11	<40 %	30-50 %	25-40 %	10-40 %	<40 %	≤40 %	≤40 %
Potassium hydroxide (KOH), caustic potash	see Table 8	-	-	-	-	<5 %	-	-
Lithium fluoride	see Table 7	-	-	-	<5 %	-	<10 %	<10 %
PVDF	see Table 6	-	2-7 %	-	-	-	-	-
Lithium salts		-	1-4 %	-	<10 %	-	-	-
Organic solvents		-	-	5-10 %	-	-	-	-
Water	-	10-30%	-	-	-	-	-	-

*lithium carbonate: < 10 %; cobalt oxide: < 30 %; manganese oxide: < 15 %; nickel oxide: < 15 %

Li-waste batteries – Hazard determination (I)

Cathode (/anode) material

Battery chemistry	CAS No.	Hazard statement code, hazard class and category code	
LCO	12190-79-3	H360Fd	Repr. 1B
NMC	various entries e.g. 179802-95-1 or 182442-95-1	H317; H330; H334; H350 ; H360 ; H372; H412	Skin Sens. 1; fatal if inhaled; Resp. Sens. 1; Carc. 1A; Repr. 1B; STOT RE 1; Aquatic Chronic 3
LMO	12057-17-9	H302 ; H332 ; H413	Acute Tox. 4; Acute Tox. 4; Aquatic Chronic 4
NCA	177997-13-6; 193214-24-3	H314; H317; H318; H330; H334; H350 ; H360; H372; H412	Skin Corr. 1B; Skin Sens. 1; Eye Dam. 1; Acute Tox. 2; Resp. Sens. 1; Carc. 1A; Repr. 1B; STOT RE 1 (lungs); Aquatic Chronic 3
LTO	12031-82-2	-	not classified
LiSOCl	not found*	-	-
LPF	15365-14-7	-	not classified

→ H360: May damage fertility or the unborn child HP 10: ≥ 0.3 %

→ H350: May cause cancer HP 7: ≥ 0.1 %

→ H302+H332: HP 6
HP 7: ≥ 25 or 22.5 %
Sum of concentration!!!

→ H350: may cause cancer HP 7: ≥ 0.1 %

*No entry for LiSOCl. But entries exist for
- SOCl_2 (H315, H319, H332, H334, H335)
- LiCl (H302, H315, H319, H335)

Li-waste batteries – Hazard determination (II)

Electrolyte

Battery chemistry	CAS No.	Hazard statement code, hazard class and category code	
LiPF ₆	21324-40-3	H301; H314; H318; H372	Acute Tox. 3; Skin Corr. 1A; Eye Dam. 1; STOT RE 1
C ₃ H ₄ O ₃	96-49-1	H302; H319; H373	Acute Tox. 4; Eye Irrit. 2; STOT RE 2 ((Kidney) (oral))



H372: Damage to organs
HP 5: ≥ 1 %



H373: May cause damage to organ, HP 5: ≥ 10 %

Chemical compounds formed during life-time

Battery chemistry	CAS No.	Hazard statement code, hazard class and category code	
HF	7664-39-3	H300 ; H310; H314; H330	Acute Tox. 2; Acute Tox. 1, Skin Corr. 1A, Acute Tox. 2



H300: Fatal if swallowed
HP 6: ≥ 0.1 %

Li-battery recycling – Hazard determination

Black mass from lithium ion batteries:

- The **cathode** and/or **anode material** but also the **electrolytes** are relevant for the classification (see lithium waste batteries).
- Mechanical recycling means the removal of casing and other parts of the battery cell (15-30%). Meaning, the **percentual share of chemical compounds with hazardous properties increases**.
- Certain technologies can **remove substances** (e.g. electrolytes, by thermal treatment). This can change the chemical composition and **possibly also the hazard classification**.
- Granulated metallic copper can be found in black mass (H411: Aquatic Chronic 2, toxic to aquatic life with long lasting effects) with a concentration limit of $\geq 2.5 \%$.

Recommendations for LoW amendment

- 44 LoW entries addressed – amended or new
- New codes for battery manufacturing waste for all chemistries proposed to be added to sub-chapter 16 06
- New codes for waste batteries proposed under 16 06 – mostly absolute hazardous
- Alignment of terminology to the Battery Regulation
- New specific intermediate fraction (black mass) codes proposed for all chemistries – hazardous
- Slags and salts also addressed

Thank you ! and keep in touch

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