Introduction

- “the initiative will modify the Directive or a proposal for a new Regulation repealing the Directive will be prepared, to notably encompass end-of-life and sustainability requirements. (… Q4 2020)” 2020 CWP

- Information from
  - Studies and consultation underpinning the assessment and evaluation of the Directive,
  - Studies and consultation carried out in the context of the ‘eco-design’ process,
  - Extensive consultation processes during and following up to the Strategic Action Plan on Batteries,
  - Two specific studies,
    - *Feasibility of measures addressing shortcomings in the current EU batteries framework system,*
    - *Study addressing particular topics on batteries (legal statuses, restrictions, etc).*

Proposed approaches and measures

- Taken from
  - EU institutions
  - Stakeholders’ proposals
  - Technical and scientific publications

- Disclaimer

This document is part of a study which is being prepared for the European Commission. However, the information and views set out in this report are those of the authors and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this initial presentation of results.

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Batteries Directive 2006/66/EC

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Initial results of the study in support of the assessment of the Batteries Directive

Measure 7: Recycling efficiencies and material recovery rates




RECYCLING

Measure 7

Recycling efficiencies and material recovery rates

Measure 7 – Recycling efficiencies and material recovery rates (I)

Problem description

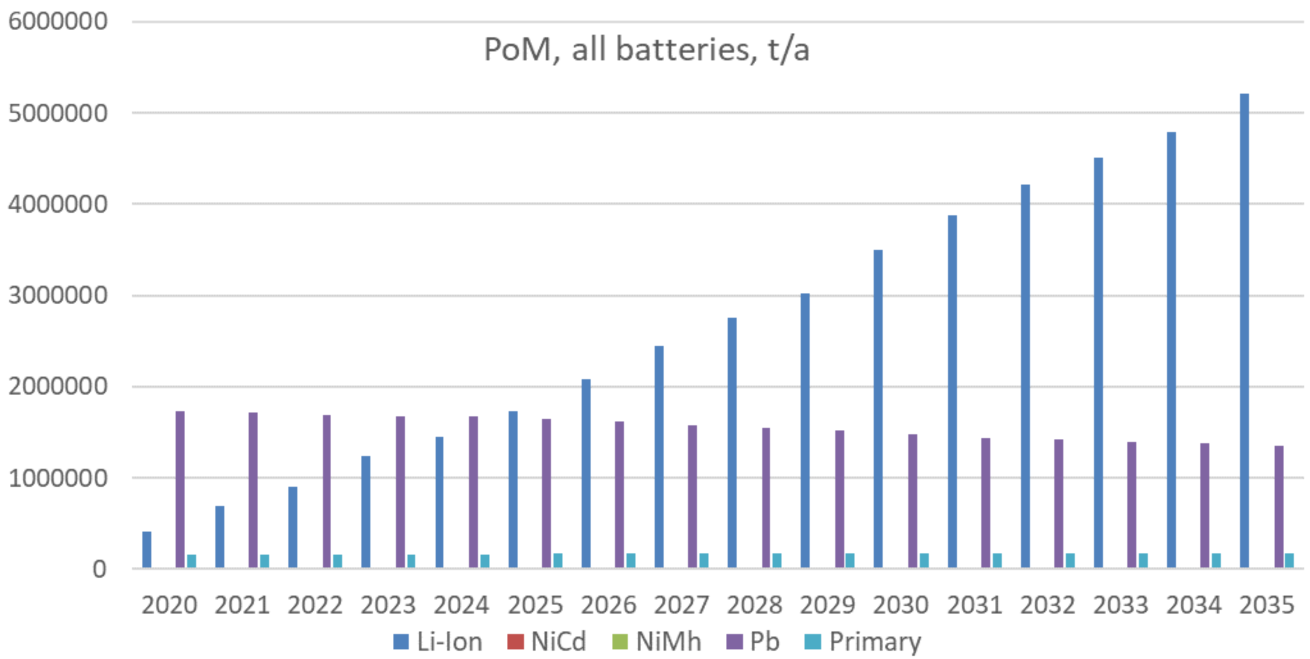
- The recycling efficiency in current version of the Batteries Directive is not orientated towards recovery of (critical) materials and the Directive does not address specific materials to be recovered as a resources. In this regards the Directive lacks provisions for additional materials (e.g. Co, Ni, Li or other critical raw materials).
- Recycling efficiency of “other batteries” applies to Li-ion batteries. “Other batteries” no longer adequately represent the amount and relevance of Li-ion batteries. There are no separate targets for Li-ion batteries, which would ensure that batteries are collected (portable and industrial) and fed into high quality recycling processes (e.g. Li and Co are recovered including a high recycling efficiency for the whole battery).
- Most of today`s recycling processes for lithium-ion batteries focus on housing materials, BMS, cobalt, and nickel. Only few processes are established to recover lithium due to economic reasons.
- This measure analyses the development of new recycling efficiencies, the material recovery of specific battery materials and investigates the impact of a change of the definition of recycling efficiency.

Measure 7 – Recycling efficiencies and material recovery rates (IIa)

Overview – batteries PoM; all chemistries and categories

(portable, industrial, automotive and Pb-acid, Li-ion, NiCd, NiMH and other (primary))

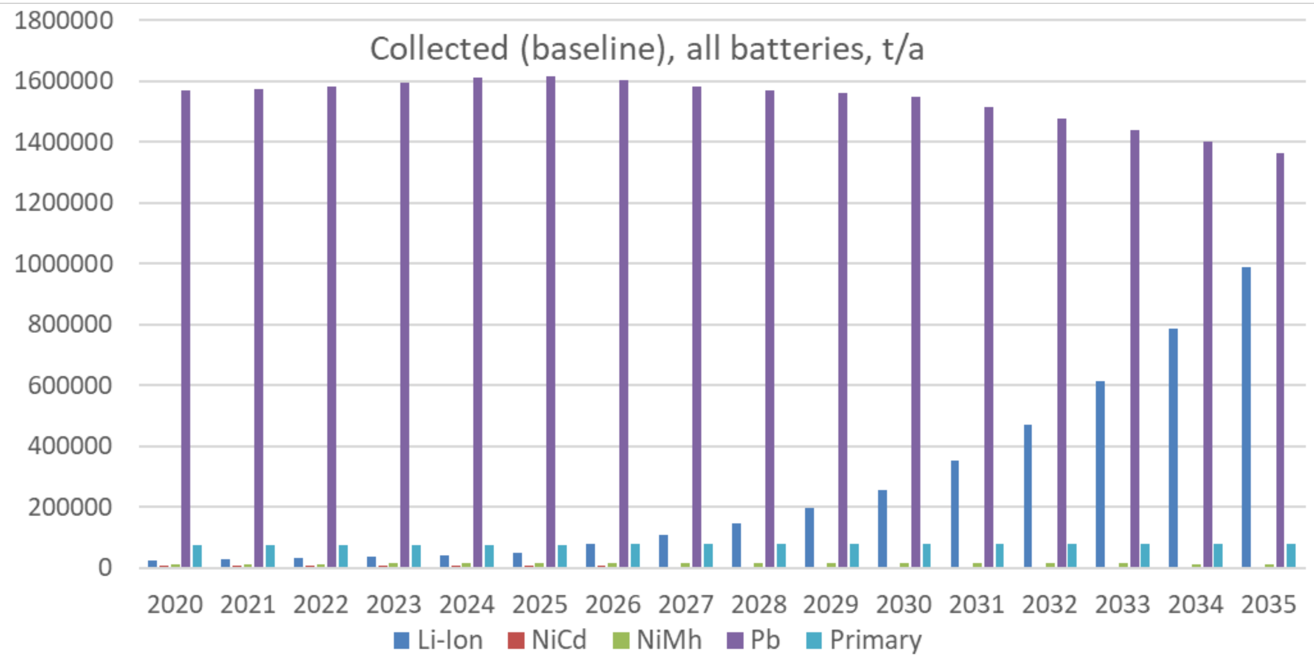
- Batteries PoM are dominated by Pb-acid (slight decrease) and Li-ion batteries (strong increase);
- Around the year 2025, more Li-ion than Pb-acid will be PoM for the first time.



Measure 7 – Recycling efficiencies and material recovery rates (IIb)

Overview – batteries collected; all chemistries and categories

- Up to 2030 waste Pb-acid batteries account for more than 80% of the total batteries collected.
- Large quantities of Li-ion batteries are only available for recycling after a delay.
- In 2026, more Li-ion than primary batteries will be collected and available for recycling for the first time.
- Primary batteries account for about 4% of the total waste batteries collected; NiMH account for less than 1% and NiCd for about 0.5% and less.



Measure 7 – Recycling efficiencies and material recovery rates (IIIa)

General approach

- Pb-acid and Li-ion batteries are by far the most relevant batteries for recycling:
  - Pb-acid and Li-ion dominate the amounts PoM and collected
  - Li-ion contains valuable and critical resources that shall be recovered
  - Pb is considered hazardous in the Directive and shall be recovered to reduce the risk of environmental pollution and health hazard
- NiMH and NiCd are only of low importance and their relavance further decreases:
  - No need to change or adapt existing recycling targets
- Primary batteries (a variety of chemistries with alkaline batteries having by far the highest share) come in third place, but their relevance continues to decline:
  - Alkaline present lower risk to environment and health (Zn compared to Pb or Ni)
  - Criticality of alkaline battery materials is lower compared Li-ion (Fe, Zn compared to Co, Li, Ni)

→ Recycling targets are analysed and assessed for Li-ion and Pb-acid batteries

→ No changes for current targets of Other batteries and NiCd batteries

Measure 7 – Recycling efficiencies and material recovery rates (IIIb)

General approach

- This measure analysis and assesses different options for recycling targets. These options are not necessarily alternatively, rather, the measure develops an comprehensive approach for provisions for the recycling of batteries.
- Options will be implemented in two steps (2023 and 2028).
- Results of the impacts depend on the difference between baseline and option.
- Negative emissions: net-reduction / benefits; secondary materials from recycling replace primary production.

Measure 7 – Recycling efficiencies and material recovery rates (IIIc)

General approach

Following options are considered:

- Option 1: Li-ion batteries
  - Option 1a: Recycling efficiency Li-ion; development of a recycling efficiency target for Li-ion batteries
  - Option 1b: Recovery rates Li-ion; development of targets for material recovery of specific battery materials of Li-ion batteries
- Option 2: Pb-acid batteries
  - Option 2a: Recycling efficiency Pb-acid; adaption of the recycling efficiency target of Pb-acid batteries
  - Option 2b: Recovery rates Pb-acid; development of targets for material recovery of specific battery materials of Pb-acid batteries
- Option 3: methodology of recycling efficiency; new approaches or changes of the methodology of the recycling efficiency

Measure 7 – Recycling efficiencies and material recovery rates (IIId)

General approach

Definition of recycling efficiency (Regulation (EU) No 493/2012):

- ‘Recycling efficiency’ of a recycling process means the ratio obtained by dividing the mass of output fractions accounting for recycling by the mass of the waste batteries and accumulators input fraction expressed as a percentage

Definition of material recovery rate (this refers to the rates of recycled content of heavy metals of Regulation (EU) No 493/2012 and shall be calculated accordingly) :

1. The rate of recycled lead content is calculated as follows:

$$R_{Pb} = \frac{\sum m_{Pb\ output}}{m_{Pb\ input}} \times 100,\ [\text{mass }\%]$$

R_{Pb} = calculated *rate of recycled lead* (Pb) from a recycling process for the purpose of Article 12(4) of Directive 2006/66/EC [in mass %];

$m_{Pb\ output}$ = the *mass of Pb in output fractions accounting for recycling* is the share of Pb contained in these fractions which results from the recycling of lead-acid batteries and accumulators per calendar year [in tonnes];

$m_{Pb\ input}$ = the *mass of Pb in the input fraction entering the battery recycling process* is defined as the yearly average Pb content of waste lead-acid batteries and accumulators multiplied by the input mass of lead-acid batteries and accumulators per calendar year [in tonnes].

Battery materials:

- Co = cobalt; Cu = copper; Fe = iron; Li = lithium; Ni = nickel; Pb = lead; Mn = manganese

Measure 7 – Recycling efficiencies and material recovery rates (IVa)

Baseline

- Current situation: According to the Directive recycling processes shall achieve the following minimum recycling efficiencies:
  - recycling of 65 % by average weight of Pb-acid batteries and accumulators.
  - recycling of 75 % by average weight of NiCd batteries and accumulators.
  - recycling of 50 % by average weight of other waste batteries and accumulators (including Li-ion batteries).
- No **quantitative** material recovery targets exist for specific materials.
- The table on the right side gives material recovery rates for specific materials, which are assumed to apply typically in today's recycling processes.

Baseline	Li-ion recovery rates 2020	Pb-acid recovery rates 2020
Aluminium	80%	
Iron	95%	
Plastics	0%	10%
Lead		93%
Nickel	80%	
Cobalt	80%	
Manganese	0%	
Lithium	10%	
Copper	80%	
Graphite	0%	

10% plastics are estimated

Measure 7 – Recycling efficiencies and material recovery rates (IVb)

Option 1: Li-ion batteries

There is general agreement that Li-ion batteries require separate recycling targets.

In the following, the development of recycling targets is explained using Li-ion traction batteries of BEV (NMC 811) as an example.

(See also table next slide)

- Outer casing / periphery (e.g. cables) account for about 23% of the entire battery weight (mainly aluminum).
- Excl. casing / periphery: selected active materials (Co, Ni, Li) and Cu account for ca. 30% % of the remaining battery.
- Excl. casing / periphery: plastics, Al and Fe account for ca. 34% and graphite and volatiles for about one fourth of the remaining battery.
- Taking into account the material recovery rates provided in ‘baseline’, 23% active material and Cu (76% recovery of the 30% content) can be recovered.
- Al, Fe, Mn, plastics, graphite and volatiles can potentially also contribute the recycling efficiency.

Measure 7 – Recycling efficiencies and material recovery rates (IVc)

Option 1: Li-ion batteries

Li-ion traction batteries of BEV (NMC 811)

- Some basic figures on the composition of the battery

	mass %	Excl. casing/periphery mass %	Contribution to recycling efficiency baseline	Contribution to recycling efficiency measure 2023
Total battery	100%			
Casing /periphery	23%			
Battery excl. casing/periphery	77%	100%		
Therefrom				
Co, Ni, Li, Cu	23%	30%	23%	26%
plastics, Al, Fe	26%	34%		

Measure 7 – Recycling efficiencies and material recovery rates (IVd)

Option 1: Li-ion batteries – initial results

Li-ion traction batteries of BEV (NMC 811); see also following slide

- 3 environmental categories are represented: GWP (global warming potential), ADP (resource depletion), human toxicity
- Results for the recycling of the battery are shown. Recovered materials replace the primary production of the same material and result in credits.
- Results demonstrate **potential** environmental benefits of recycling (assumption of 100% recovery of all materials).

	ADP Potential (100% recovery)	**GWP** Potential (100% recovery)	**Hum Tox** Potential (100% recovery)
Total battery	100%	100%	100%
Casing /periphery	10%	31%	9%
Battery excl. casing/periphery	90%	69%	91%
Therefrom			
Co, Ni, Li, Cu	78%	22%	80%

Measure 7 – Recycling efficiencies and material recovery rates (IVe)

Option 1: Li-ion batteries – initial results

Li-ion traction batteries of BEV (NMC 811); continued

Results for the recycling of the Li-ion battery; ADP, GWP, human toxicity:

- Recycling of outer casing / periphery account for about 30% (due to aluminium recycling) of the entire credits of GWP from battery recycling.
- For ADP (ca. 10%) and human toxicity (ca. 9%) recycling of outer casing / periphery are less relevant.
- The active materials (Co, Ni, Li) together with Cu account for about 90% of ADP and human toxicity of the entire battery.
- The other materials (plastics, Cu, Al) account for almost one third of ADP and human toxicity of the entire battery.

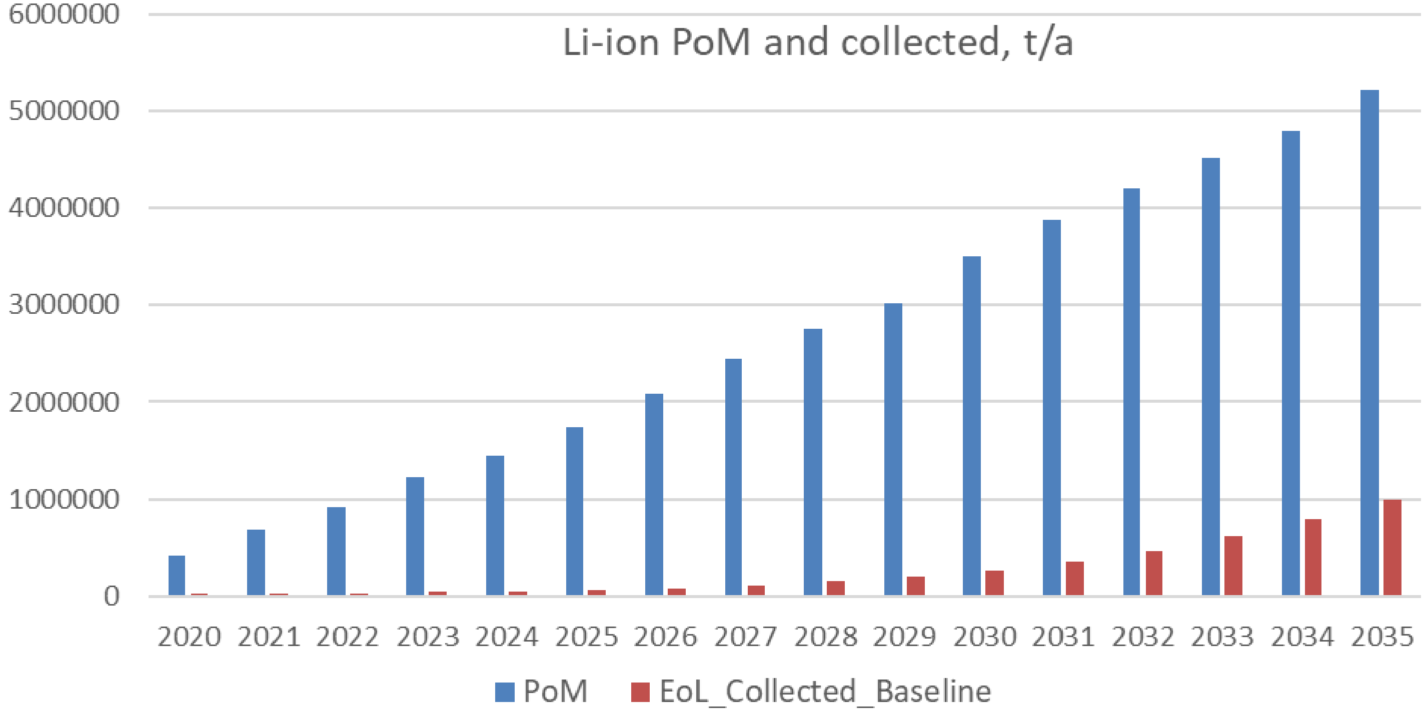
Measure 7 – Recycling efficiencies and material recovery rates (IVf)

Option 1: Li-ion batteries – initial results

Developement of Li-ion batteries PoM (all applications) (in t/a) in the EU from 2020 to 2035 and the amounts collected at EoL in the same period.

Share of EV Li-ion batteries of total Li-ion PoM increases from 70% (2020) to about 90% (2035).

Amounts collected increase from about 25 000 tonnes in 2020 to about 1 million tonnes in 2035.



Measure 7 – Recycling efficiencies and material recovery rates (IVg)

Impacts of Option 1a: Recycling efficiency Li-ion – initial results

Recycling of outer casing / periphery

- Outer casing / periphery are mainly massive parts which are mostly made of one material (EV traction batteries: Al).
- Outer casing / periphery can be dismantled relatively easily.
- Recycling of outer casing / periphery account for about 30% (due to aluminium recycling) of GWP of the entire credits.

An obligation of recycling outer casing and BMS?

- Due to the high economic value of Al and Cu outer casing / periphery of EV batteries will be recycled to a large extend anyway.
- Other batteries, e.g. e-bike, power tools, laptops, also have an outer casing, but small and usually made of plastic: high costs for dismantling, possible contamination by e.g. flame retardants, and in comparison a comparatively small environmental benefit.

→ In conclusion, for industrial batteries above a certain weight (e.g. 5 kg, the value would still have to be examined in detail), the recycling of the outer casing / periphery should be made mandatory by law.

Measure 7 – Recycling efficiencies and material recovery rates (IVh)

Impacts of Option 1a: Recycling efficiency Li-ion – initial results

Recycling efficiency target

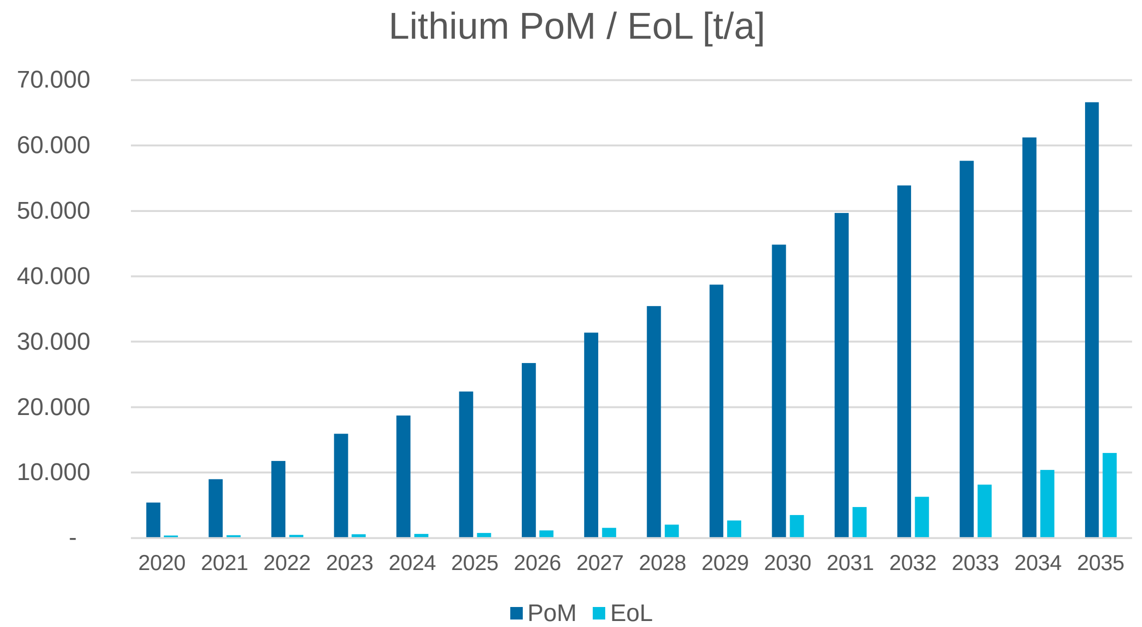
- In the following a recycling efficiency target is developed. This considers the current methdology for calculating the target (Regulation (EU) 493/2012)
- Outer casing and BMS shall not be taken into account for the recycling efficiency.
- Considering only active materials (Co, Ni, Li) and Cu:
  - 23% of the battery can be recycled (based on the recovery rates of the baseline)
  - and 26% of the battery can be recycled (based on higher recovery rates of the measure in slide 19).
- So far only the metal content is taken into account. In practice, the metal is recovered as e.g. oxide.
- The additional mass of oxide (or other components) and potential recycling of additional materials as e.g. Mn, graphite, etc. also add to the recycling efficiency.

→ Overall, a recycling efficiency target of about 50% to 60% is considered feasible.
→ The recycling efficiency target shall apply for all Li-ion chemistries.

Measure 7 – Recycling efficiencies and material recovery rates (IVi)

Impacts of Option 1b: Recovery rates Li-ion – initial results of Li

Developement of Li used in Li-ion batteries PoM (in t/a) in the EU from 2020 to 2035 and amounts of Li contained in batteries EoL in the same period.
The market for Li is increasing very rapidely due to the increase of Li-ion batteries PoM.
Due to the time delay until Li-ion batteries are recycled, the amount of recovered Li remains significantly below the quantities of the primary material PoM.



Measure 7 – Recycling efficiencies and material recovery rates (IVj)

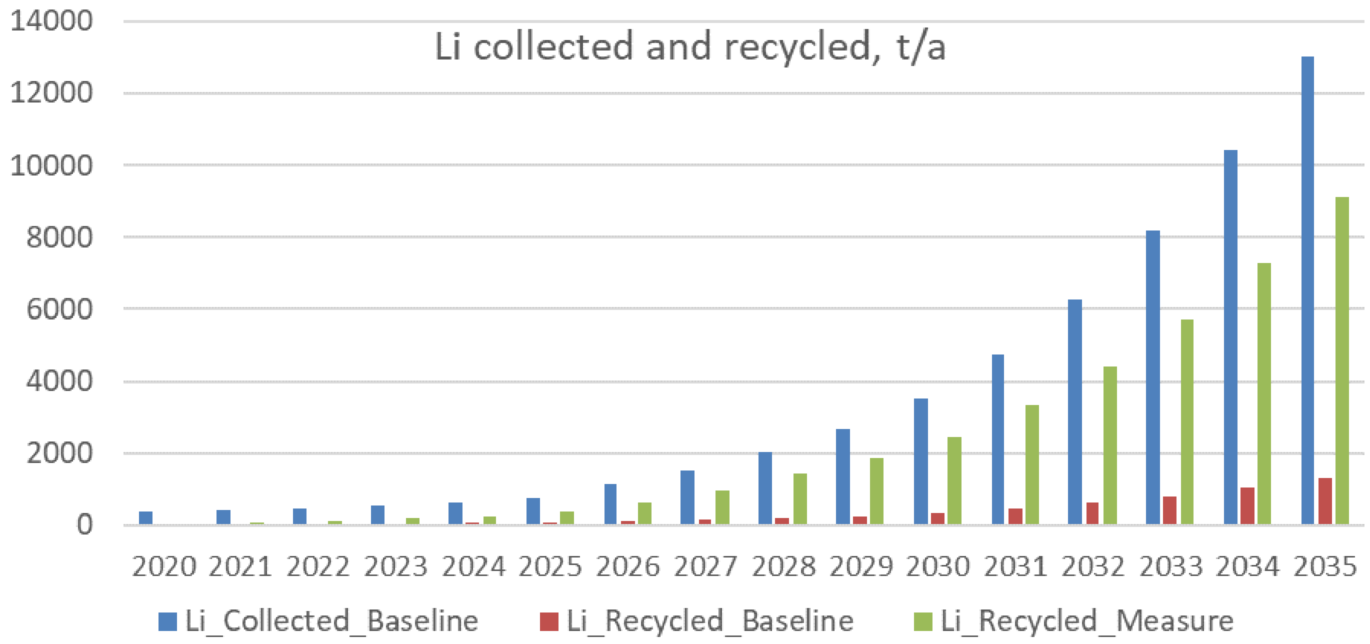
Impacts of Option 1b: Recovery rates Li-ion – initial results of Li

Developement of Li (in Li-ion) collected (Li_Collected_Baseline) and recycled (in t/a) in the EU from 2020 to 2035.

Increase of Li recovery rate from 10% (Baseline) to 35% (Measure) in 2023 and 70% (Measure) in 2028 (no further changes up to 2035)

About 100 to 2 100 tonnes of Li are additionally recoverd every year (from 2023 to 2030).

In total, about 7 000 tonnes of Li are additionally recovered from 2023 to 2030 (cumulative).

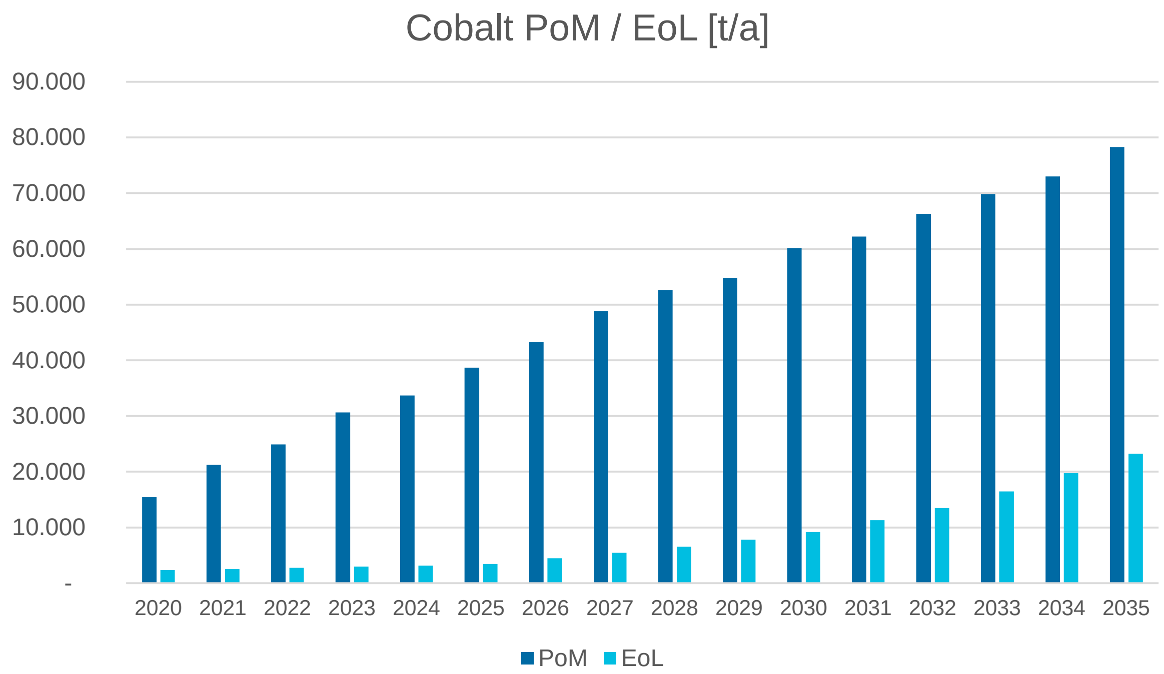


Measure 7 – Recycling efficiencies and material recovery rates (IVk)

Impacts of Option 1b: Recovery rates Li-ion – initial results of Co

Developement of Co used in batteries PoM (in t/a) in the EU from 2020 to 2035 and amounts of Co contained in batteries EoL in the same period.

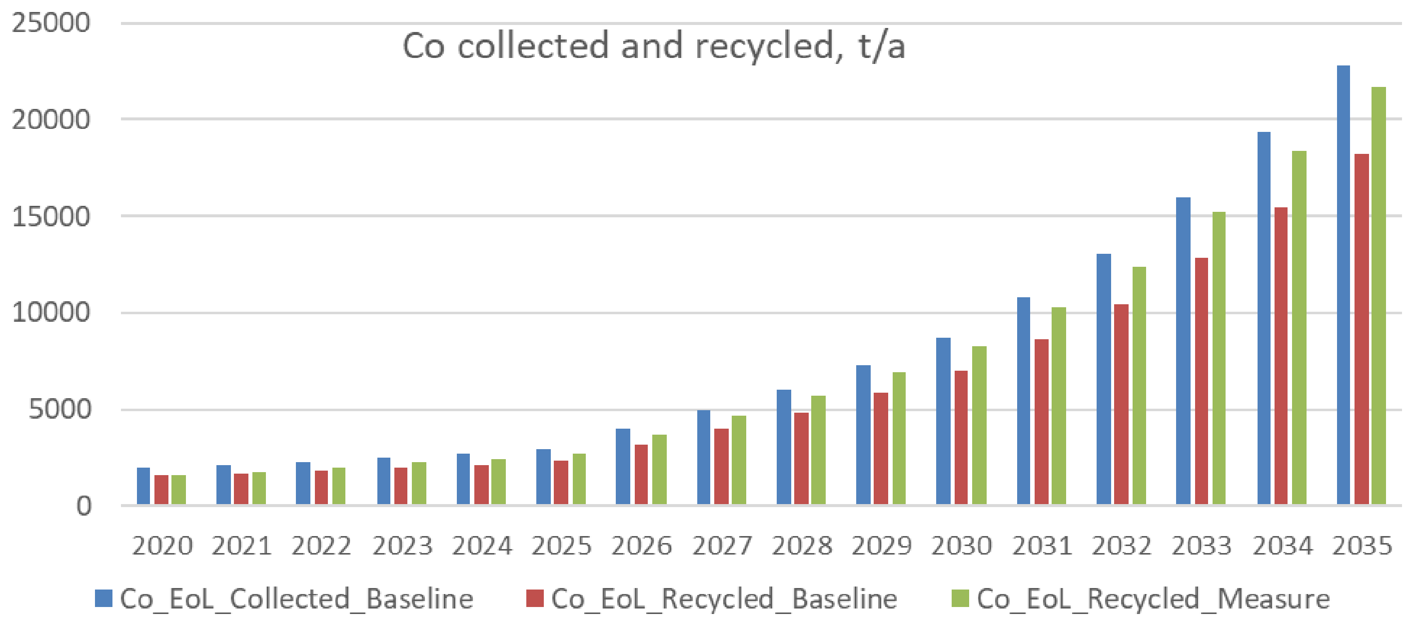
The market for Co is increasing very rapidely due to the increase of Li-ion batteries PoM. Due to the time delay until Li-ion batteries are recycled, the amount of recovered Co remains significantly below the quantities of the primary material PoM.



Measure 7 – Recycling efficiencies and material recovery rates (IVI)

Impacts of Option 1b: Recovery rates Li-ion – initial results of Co

Developement of Co (in Li-ion) collected and recycled (in t/a) in the EU from 2020 to 2035.
Increase of Co recovery rate from 80% (baseline) to 90% (measure) in 2023 and 95% (measure) in 2028 (no further changes up to 2035)
About 300 to 1 300 tonnes of Co are additionally recoverd every year (from 2023 to 2030).
In total, about 5 400 tonnes of Co are additionally recovered from 2023 to 2030 (cumulative).

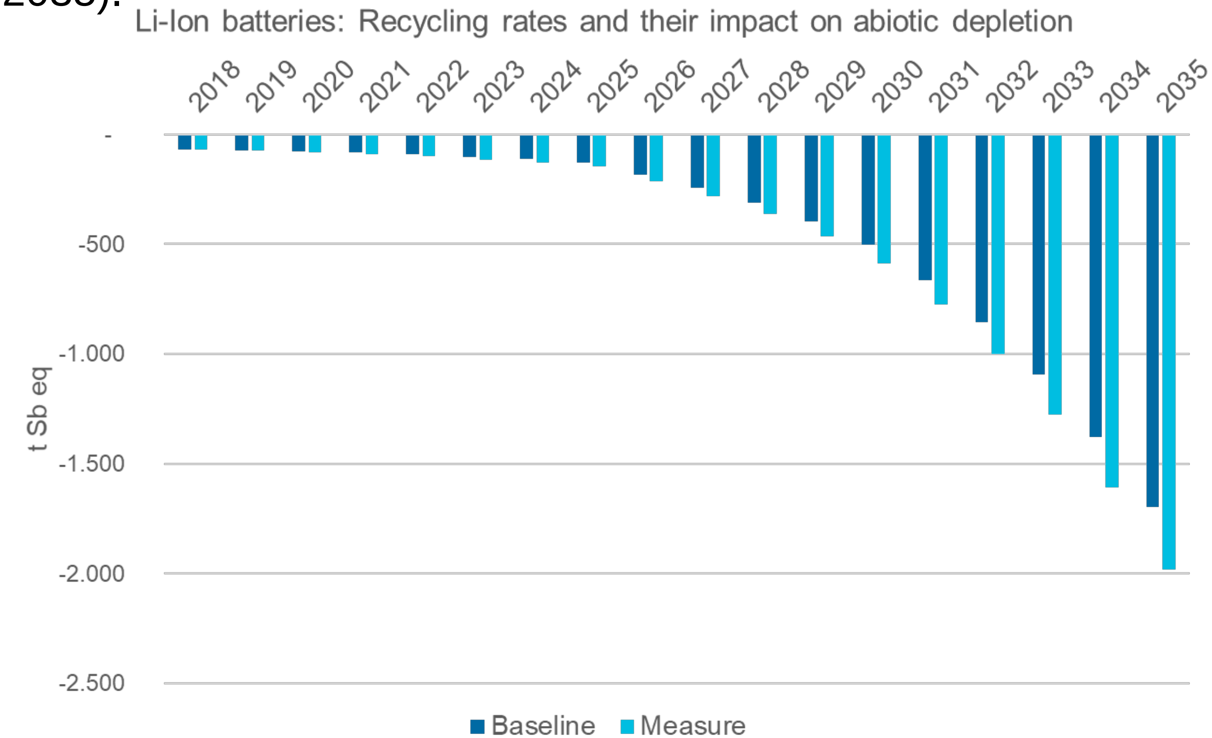


Measure 7 – Recycling efficiencies and material recovery rates (IVm)

Impacts of Option 1b: Recovery rates Li-ion – initial results ADP

Abiotic depletion: Negative emissions: net-reduction / benefits; secondary materials from recycling replace primary production.

ADP of Li-ion recycled in the EU from 2020 to 2035; comparison of baseline and Option 1b. Increase of recovery rates of Co, Ni, Li and Cu (Option 1b) in 2023 and in 2028 (no further changes up to 2035).

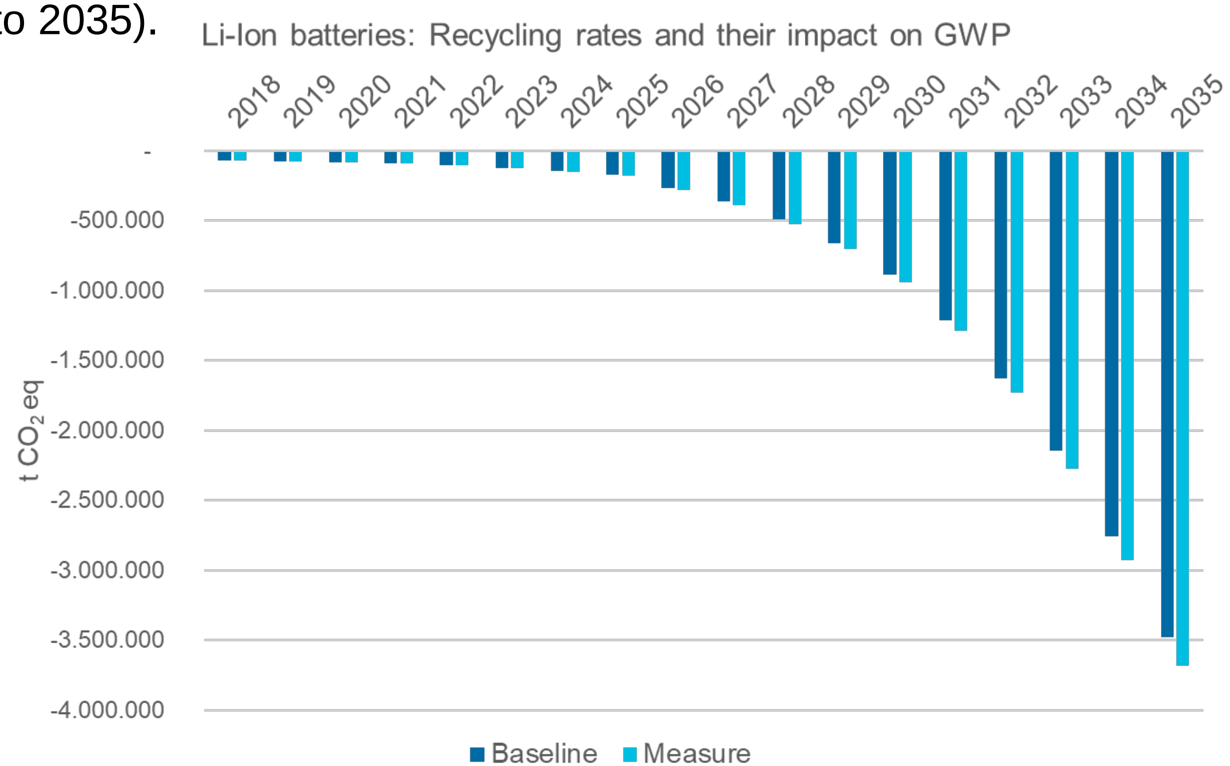


Measure 7 – Recycling efficiencies and material recovery rates (IVn)

Impacts of Option 1b: Recovery rates Li-ion – initial results GWP

GWP: Negative emissions: net-reduction / benefits; secondary materials from recycling replace primary production.

GWP of Li-ion recycled in the EU from 2020 to 2035; comparison of baseline and Option 1b. Increase of recovery rates of Co, Ni, Li and Cu (Option 1b) in 2023 and in 2028 (no further changes up to 2035).



Measure 7 – Recycling efficiencies and material recovery rates (IVo)

Impacts of Option 1b: Recovery rates Li-ion – initial results

Material recovery targets

- Due to the high relevance of the active materials (e.g. critical metal Co; more than 50% of ADP and human toxicity) specific targets for the recovery of these materials are considered to be necessary.
- Mn and graphite are currently not included in the active materials. (Recovery rates for Mn and graphite can be foreseen at a later stage)
- No targets are defined for Mn (recycling processes not economically feasible) and graphite (usually used for energy generation. No recycling process for recovery of high-quality secondary graphite established).
- Material recovery targets can be introduced successively over time:
  - Co 90%, Ni 90%, Li 35% and Cu 90% (e.g. starting in 2023)
  - Co 95%, Ni 95%, Li 70% and Cu 95% (e.g. starting in 2028).
- Currently, only targets up to 2028 are proposed; a further increase in targets after 2030 may be considered at a later stage.

Measure 7 – Recycling efficiencies and material recovery rates (IVp)

Impacts of Option 1b: Recovery rates Li-ion – initial results

Material recovery targets

‚Sum' target for all active materials together (Co, Ni, Li) instead of individual targets?

- ➢ A sum target would provide higher flexibility to recyclers.
- ➢ However, a sum target may result in economically less valuable materials (Li) not being recycled.

→ A sum target is not recommended.

General recycling aspects of Options 1a and 1b

- ❖ Material recovery and recycling efficiency targets apply for all chemical types and all applications of Li-ion batteries.
- ❖ Recovery targets apply independently of the share of a metal in the battery.
- ❖ Only high-quality recycling is accounted for material recovery targets (no down-cycling).
- ❖ Battery chemistries in particular of Li-ion may change comparatively fast. → In order to allow for an easier adaptation of targets, recycling targets should be laid down in a regulation.

Measure 7 – Recycling efficiencies and material recovery rates (Va)

Option 2: Pb-acid batteries – initial results

- A content of about 68 mass-% Pb is assumed to be a typical value for the composition of a Pb-acid batteries.
- Recycling of Pb-acid batteries primarily focuses on recovering Pb.
- Environmental impact categories GWP and ADP from Pb-acid recycling are presented.
- Recovered materials replace the primary production of the same material and result in credits.
- Results present **potential** environmental benefits of recycling (assumption of 100% recovery of all materials).
- Enironmental benefits from recycling Pb and plastics are in focus (see details next slide); other potential recycling (e.g. to produce sulfuric acid or components of fertilizer) are not taken into account.

		100% recovery rate	100% recovery rate
	Composition	**ADP**	**GWP**
Pb	68%	100%	70%
plastics	12%	0%	30%
Total	100%	100%	100%

Measure 7 – Recycling efficiencies and material recovery rates (Vb)

Option 2: Pb-acid batteries – initial results

Results for the recycling of Pb and plastics; GWP and ADP (see table of the previous slide)

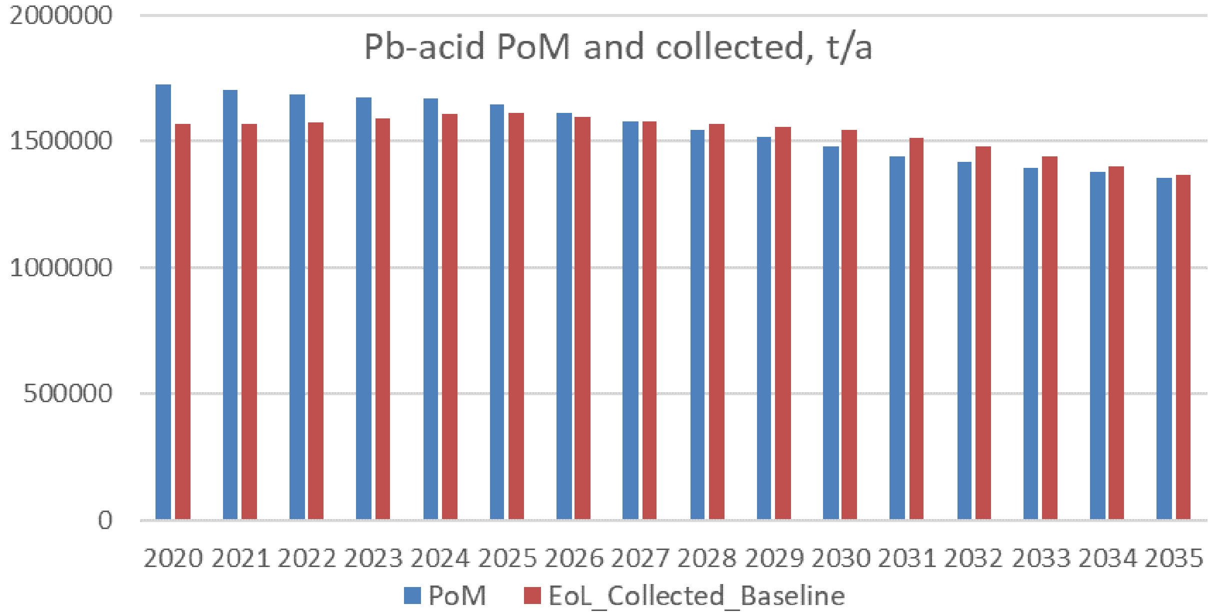
- All environmental impacts are dominated by the recycling of Pb.
- Recycling of plastics (casing) is relevant for credits of GWP (ca. 30%). However, resource depletion is neglectable for plastics.
- Pb can be considered as a hazardous substance in the Directive and therefore presents a main reason for Pb-acid recycling → Recovery of Pb has the highest priority

→ To support the highest possible recovery of Pb a quantitative material recovery target shall be established.

Measure 7 – Recycling efficiencies and material recovery rates (Vc)

Option 2: Pb-acid batteries – initial results

Developement of Pb-acid batteries PoM (in t/a) in the EU from 2020 to 2035 and the amounts collected at EoL in the same period.
Due to the decrease of automotive batteries PoM the amounts collected exceed PoM after 2026.
Amounts collected decrease from about 1.61 million tonnes in 2025 to about 1.36 million tonnes in 2035.
About 250 000 tonnes (15%) less recycling capacities are required within 10 years.



Measure 7 – Recycling efficiencies and material recovery rates (Vd)

Option 2a: Recycling efficiency Pb-acid – initial results

Recycling efficiencies - current situation

- Recycling processes for Pb-acid are well established in the EU.
- Most average Pb-acid recycling efficiencies reported by MS to Eurostat are significantly higher than the current target values of 65%.
- On EU-level, average recycling efficiencies range from about 81% to 83%. Most MS data range from about 70% to more than 90%. Only 3 MS reported recycling efficiencies below 75% for the reference year 2017.

Measure 7 – Recycling efficiencies and material recovery rates (Ve)

Option 2a: Recycling efficiency Pb-acid – initial results

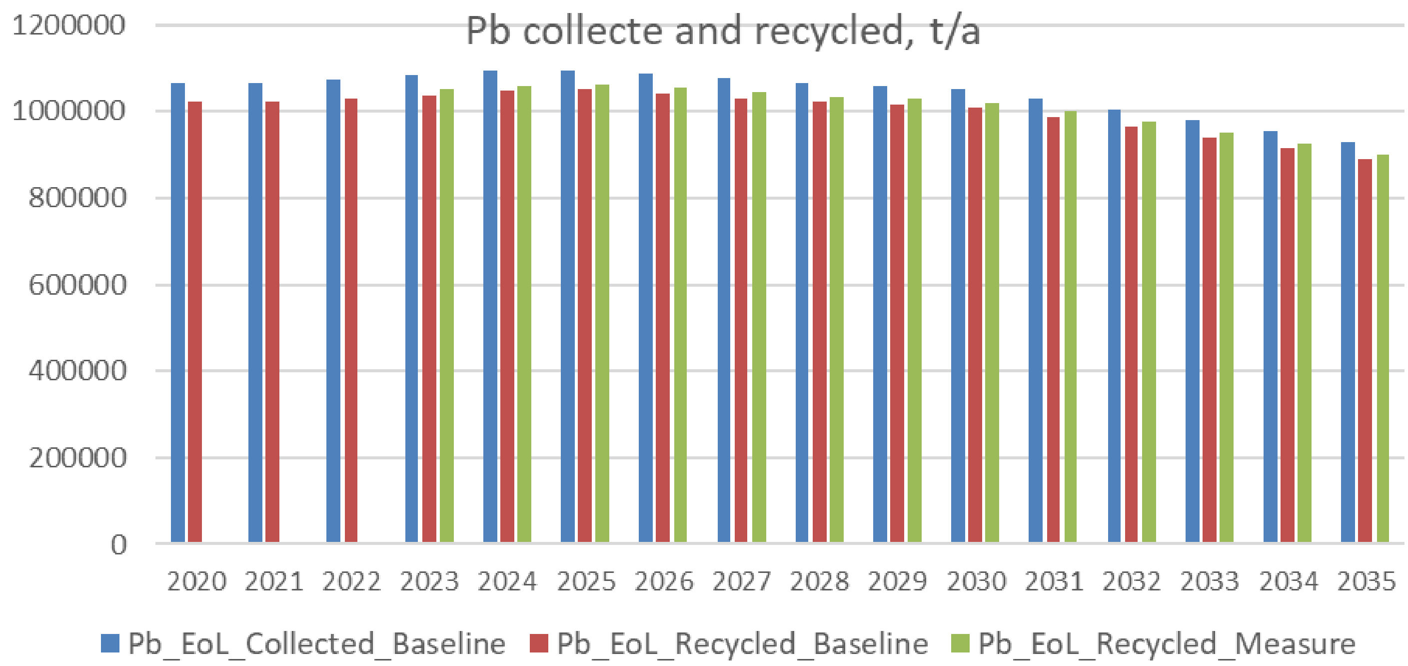
Adaption of the recycling efficiency target of Pb-acid

- For the reference year 2017, an average recycling efficiency of 83.4% was achieved on EU-level.
- Only 3 MS reported recycling efficiencies below 75% for the reference year 2017.
- A target value of 75.0% (3 MS would have to adapt to 75%) would result in an increase of the average recyling efficiency from 83.4% to 83.6% on the EU-level.
- A target value of 80.0% (6 MS would have to adapt to 80%) would result in an increase of the average recyling efficiency from 83.4% to 84.4% on the EU-level.
- MS data present an average from different plants. Thus, a target value is likely to result in a different increase if applied to individual plants.

Measure 7 – Recycling efficiencies and material recovery rates (Vf)

Option 2b: Recovery rates Pb-acid – initial results

Developement of lead (in Pb-acid) collected and recycled (in t/a) in the EU from 2020 to 2035.
Increase of Pb average recovery rate from 95.9% (baseline) to 97.0% (measure) (starting in 2023)
About **12 000** tonnes of Pb are additionally recoverd every year (from 2023 to 2030).
In total, about **95 000** tonnes of Pb are additionally recovered from 2023 to 2030 (cumulative).



Measure 7 – Recycling efficiencies and material recovery rates (Vg)

Option 2b: Recovery rates Pb-acid – initial results

New target for a material recovery rate of Pb

- Average recovery rates for Pb on EU-level range from about 93% to 96% (MS data reported to Eurostat). However, some MS show a significant deviation from the average value.
- In the reference year 2017, an average recovery rate of Pb of 95.9% results on the EU-level. Recovery rates of 6 MS are below 95%.
- A target value of 95.0% (6 MS would have to adapt to 95%) would result in an increase of the average recovery rate from 95.9% to 97.0% on the EU-level.
- A target value of 96.0% (6 MS would have to adapt to 96%) would result in an increase of the average recovery rate from 95.9% to 97.3% on the EU-level.
- MS data present an average from different plants. Thus, a target value is likely to result in a different increase if applied to individual plants.
- PRO may only contract recyclers who meet the targets (material recovery rates and recycling efficiency).
- If less recycling capacity is required in the future, those recyclers who meet the highest standards (therefore new targets need to be established) should be awarded the contract in a competitive process.

Measure 7 – Recycling efficiencies and material recovery rates (Vh)

Option 2: Pb-acid batteries – initial results

Initial conclusions

- Adapt the current target value of the recycling efficiency of Pb-acid from 65.0% to 75.0%.
- Additionally, adapt the recycling efficiency according to the measure on process/plant specific minimum targets.
- Additionally, introduce a material recovery target for Pb: 95.0% (according to the measure on process/plant specific minimum targets). A further increase could be considered e.g. after 5 years.
- Additionally, an obligation to recycle the outer casing of automotive and industrial Pb-acid batteries (above e.g. 5 kg) .

Measure 7 – Recycling efficiencies and material recovery rates (VIa)

Option 3: methodology of recycling efficiency – initial results

Major changes of the recycling efficiency are already addressed in the measure on process/plant specific minimum targets and would also apply for this measure.

The methodology how to calculate the recycling efficiency is addressed in this option:

- Calculation based on the metal content: in case a metal is recovered e.g. as an oxid (or any other compound) only the metal content is accounted for recycling. (see material recovery rates)
- Only high-quality recycling (material recovery) is accounted for. Thus, downcycling, e.g slags going into road construction or active carbon potentially resulting from graphite, as well as energy recovery are not taken into account. If valuable materials are used in cement or in road coatings, filling salt mines etc. – these kind of uses should not be considered toward achieving recycling rates. Standards on what is considered high-quality recycling need to be defined. (see slags etc.)
- What is accounted for as recycling has to be calculated over the entire process route incl. also additional process steps which happen at the end of the entire recycling chain. (see process/plant specific minimum targets)
- New recycling efficiency targets (lower than the current targets) have to be defined.

Measure 7 – Recycling efficiencies and material recovery rates (VIb)

Option 3: methodology of recycling efficiency – initial results

- Future developments need to be taken into account; graphite is so far not recovered, however, technical progress might make it an option to also recover graphite.
- Specific standards should be developed for different chemistries, e.g. LFP and NMC separately.
- **Outer casing / periphery are not taken into account for the recycling efficiency.**
- Additionally and separately, **material recovery rates for specific active and other materials will apply**.
- Recycling data of other batteries are generated separately (e.g. for NiMH and alkaline) but are at a later stage aggregated. **For transparency, harmonized data, comparability and fair competition this data should be kept separately and reported separately.**
- **Currently, contracts are awarded on the basis of price. This means that the recycler with the most favourable offer is awarded the contract. In the future, the recycler with the highest recycling efficiency and material recovery rates should be awarded the contract.**

Measure 7 – Recycling efficiencies and material recovery rates (VIc)

Option 3: methodology of recycling efficiency – initial results

- ❖ Main advantages of this option: simplified calculation, better comparability, fair competition
- ❖ Main disadvantages:
  - Extensive works and time consuming procedure to develop and coordinate a new calcluation methodology and to define new and ambitious recycling efficiency targets.
  - Defining standards on what is considered high-quality recycling (in particular for non-metals, e.g. plastics) can be difficult and potentially controversial.
  - New battery chemistries would require new or adapted recycling efficiencies and thus require once again a complicated target setting process.

→ If all other measures (process/plant specific minimum targets, recovery rates, auditing system, slags) are implemented, it is questionable whether the remaining additional benefits of this measure will justify the high effort of developing a new methodology for recycling efficiency.

→ Specific aspects mentioned in this measure are important (highlighted in **bold** in the previous slides; if not already part of another measure) and should be considered independent of a new methodology for recycling efficiency.

Measure 7 – Recycling efficiencies and material recovery rates (VId)

Impacts of the options – initial results

Economic impacts

- Increasing costs for recyclers to establish processes for new recovered materials, e.g. Lithium. Sometimes additionally recycled materials have lower value, e. g. manganese.
- Also costs for established recycling processes may increase if higher recycling efficiencies and recovery rates are set.
- Chemistry of batteries evolves very fast. If e.g. the share of Co decreases over the years the costs may increase for achieving a certain efficiency target for this metal.
- For critical materials, e.g. Co, Li additional amounts are available for the European market.
- Higher targets of recycling efficiencies and material recovery rates will result in higher revenues of secondary materials within the EU.

Social impacts

- Probably low effects in the EU.

Measure 7 – Recycling efficiencies and material recovery rates (VIIa)

Overview – Initial conclusions

- The table summarizes the proposed recycling efficiencies and material recovery rates for Li-ion and Pb-acid batteries.
- Baseline figures are included for comparison.

	Baseline	Target	Target	Baseline	Target
Baseline	Li-ion recovery rates 2020	Li-ion recovery rates 2023	Li-ion recovery rates 2028	Pb-acid recovery rates 2020	Pb-acid recovery rates 2023
Aluminium	80%				
Iron	95%				
Plastics	0%			10%	
Lead				93%	**95%**
Nickel	80%	**90%**	**95%**		
Cobalt	80%	**90%**	**95%**		
Manganese	0%				
Lithium	10%	**35%**	**70%**		
Copper	80%	**90%**	**95%**		
Graphite	0%				
Recycling efficieny		**50%**	**60%**	65%	**75%**

Measure 7 – Recycling efficiencies and material recovery rates (VIIb)

Overview – Initial conclusions

- The table provides an overview on the options (recycling efficiency and material recovery rates incl. recycling of casing / periphery) and measures that determine the new regulatory framework for battery recycling.
- Options and measures are linked to the different battery types.
- The table indicates which option and measure applies to which battery type.

Options / Measures	Recycling efficiency	Material recovery rates	Casing / periphery	Process/ plant specific minimum targets	Slags etc.	Auditing system
Pb-acid	adapt	X	X	X	X	X
NiCd	no change			X	X	X
Li-ion	new	X	X	X	X	X
Other	no change			X	X	X

Measure 7 – Recycling efficiencies and material recovery rates (VIII)

Initial conclusions

- ✓ Recycling targets (material recovery rates and recycling efficiencies) for Li-ion and Pb-acid batteries should be newly developed or adapted.
- ✓ Setting targets for material recovery rates for specific materials (Co, Ni, Li, Co, Pb) leads to higher environmental benefits.
- ✓ For critical metals needed in rapidly growing markets, e.g. Li, Co in Li- ion batteries, the effects will occur with a significant time delay.
- ✓ Recycling differs considerably between plants. New or higher recycling efficiency and material recovery targets will increase the overall recycling standards.
- ✓ For industrial batteries above a certain weight (e.g. 5 kg), the recycling of the outer casing / periphery should become mandatory.