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).*

European Commission

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 4: Restriction of primary batteries

Measure 4

Restriction of primary (single use) batteries

Measure 4 – Restriction of primary batteries

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Measure 4 – Restriction of primary batteries (I)

Problem description

- The volume of portable batteries placed on the market is increasing, of which primary batteries have a large share (ca. 70%);
- In some cases consumers choose to use primary batteries as they are often cheaper (e.g. AA, AAA) and in others secondary replacements may not be available in all sizes (button cells). In both cases this preference contributes to the large numbers of primaries placed on the market and subsequently to impacts from battery disposal.
- Many single-use batteries are not disposed of properly, which contributes to such batteries having an overall negative impact on the environment;
- In contrast to secondary batteries that can be recharged and used again, the fact that primaries can only be used until the battery is empty suggests reducing the volume of such batteries on the market would also lead to a large reduction of impacts related to improper disposal.
- Existing LCAs suggest that in many cases where primary batteries are replaced with rechargeables, impacts on the environment decrease in light of the multiple recharge cycles that lower the total impact per Wh energy supplied, however this is usually associated with the number of recharge cycles and may differ from user to user and will thus be looked into in the assessment;

Measure 4 – Restriction of primary batteries (IIa)

Alternative options

- Proposed options address primary batteries, i.e., the permissibility of placing these on the market. Direct impacts are thus expected in relation to market flows of batteries and related impacts.
- Nonetheless, a prohibition of primary batteries (all or some) will also affect the sales and use of rechargeable batteries and thus also their related impacts. (e.g., NiMH, Li-Ion);
- The design of battery operated devices placed on the market may also be affected in some cases;
- It is considered that some consumers shift from primary batteries to rechargeable ones even without a prohibition – i.e. as observed in the current market shares of such batteries. This “natural shift” to rechargeable batteries (baseline) is considered the same under all options and excluded from the comparison of impacts. In this sense, the analysis considers only the shift to rechargeable batteries that is driven by the regulatory provisions.

Measure 4 – Restriction of primary batteries (IIb)

Alternative options

Baseline: Business-as-usual (BAU)

- Current situation without any prohibition for primary batteries.
    - On the one hand it is expected that the number of primary batteries increases with the general increase in portable batteries POM;
    - On the other hand there is a natural shift from primaries to rechargeables and despite the nominal growth, the share of primary batteries from all portables is not increasing;
- In total the nominal share of primary batteries POM of all portables shows a slight decrease, but the tonnage shows a slight increase, see above.
- This affects the various forms of primary batteries similarly (round cell, block cell, button cell)

Measure 4 – Restriction of primary batteries (IIc)

Alternative options

Option 1 (OP 1): Total prohibition of all primary batteries by 2025

- All primary batteries to be replaced as of 2025;
- This affects the various forms of primary batteries similarly (round cell, block cell, button cell):
  - Some users are to replace primaries with drop-in replacements of the same format (e.g., NiMH);
  - Some users are to replace primary operated devices with rechargeable operated devices with other format (e.g., Li-Ion) → in some cases such batteries are integrated, in others they can be replaced (e.g. camera examples middle and right)

Measure 4 – Restriction of primary batteries (IId)

Alternative options

Option 2 (OP 2) : Total prohibition of all primary batteries by 2025 with exemptions

- A certain share of primary round and block batteries to be exempted;
- All primary button cells to be exempted;
- All other primary batteries to be replaced with a spilt between primaries being replaced with drop-in replacements and device replacements.

Measure 4 – Restriction of primary batteries (IIIa)

Main assumptions

- The **scope of batteries** looked at under this measure is portable batteries in the sense that batteries to be affected by the primary prohibitions and their related impacts are to be considered:
  - Primary batteries – all (phased-out) ;
  - Secondary batteries (or rechargeables) – those to be placed on the market as a replacement for primaries once the measure becomes effective.
- A few types of **battery replacement routes** are expected:
  - Drop-in replacement; a primary battery is replaced with a rechargeable of the same form (e.g., NiMH)
  - Device replacement: instead of replacing the battery within the device the consumer shall purchase a new device (e.g., with a Li-Ion battery that can be replaced or that is integrated or cable operated) and the old device will be scrapped;
  - No-replacement – in some cases the device will be scrapped without replacement (devices no longer needed, like toys)
- The prohibition thus also impacts a scope of devices (depends on replacement route):
  - Drop-in replacement: Some consumers will purchase a **charger** for the battery;
  - Device replacement: New devices purchases, some with charging device.

Measure 4 – Restriction of primary batteries (IIIb)

Main assumptions

The modelling of options:

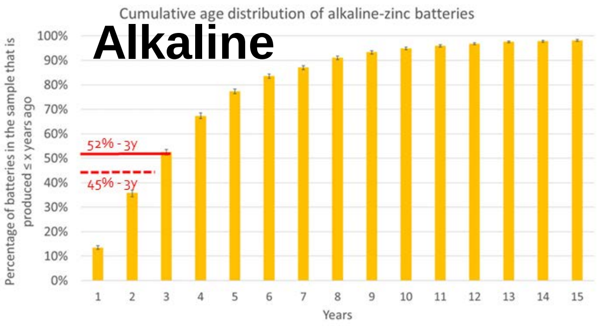
- In the modeling of options with prohibition we look only at **alkaline** round and block cells in the primary category and thus at **NiMH** and **Li-Ion** batteries in the secondary category.
- It is assumed that a transition period (until 2025) is sufficient for development of replacements;
- The starting point for the modelling is a forecast for alkaline POM in the baseline scenario (tonnage), used as a basis to conclude how many batteries are to be replaced and when.
- EUCOBAT & Mobius (2017)* estimated the average age of batteries of various chemical families arriving at collection. The study also provides estimations as to how many batteries reach EoL within a shorter or longer lifespan and within the average lifetime.
    - This was used to determine when alkaline batteries shall reach EoL and need replacement as a first step.

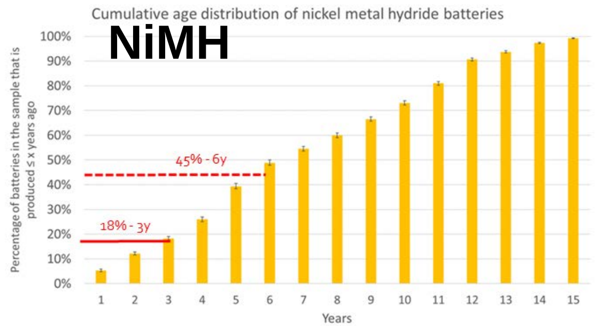
*EUCOBAT & Mobius (2017) How battery life cycle influences the collection rate of battery collection schemes - Consolidated European report

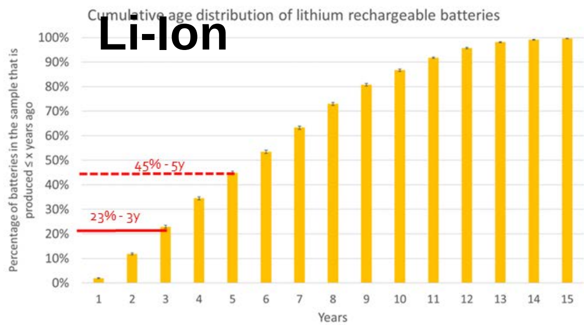
Measure 4 – Restriction of primary batteries (IIIb)

Main assumptions

- The EUCOBAT & Mobius (2017) lifespan trends:







- It was assumed that the prohibition comes into force from 2025, meaning alkaline batteries could no longer be placed on the market in 2025.
- Thus when alkaline batteries reaching EoL in 2025 and shortly after are replaced, this represents the "first time replacement" with a secondary battery (NiMH or Li-Ion).
- The first time replacement has a longer service life, depending on its chemistry and thus further replacements occur based on the EUCOBAT & Mobius (2017) estimations for that battery chemistry.
- In this way, the alkaline POM and EoL is used to determine the NiMH and Li-Ion POM and EoL in options where the prohibition applies.

*EUCOBAT & Mobius (2017) How battery life cycle influences the collection rate of battery collection schemes - Consolidated European report

Measure 4 – Restriction of primary batteries (IIIc)

Main assumptions

- In BAU all alkaline EoL batteries are replaced with a new alkaline battery (total aggregated tonnage for 2025-2035)
- For replacements in other scenarios weight-based factors were calculated based on the comparative weight of an AA alkaline, an AA NiMH and an EN-EL3a Li-Ion battery (reflex camera) considered to replace 2 batteries. These batteries also provide the basis for comparison of costs and energy consumption (explained later).
- In OP 1 alkaline EoL batteries are replaced with NiMH and Li-Ion batteries using a weight factor (first time replacement). Further replacements follow the EUCOBAT & Mobius (2017) average age estimations to determine POM and EoL tonnage for NiMH and Li-Ion batteries.
- In OP 2, 10% alkaline EoL batteries are replaced with alkaline and the rest split between NiMH and Li-Ion as described for OP 1.
- We have assumed:
  - 30% drop-in replacements with NiMH;
  - 70% device replacement with Li-ion;
  - The no-replacement route has not been considered in modeling impacts (conservative assumption)

Measure 4 – Restriction of primary batteries (IIId)

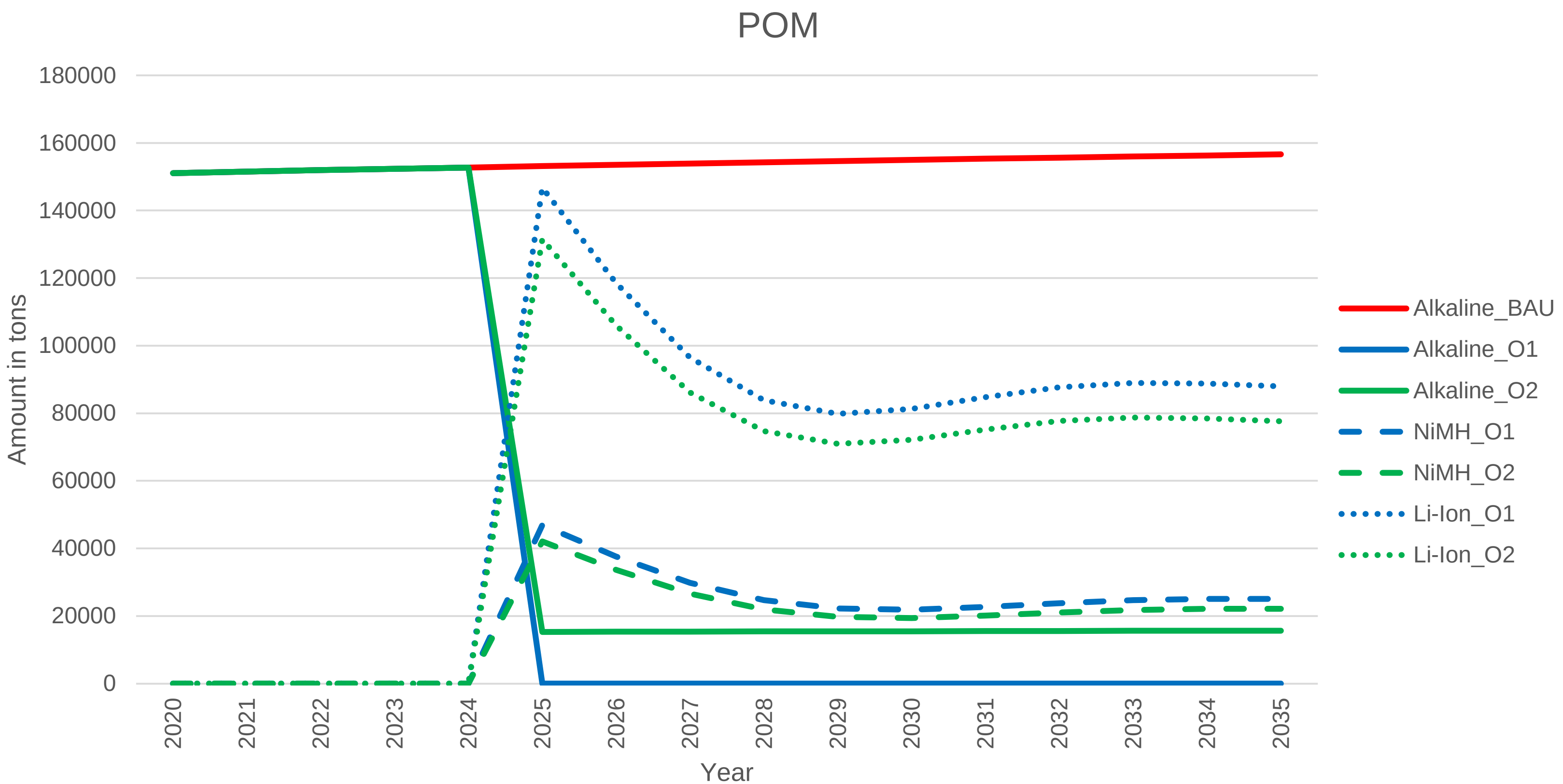
Main assumptions

- The calculated number of POM for each battery chemistry is used as a basis to calculate resource consumption and most other environmental impacts and later also to calculate purchase costs for consumers.
- Calculating energy consumption based on the POM was not straightforward and a product example has been chosen in this case to demonstrate the general expectations regarding energy consumption. For rechargeable batteries energy consumption is based on the number of expected recharge cycles of a battery before it is replaced and the energy consumption of recharging. The following has been assumed:
  - NiMH: 10 recharge cycles;
  - Li-Ion: 20 recharge cycles;
- The number of batteries collected and recycled is calculated based on the share of batteries arriving at EoL and brought to a battery waste management operator.

Measure 4 – Restriction of primary batteries (IVa)

Impacts of the options – initial results for round and block cells

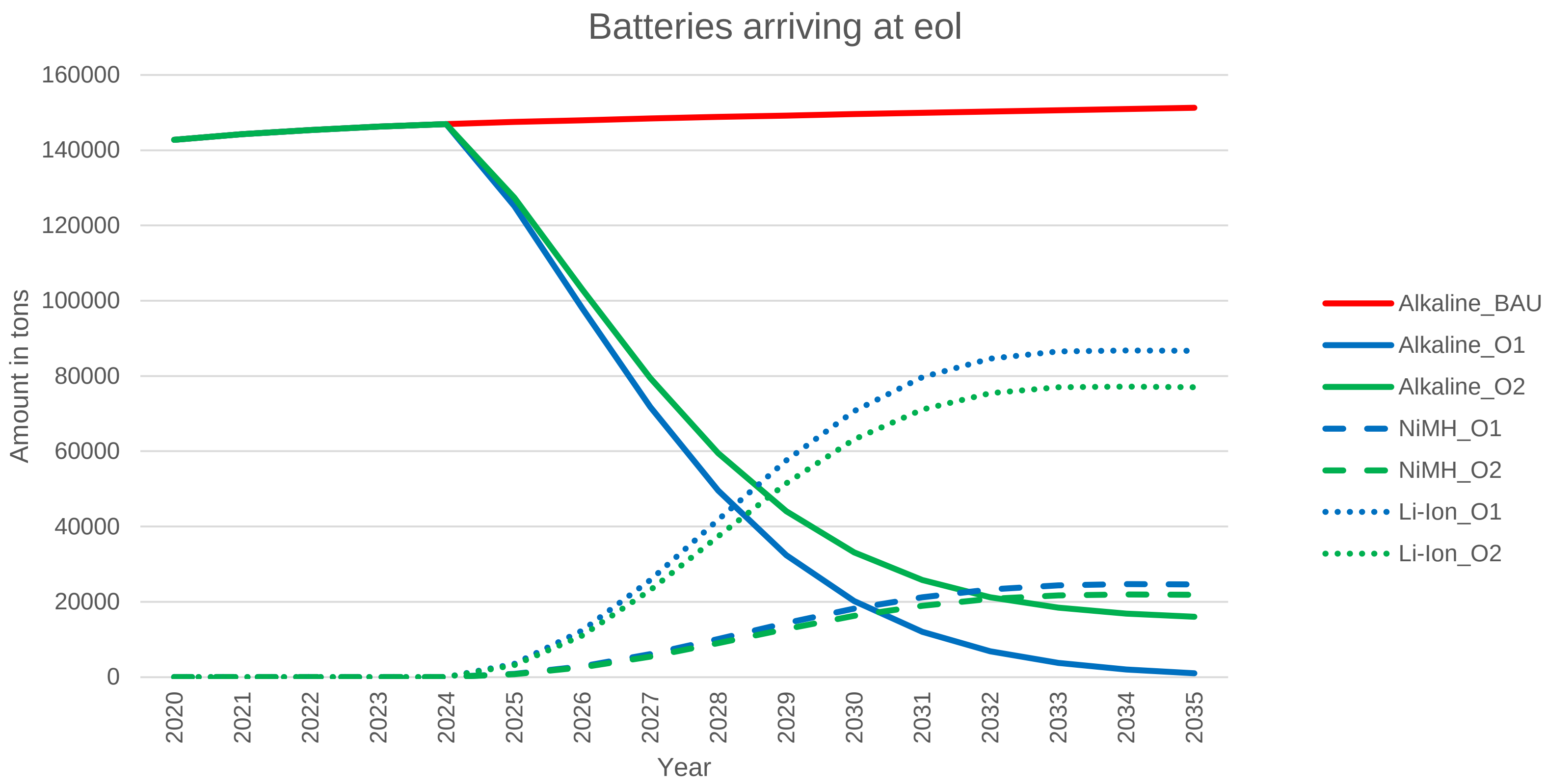
Differences between BAU and options 1 & 2 in the POM;
In the scope of this provision, NiMH and Li-Ion batteries are not POM in the baseline, in which zero regulatory driven replacements are assumed; The complete prohibition in OP 1 results in large sales of such batteries in 2025, which slowly decrease and stabilise towards 2032. In OP 2 this process is slightly decreased as some alkaline are exempted.



Measure 4 – Restriction of primary batteries (IVb)

Impacts of the options – initial results for round and block cells

Differences between BAU and options 1 & 2 in the batteries arriving at EoL;
Alkaline batteries arriving at EoL decrease quickly after the prohibition and are expected to almost disappear around 2035 in OP1. In there place, NiMH and Li-Ion increase slowly from 2025 and on, stabilising in 2032. In OP 2 the process is a bit more gradual.

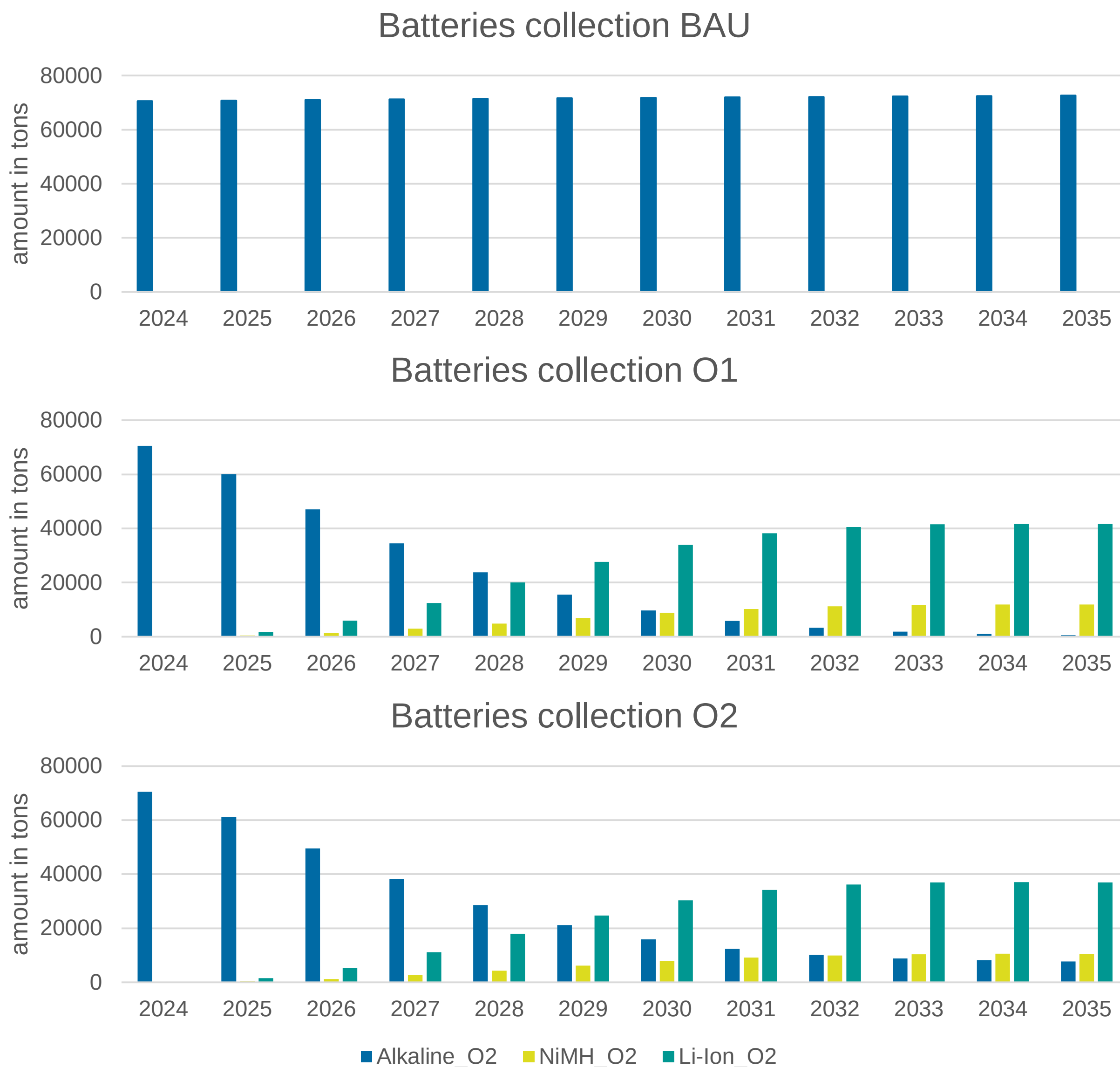


Measure 4 – Restriction of primary batteries (IVc)

Impacts of the options – initial results for round and block cells

Differences between BAU and options 1 & 2 in the batteries collected; The decrease in the alkaline tonnage in OP 1 is set-off in part by NiMH and Li-Ion tonnage of collected batteries. The total tonnages of bateries collected in thousand tonnes:

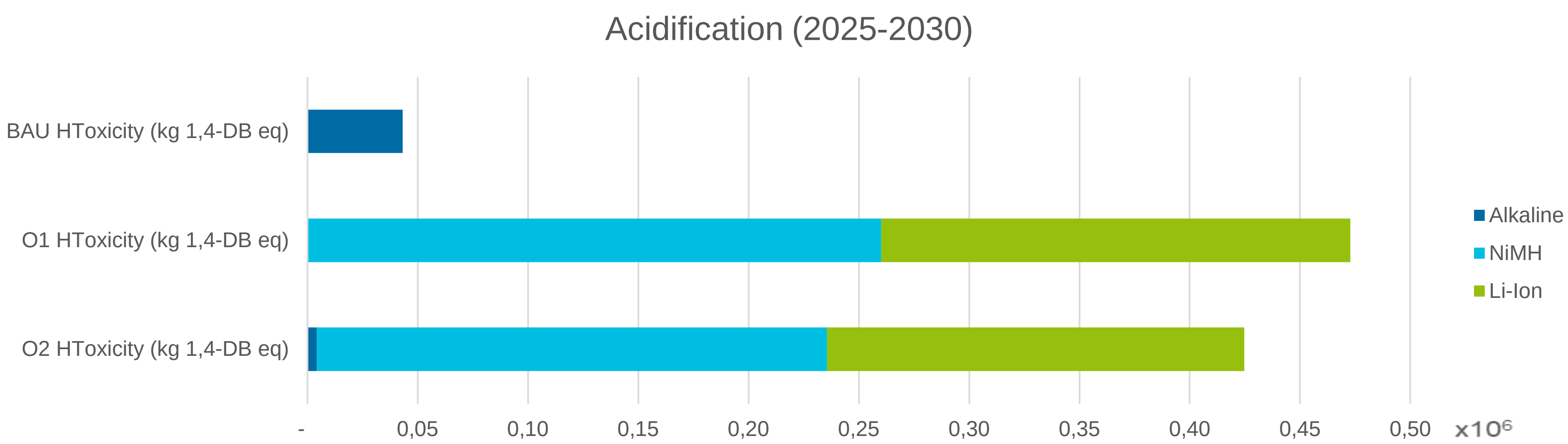
- BAU: 789
- OP 1: 590
- OP 2: 607



Measure 4 – Restriction of primary batteries (IVe)

Impacts of the options – initial results for round and block cells

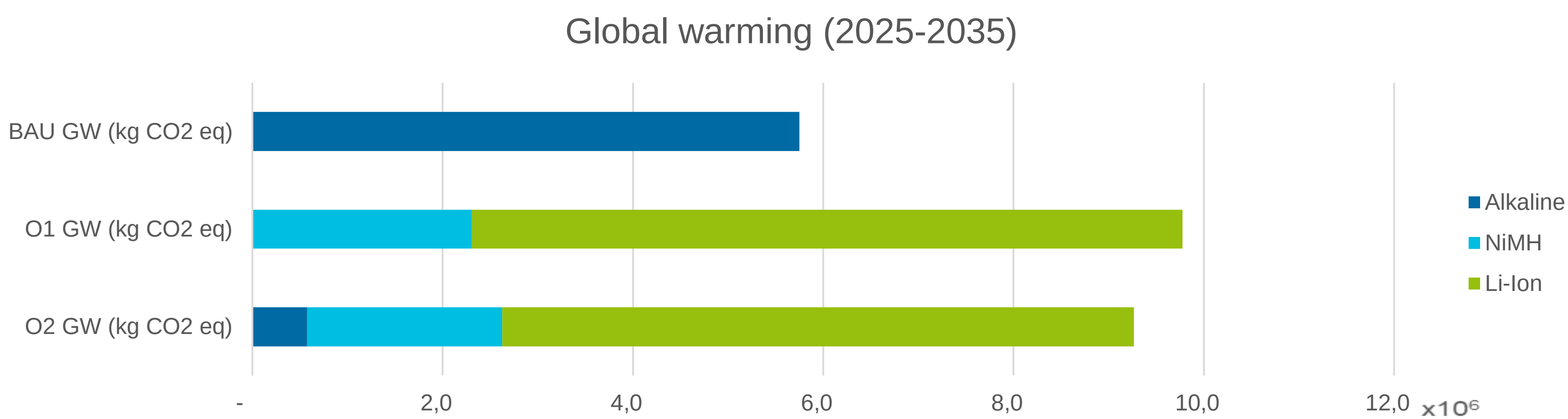
Differences between BAU and options 1 & 2 in environmental impacts;
In relation to acidification, the phase-out of alkaline batteries results in a large increase of such impacts on the environment in OP 1 and OP 2, with both NiMH and Li-Ion batteries contributing to such impacts.

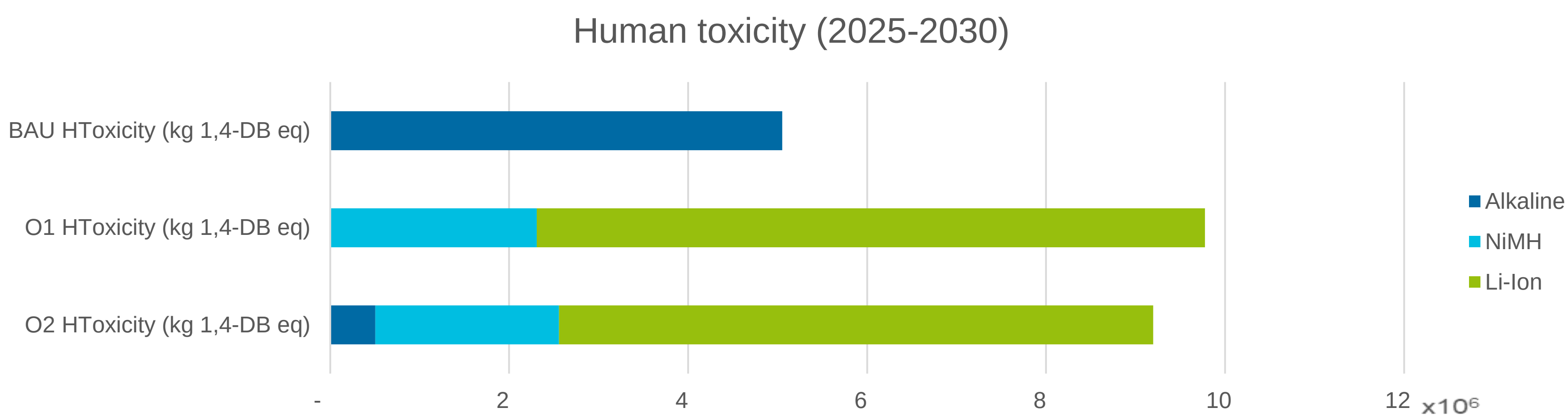


Measure 4 – Restriction of primary batteries (IVe)

Impacts of the options – initial results for round and block cells

Differences between BAU and options 1 & 2 in environmental impacts;
For global warming as well as for human toxicity, though alkaline batteries show significant impacts, particularly in the baseline, the contribution of Li-Ion batteries outweighs such environmental impacts for both these parameters in OP 1 and OP 2.

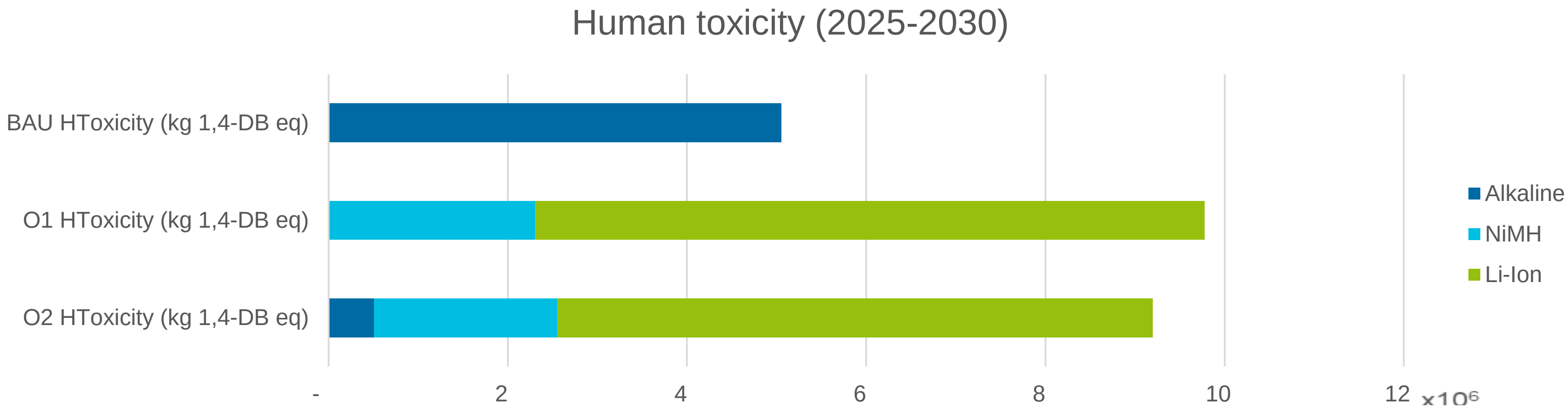


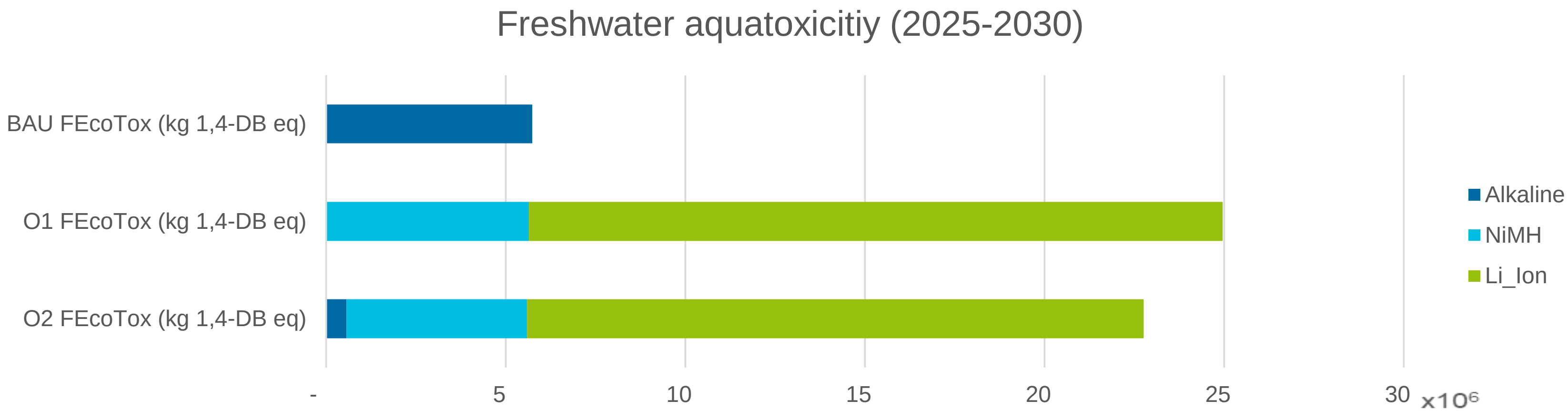


Measure 4 – Restriction of primary batteries (IVe)

Impacts of the options – initial results for round and block cells

Differences between BAU and options 1 & 2 in environmental impacts;
For both eco-toxicity parameters (fresh water and marine water), though alkaline and NiMH batteries also have negative impacts on the environment, in OP 1 ad OP 2 the impacts from Li-Ion batteries have the highest contribution to this area.

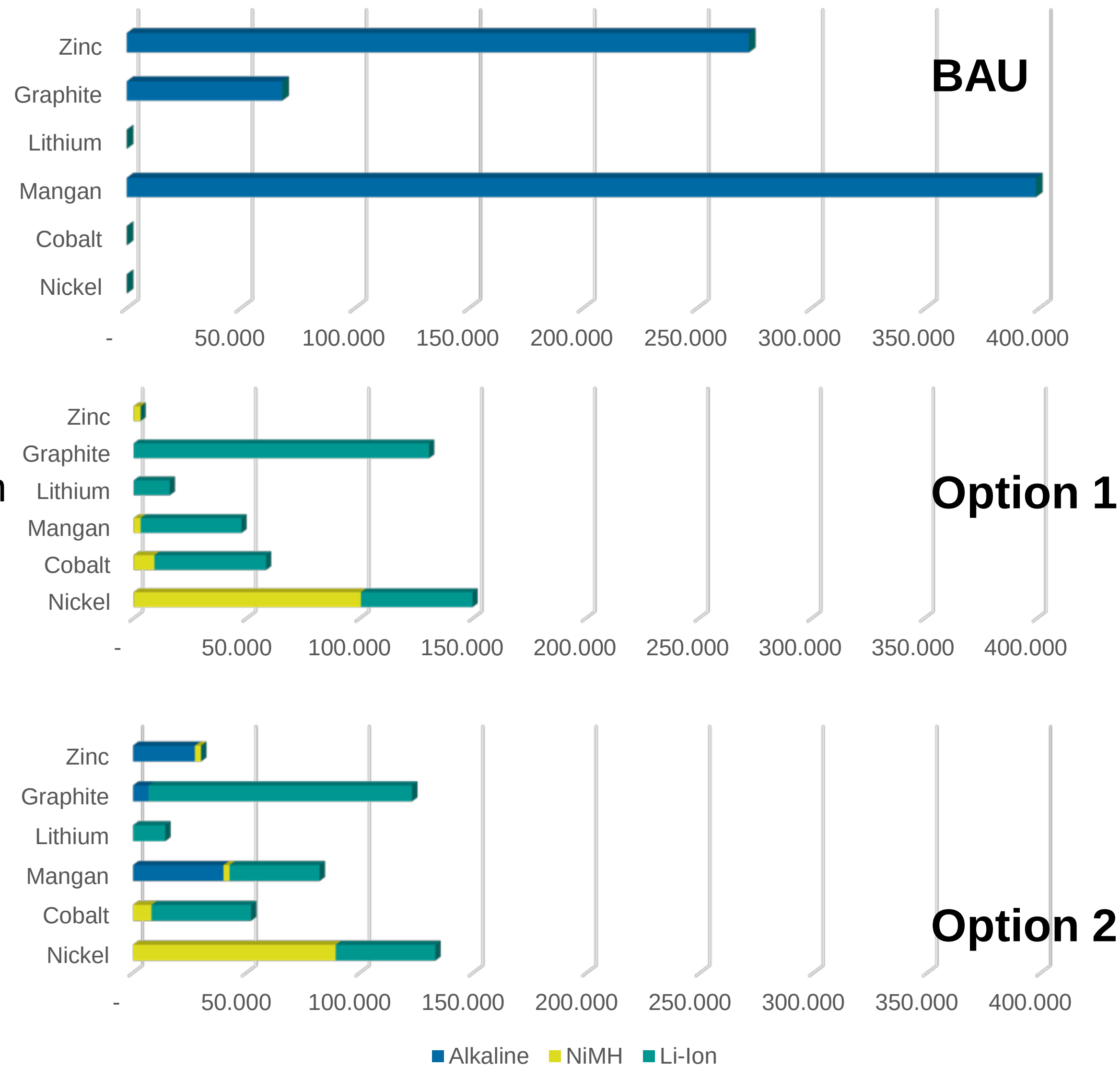




Measure 4 – Restriction of primary batteries (IVf)

Impacts of the options – initial results for round and block cells

Differences between options in resource consumption. The Baseline consumes almost twice as much resources. Toxicity should also be checked, but from an economic perspective OP 1 and OP2 consume larger CRM amounts. Recycling of some active materials is low (graphite, lithium, manganese) and for others high (cobalt, nickel, zinc) also variing between the options.



Measure 4 – Restriction of primary batteries (IVg)

Impacts related to energy consumption and total service life of battery operated devices

It is not straightforward to calculate differences between the options in energy consumption and energy costs so an indicative example was developed:

Looking at the example of a camera, it is assumed that:

- An Alkaline battery provides sufficient energy to photograph 200 photos, a NiMH battery provides sufficient energy to photograph 650 photos when fully charged and a Li-Ion battery 950 photos.
- For alkaline and NiMH the camera requires two AA batteries to operate. Only one Li-Ion battery is needed (e.g., EN-EL15a) for the above service.
- Assuming the average lifetime of a camera is 20,000 photos, a user will need ca.200 AA alkaline batteries, 6.2 NiMH AA batteries recharged 10 times each and 1.1 Li-Ion batteries recharged 20 times each.
- Using average costs for batteries and chargers (0.96-24 € for batteries; 18-36€ for chargers), and energy costs of 0.22 € per kWh for 2025 the total service cost per user was calculated as follows:
- Using alkaline batteries total service costs are 192.00 €;
- Using NiMH batteries total service costs are 48.73 €;
- Using Li-Ion batteries total service costs are 56.51 €.

It is concluded that though the initial purchase cost of a single rechargeable battery is more expensive than a primary battery, the consumer saves costs through recharging and reduced purchase for further batteries.

Measure 4 – Restriction of primary batteries (IVh)

Impacts of the options – initial results

Environmental impacts – part 1

- POM of batteries: The prohibitions lead to a lower total tonnage of batteries being POM between 2025-2035 in OP1 and OP2 (~20% less than BAU). Annually, after stabilization, at the end of the period in 2035, the POM tonnage in OP 1 is 28% lower than in BAU and 26 % lower in OP2 than in BAU. Subsequently, impacts related to the POM are as follows:
  - Battery collection: Battery collected tonnage (and recycling) in both OP 1 and OP 2 is about 25% lower than in BAU, however with a decrease collected primaries and increase in collected rechargeables.
  - In OP 1 and OP 2 users shall have additional costs for energy needed to recharge batteries, however this is assumed to be significantly less than the cost of purchase of replacement primary batteries.
  - Resource consumption – looking at active materials, the baseline consumes a larger amount of resources, but more CRMs are consumed in OP1 and OP 2 – this will affect also the amount of resources that can be recycled and respective revenues.

Measure 4 – Restriction of primary batteries (IVh)

Impacts of the options – initial results

Environmental impacts – part 2

- Environmental impacts calculated based on POM are as follows:
  - The **global warming** impacts of Li-Ion batteries are similar to those of alkaline batteries and thus the options are not far in terms of total impacts (5.7-9.8 million tonnes CO_2 eq) OP 1 and OP 2 have a total higher impact to GW.
  - **Acidification** impacts are relatively low in all options (0.04-0.47 million tonnes SO_2 eq), with the baseline having factor 10 lower impacts than other options.
  - The contribution of OP 1 to **human toxicity** impacts is about twice that of the baseline, with OP 2 lagging only a bit behind. Human toxicity impacts range in this case between 5 to 15 million tonnes 1,4-DB eq.
  - Looking at **Eco-toxicity** (aquatic fresh water and marine), the baseline also scores more favorably, with OP 1 having around 5 times higher impacts and OP 2 just a bit lower. Fresh water impacts range between 6 to 25 million tonnes 1,4-DB eq and marine impacts between 21 to 91 million tonnes 1,4-DB eq.

Measure 4 – Restriction of primary batteries (IVh)

Impacts of the options – initial results

Economic impacts – part 1

Collection and recycling

- In Option 1 and 2 the tonnage of batteries available for collection is to decrease by about 25%. EBRA stated that this could lead to an increase of recycling costs per tonne. In this respect it is however noted that while recyclers of primary batteries would lose business, those of rechargeables would see an increase, though the additional amounts of rechargeables may be too low to affect the per tonne cost of recycling in this case.

Macro-economic effects

- In Option 1 and 2 revenues of battery producers shift from primary to secondary and thus to a large degree also outside the EU
- Option 1 would result in costs for redesign of products (shift to Li-Ion) but also lead to revenue related to sale of such products. In Option 2 such costs would be somewhat lower in light of the exemptions.
- Option 1 would affect manufacturers of devices using primary batteries (watches where integrating charger may be difficult, but also the metering industry (remote applications), internal batteries used for back-up (power tools) etc. In some cases this would result in redesign costs and in others in loss of business. It is assumed that these negative impacts do not arise in OP 2 in light of exemptions.

Measure 4 – Restriction of primary batteries (IVi)

Impacts of the options – initial results

Economic impacts – part 2

Consumer costs

- Comparing the options, consumers will have higher **purchasing costs** for batteries (about 60% higher in OP1 than in BAU), however rechargeables are used multiple times and save costs of purchasing additional alkaline batteries. These savings also cover the additional **energy costs** that consumers have during the use of such batteries. In other words total service costs are expected to be in favor of OP 1 and OP 2.
- Consumers would also have **additional purchasing costs** where chargers or new devices need to be purchased.

Administrative costs

- Option 2 and 3 would lead to one-time costs for MS for transposition of prohibition and to operative costs (increase) in relation to enforcement and market surveillance that the prohibition is implemented. The latter shall be higher in OP 2 in light of need to differentiate between exempted and non-exempted primary batteries.

Safety risks

- Stakeholders mentioned a higher risk for safety related to incidents during the charging phase. (identification of faulty batteries by consumers). Safety risks related to Li-Ion batteries not removed from equipment may also rise.

Measure 4 – Restriction of primary batteries (IVIj)

Impacts of the options – initial results

Social impacts

Employment effects

- BAU: This option has the largest amount of primary batteries placed on the market throughout the observed period. Such batteries (alkaline, lithium, etc.) are manufactured in the EU and thus this option is the most favorable for EU employment;
- Option 1: Here the prohibition would lead to a still-stand in EU manufacture of primaries and subsequently to loss of all employment related to EU POM by 2025. Eurobat estimate that all jobs related to industrial lithium primary battery manufacturing and its supply chain including recycling would be lost. Such employment could theoretically shift to NiMH and Li-Ion employment, however manufacture of NiMH is in decrease in general and Li-Ion batteries are mainly produced outside the EU.
- Option 2: Here an exemption allows the further manufacture of 10% of round and block cells and of all button cells, resulting in a share of manufacture and thus of employment continuing.

Measure 4 – Restriction of primary batteries (V)

Comparison of options

Impact	BAU	Option 1 Total prohibition	Option 2 Exemptions
Environmental impacts	- - - - /	- - - Global warming - - - Acidification - - - Human and Eco toxicity - - - Energy consumption depends on charging behaviour	- - - Global warming - - - Acidification - - - Human and Eco toxicity - - Energy consumption depends on charging behaviour
Battery and device manufacture	/	- - Additional design costs + + Additional revenue from sales	- Additional design costs + Additional revenue from sales
Collection and recycling costs	/ process cost + revenue	/ Higher for primary, lower for others + + + Revenue from secondary material sale	/ Higher for primary, lower for others + + Revenue from secondary material sale
Consumer costs	/ /	- - for batteries and devices + + + For total service cost	- for batteries and devices + + For total service cost
Administrative burden (yearly)	/	- MS enforcement and market surveillance	- - MS enforcement and market surveillance
One-time administrative burden	/	- MS transposition of prohibition	- MS transposition of prohibition
Safety risks	/	- Increase in risk of recharge incidents	(-) Increase in risk of recharge incidents
Employment	/	- - loss of alkaline employment	- partial loss of alkaline employment

Measure 4 – Restriction of primary batteries (VI)

Initial conclusions – part 1

- ✓ Restriction provisions shall promote the shift from primary batteries to rechargeables, affecting the POM of various battery chemistries and subsequently the amount and type of collected batteries.
- ✓ Costs of battery recycling shall increase for primaries as collected amounts decrease. Costs of recycling rechargeables could increase, though the additionally collected amounts are probably small in relation to current recycling activities. In contrast additionally collected and recycled batteries would increase the amounts of secondary materials recycled therefrom.
- ✓ An increase in use of rechargeables shall also affect product design where the device replacement route is preferred over drop-in replacement or chosen in light of lacking drop-in replacements. Where the battery is integrated, this could be associated with problems of battery removability (depending on whether provisions adopted here achieve higher removability in waste phase or not).
- ✓ Shift to rechargeables may increase safety issues of improper recharging (unclear how severe this risk is) and possibly also risk of fires and related damages of batteries not removed (Li-Ion).

Measure 4 – Restriction of primary batteries (VI)

Initial conclusions – part 2

- ✓ The change in battery chemistries coming on the market shall lead to higher environmental impacts related to the production of batteries. It is not clear if the increase of collected batteries and their recycling suffice to off-set this – this will be checked for the final report.
- ✓ Consumers will face an increase in costs for batteries and devices in terms of initial investments, however this will be set-of through the possibility to recharge and reuse secondary batteries which saves purchase costs of additional primary batteries
- ✓ At the same time, administrative burdens are expected, to transpose the provisions and to enforce their implementation (the latter probably higher in OP 2).
- ✓ The measure has various economical impacts (costs and benefits for various actors) but does not lead to a decrease in environmental impacts. It is possible that enacting measures that increase the collection of primary batteries would be more effective, for example in the form of a deposit on single-use batteries. In this case, it is anticipated that "heavy" users would return batteries and thus not bear high costs of the deposit, whereas deposits from "light users" that do not return batteries could be ear marked towards campaigns for promoting battery collection.