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COMPARATIVE LIFE CYCLE ASSESSMENT OF ALKALINE CELLS AND NI-MH RECHARGEABLE BATTERIES

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Abstract

The present study presents some results obtained by applying the LCA methodology to evaluate the environmental footprint of alkaline cells and Ni-MH batteries. The approach is motivated by the increasing number on markets of electronic systems needing local and portable electricity.

The proposed study focuses on a comparison between these two elements on the basis of the same produced energy. The environmental impacts are evaluated by using the Eco-invent 2.0 data-base, with midpoint indicators associated to the CML method.

The main result of the study let appear that the difference between the environmental impacts of the studied elements is mainly due to the transportation phase. Besides, the emphasis on rechargeable batteries is only justified from an environmental point of view if the consumer uses them according to recommendations of use, i.e. recharges them 250 times.

Keywords

Life Cycle Assessment, LCA, batteries, alkaline cells, environmental impacts, climate change indicator

1. INTRODUCTION

Rechargeable or not, cells and batteries are known to greatly impact the environment. There are supposed to be sorted following a specific way which depends on the country. For example, in France, a transposition of the EU directive 2006/66/CE has modified the L.541-10 article of the environment code, and lead to the decree 2009-1139 [1].

Nevertheless, these chemical elements can be often found in classical trash cans, among usual wastes. In France, data for year 2009 are the following [2]:

- Among the 250 000 tons which were put on the market for all the categories, about 127 000 tons concerned cells and portable batteries;
- More than 207000 tons of used cells and batteries have been collected (concerning cells and portable batteries, the collection rate is 32%)
- There are about 40000 places where the collection is organized.
- The collected cells and batteries 84% are recycled and 90% are recovered.

In other words, less than 30% of these elements are really recycled or recovered. Besides, in all cases, the real question is to know their impact on the environment. But such studies are not so numerous. A recent research report [3] has studied the environmental impact of alkaline batteries. Another report [4] shows that by identifying portable batteries (with RFID), it is possible to connect a product's end of life datum to their design and manufacturing, which should help sustainability on the whole life cycle.

The Life Cycle Assessment methodology, which is a standardized approach [5,6] allows the quantification of the environmental footprint for goods, services and processes. It is then possible to identify some main points allowing the diminution of the environmental impacts since their earlier design stage. This methodology has been recently used in the field of cells and batteries [7] by a manufacturer who concluded that rechargeable batteries have up to 32 times less impact than classical cells.

We have recently used the LCA methodology for performing some case studies concerning building elements [8,9]. The idea was to show that the “common sense” generally leads to amazing conclusions, with environment impacts which can be higher for products said to be environmentally friendly. The same conclusion has been recently obtained for a system using renewable energy, especially because of the use of portable batteries [10].

In the present work, we aim to do a comparative study of the environmental impacts of Ni-MH rechargeable batteries and alkaline cells. To achieve this aim, a LCA study is made following the standardized methodology reported on figure 1.

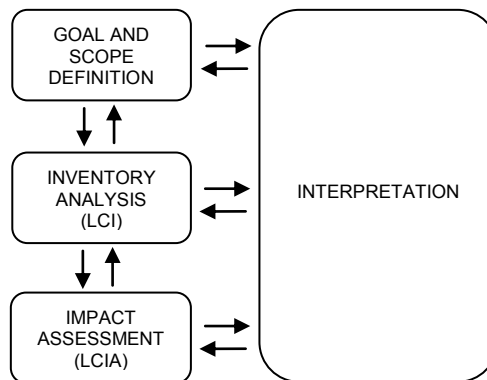


Figure 1: Different phases of the LCA methodology [5, 6]

2. GOAL AND SCOPE DEFINITION

The goal of the present study is the comparison of environmental impacts of the two following elements:

- An alkaline cell (AA type made of alkaline manganese, 1.5 V, 2850 mAh)
- A portable battery (AA Nickel metal hybrid battery, 1.5 V, 650 mAh)

To compare the two elements using the LCA methodology, a Functional Unit must be chosen: in the present study, it corresponds to a delivered power of 1W during 1000 hours, i.e. an energy of 1kWh. This energy is the one which has been used in reference [7]. Let us notice that this energy corresponds to 234 alkaline cells or 5.2 Ni-MH batteries (supposed to be rechargeable 250 times). As the quality of the data is not insured, we admit in the scope definition that the results will only be quantitative in terms of range of order, which means that they can only be significant if the difference between the environmental impacts of the two elements is significant.

The power adapter is not considered in the study.

3. INVENTORY ANALYSIS (LCI)

Data are not reported in the following. More details about the inventory analysis can be found in ref [11]. Let us notice that the four steps of the LCA methodology are considered: the production phase, the transportation, the use and the end of life. The use phase is only useful for Ni-MH batteries because of the charge.

4. IMPACT ASSESSMENT (LCIA)

In order to evaluate the environmental impacts from the inventory analysis, the Eco-invent 2.0 data-base is used [12]. The environmental impacts were estimated using midpoint indicators associated with the CML method [13]. Since each indicator has a different scale and unit of measurement, the relative impacts are normalized, according to the specifications of ISO procedures [5,6]. Each indicator is then expressed in points. A point represents the potential impact for a given indicator divided by the value of the same impact for a mean European people during one day. The chosen indicators and the corresponding units are reported in table 1. Because all the data are not known (for example the weights of the materials in the cells or batteries), and because the processes are not all known, some approximations are made according to the scope of the study (step 1). The results of the calculation are reported in the figure 2.

Table 1 – Chosen indicators for the calculation of the environmental impacts

Letter	Indicator	Unit
NRE	non-renewable energy consumption	MJ eq.
RD	resources depletion	kg Sb eq.
GWP	100 year Global Warning Potential	kg CO ₂ eq.
A	Acidification	kg SO ₂ eq.
E	Eutrophication	kg PO ₄ ²⁻ eq.
PP	photochemical pollution	kg C ₂ H ₄ eq.
AT	aquatic toxicity	kg 1.4-DB eq.
HT	human ecotoxicity	kg 1.4-DB eq.

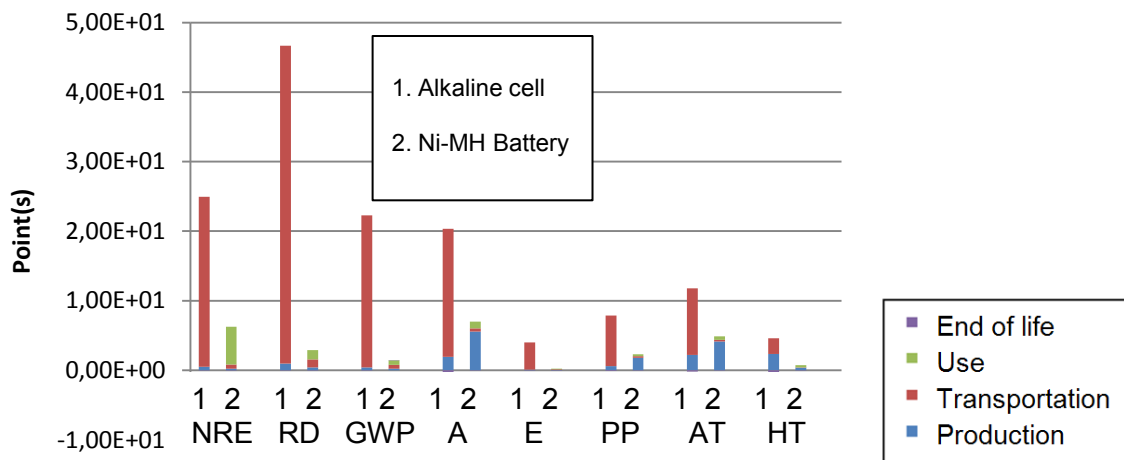


Figure 2: Environmental impacts for each life phase
(1) alkaline cells (2) Ni-MH batteries

4. INTERPRETATION

Two main conclusions can be deduced from the environmental impact assessment:

- For the whole life cycle, the alkaline cell seems to have the greatest impact on the environment than the Ni-MH batteries whatever the indicator;
- The difference between the two studied elements is essentially due to the transportation phase needed for the alkaline cells.

This is mainly due to the different number of elements in the two cases to achieve the same function: 1kWh of energy: 45 times more cells than batteries. The main results of the

present study are reported in the table 2: it is shown that, except for photochemical pollution, the present results and those of ref. [7] are of the same range of order. Let us remind that the UNIROSS study takes the adapter into account [7] but does not communicate all the results. Besides, the studied batteries are not exactly the same in the two studies.

Table 2 – Main results and comparison with ref. [7] (n.c.: not communicated)

	(I) Alkaline cells	(II) Ni-MH batteries	I/II (present study)	I/II ref [7]
NRE	25	6.2	4.0	n.c.
RD	47	2.9	16	23
GWP	22	1.5	15	28
A	20	7.0	2.9	9
E	4	0.23	18	n.c.
PP	7.8	2.3	3.4	30
AT	12	4.8	2.4	n.c.
HT	4.2	0.71	6.0	n.c.

4. CONCLUSION

The UNIROSS study concludes that the main origins of environmental impact are:

- the production and use phases (charge cycles) for rechargeable batteries
- the production phase (between 70 and 100%) for disposable batteries

On the contrary, the present study shows that it is the transportation phase which creates the greatest impact, and makes consequently the difference between the two elements.

The present study does not take into account the adapter, and the calculations must be refined. However, the Ni-MH battery is supposed to be recharge 250 times. If it is not the case (with for example only 25 recharges), and/or if the adapter is used more than necessary, the previous results could be very different. This shows that the emphasis on rechargeable batteries is only justified from an environmental point of view if the consumer uses them according to recommendations of use.

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ACV COMPARATIVE DES PILES ALCALINES ET DES ACCUMULATEURS Ni-MH

Depuis la récente étude d'Uniross, marque internationale qui commercialise des accumulateurs à usage individuel, il semble acquis que les accumulateurs impactent moins l'environnement que les piles classiques.

Le but de l'étude est de comparer l'impact environnemental d'un accumulateur Ni-MH et de son équivalent en piles jetables, pour un total de 1kWh d'énergie électrique produite. Cette comparaison est effectuée en utilisant l'analyse du cycle de vie, via la base de données eco-invent et la méthode CML pour la caractérisation des impacts. Les 4 étapes classiques du cycle de vie sont considérées. L'accumulateur est supposé être rechargé 250 fois. Le chargeur n'est pas pris en compte dans l'étude.

Les résultats montrent notamment que les accumulateurs génèrent globalement beaucoup moins d'impact sur l'environnement que les piles classiques, quel que soit l'indicateur considéré, et que la différence est essentiellement due à la phase de transport.

Ces résultats paraissent sans appel. Pourtant, on voit que le nombre de charges théorique est probablement très élevé par rapport à ce qu'il est dans la réalité. Dans certains cas, les résultats pourraient ainsi être inversés. Par ailleurs, le temps de charge n'est pas toujours significatif dès lors que très souvent les chargeurs restent alimentés après la recharge complète.

On voit donc que le moindre impact attribué aux accumulateurs par rapport aux piles alcalines n'est justifié que dans la mesure où le consommateur les utilise conformément à leurs préconisations d'usage.