# Saving Potential of Reused Batteries by Waste Production

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*Abstract:* - The amount of waste generated in the production and social sphere is for many reasons still increasing. Therefore, it is necessary to find new approaches how could be this amount reduced and find certain measures by which this production will be regulated. One of biggest problem of the waste management is related to portable batteries, The aim was to verify whether the selected number of batteries that had been submitted for recycling were been really useless or just damaged by improper use..

*Key-Words:* - Accumulators, recovery, waste disposal, savings, waste reduction.

## 1 Introduction

Reduction of wastes and their subsequent safe, environmental and economic removal is currently one of the biggest economic problems around the world [7,9,11,13,15]. "The basic legislation of the European Parliament and of the Council that constitute a framework for Community action in the field of water policy are the Directive 2000/60/ES of The European Parliament and of The Council of 23 October 2000 that establish a framework for Community action in the field of water policy, and the Council Directive 91/271/EEC of 21 May 1991 that addresses the urban waste –water treatment" [10]. The amount of waste generated in the production and social sphere is increasing. Therefore, it is necessary to introduce certain measures by which this will be regulated. Funding for these activities can be done, for example, including within the EU supporting programmes [14]. Waste disposal must be changed for all producers of waste, i.e. not only for manufacturers but also among the general public. The waste disposal should be both economically viable and environmentally acceptable. [8,16]

One of biggest problem of the waste management is related to portable batteries, which are a part of everyday life and which are abundantly used in various devices such as cameras, mobile phones, lights, MP3 or MP4 players, toys and various home appliances, etc. [5,9,11].

The aim was to verify whether the selected number of batteries that had been submitted for recycling were been really useless or just damaged by improper use (or charging). And subsequently determinate, whether this state of battery cells will be already permanent, or whether there is a chance, that these batteries become reusable in some cases.

### 1.1 Determination of the Problem

In 2008, the EU adopted a new directive on waste (75/442/EEC), which contains the basic principles of waste management - the five step hierarchy.

All EU countries are required to comply with these mandated preferences (in order from top to bottom), which relate to the waste management. Waste should go through all the steps, especially through the step further possible utilization (recycling into new products or energy production). In case it is not possible to further use it, then comes the economic method of their elimination. [3,5,9]

## 2 Portable batteries and accumulators

About 100 million new battery cells are sold every year in the Czech Republic, I.e. 14 pieces per person. Unfortunately, just a small part of these batteries is given back to recycling. In 2012, everyone gave back in average 2.25 of used cells, which is not enough to meet EU requirements. (In 2012, everyone should give back in average 4 discharged accumulators.) [2,6] Most people buy more primary (classical) cells than secondary (rechargeable), from the environmental point of view this should be contrariwise. Rechargeable batteries come in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of chemicals are commonly used, including: lead–acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

The negative environmental impact of batteries and accumulators consists in the content of toxic substances (cadmium, lead, mercury, nickel, lithium), these can contaminate ground water, plants, animals, and soil for up to 50 years. NiCd batteries are worst for environment. NiCd batteries contain between 6% and 18% cadmium, which is a toxic heavy metal and therefore requires special care during battery disposal. Cadmium, being a heavy metal, can cause substantial pollution when landfilled or incinerated. A number of measures is accepted to reduce the environmental burden - reduction of toxic substances, separate take-back and reuse of secondary cells. Under the so-called "batteries directive" (2006/66/EC) [1], the sale of consumer NiCd batteries has now been banned within the European Union except for medical use; alarm systems; emergency lighting; and portable power tools. This last category is to be reviewed after 4 years. Under the same EU directive, used industrial NiCd batteries must be collected by their producers in order to be recycled in dedicated facilities.

According to the results of the French study, the rechargeable batteries have less impact on the environment than non-rechargeable batteries. Some rechargeable battery types are available in the same sizes as common consumer disposable types. Rechargeable batteries have a higher initial cost but can be recharged inexpensively and reused many times. Using of accumulators (instead of non-rechargeable batteries) would prevent about 330,000 tons of waste generated around the world, in Europe the waste production would decrease by about 99,000 tons. In the Czech Republic this would mean about 2,000 tons of waste batteries less yearly, i.e. 66% of the weight of all portable articles, which are yearly placed on the market [3],[5].

Nowadays, NiMH batteries are probably the most used, because there will be briefly described their principle. The nickel-metal hydride battery chemistry is a hybrid of the proven positive electrode chemistry of the sealed nickel-cadmium battery with the energy storage features of metal alloys developed for advanced hydrogen energy storage concepts. This heritage in a positive-limited battery design results in batteries providing enhanced capacities while retaining the well-characterized electrical and physical design features of the sealed nickel-cadmium battery design. [4]

NiCd and NiMH batteries are based on similar electrochemical reactions at each of the electrodes are reversible. This enables energy to be stored during charging and released during discharging. Electrical energy during charging is stored by transformation to chemical energy.

At the positive electrode, the charge reaction is based on the oxidation of nickel hydroxide and discharge reaction is based on the reduction of nickel oxyhydroxide to its lower valence state, nickel hydroxide.

$$Ni(OH)_2 + OH^- \xrightarrow{charging} NiOOH + H_2O + e^-$$

$$NiOOH + H_2O + e^- \xrightarrow{discharging} Ni(OH)_2 + OH^-$$

At the negative electrode, the charge reaction is based on the decomposition of water in the electrolyte into hydrogen atoms, which are absorbed into the metallic alloy, and hydroxyl ions as indicated below.

$$M + H_2O + e^- \xrightarrow{charging} MH + OH^-$$

$$MH + OH^- \xrightarrow{discharging} M + H_2O + e^-$$

The basic concept of the nickel-metal hydride battery negative electrode emanated from research on the storage of hydrogen for use as an alternative energy source in the 1970s. Certain metallic alloys were observed to form hydrides that could capture (and release) hydrogen in volumes up to nearly a thousand times their own volume. By careful selection of the alloy constituents and proportions, the thermodynamics could be balanced to permit the absorption and release process to proceed at room temperatures. The much smaller hydrogen atom is shown absorbed into the interstices of an alloy crystal structure. The metal hydride electrode has a theoretical capacity >40 percent higher than the cadmium electrode in a nickel-cadmium couple. As a result, nickel-metal hydride batteries provide energy densities that are >20 percent higher than the equivalent nickel-cadmium battery. [4]

Charge is the process of restoring a discharged battery. Various methods are used to charge rechargeable batteries e.g. constant current charging, constant voltage charging, trickle charging, fast charging. Since different battery systems have their own characteristics and applications have their own integrated electrical input/output requirements, it is vital to select a charging method that suits both the battery system and the application. For example, some NiCd charger should not be used as a substitute for an automatic NiMH charger. Both kinds NiMH and NiCd batteries are the build-up of temperature and internal pressure due to high overcharge rates. The cell design applies the concept of oxygen recombination in lowering the battery's internal oxygen level during standard charging. However, if the cell is subjected to severe charging conditions (such as overcharging at a current rate over 1C), the rate of oxygen evolution from the positive electrode increases rapidly, exceeding the recombination reaction rate. As the oxygen recombination reaction is exothermic, this results in excessive oxygen pressure and increased temperature. The excessive pressure will then be released through the safety vent causing a reduction in the cell electrolyte; the excessive heat will eventually degrade the cell's internal contents. These two factors are considered to be the major limitations to the battery's service life. For this reason, charge control is very important in battery charging.

# 3 Problem Solution

As already mentioned, rechargeable batteries have less impact on the environment than conventional disposable batteries. The question is if people know how to use these batteries properly. Of course, there are a plenty of chargers offered on the market. Cheaper chargers are of a poor quality and they probably degrade and considerably shorten service life of the batteries. Greater consumption may suit manufacturers of these chargers and accumulators, because it enhances their turnover, but at the expense of the environmental burden.

## 3.1 Sample characteristics

To verify the assumption that people do not handle rechargeable batteries correctly and throw away still useful cells, the sample of accumulators given back to various collection boxes in different stores (mostly electronic stores) to recycling was selected. Analyzed sample comes from the Czech Republic, mostly from the Regions Hradec Králové and Pardubice and includes 186 used batteries consigned for recycling, the parameters of which were analyzed using a special charger - Charge Manager 2015, which was used for the study.

The research analyzed the total amount of 186 used accumulators, which have a different brand, size, composition and specifications. Graph on fig. 1 shows composition of the reference sample according to manufacturers, or commercial designation.

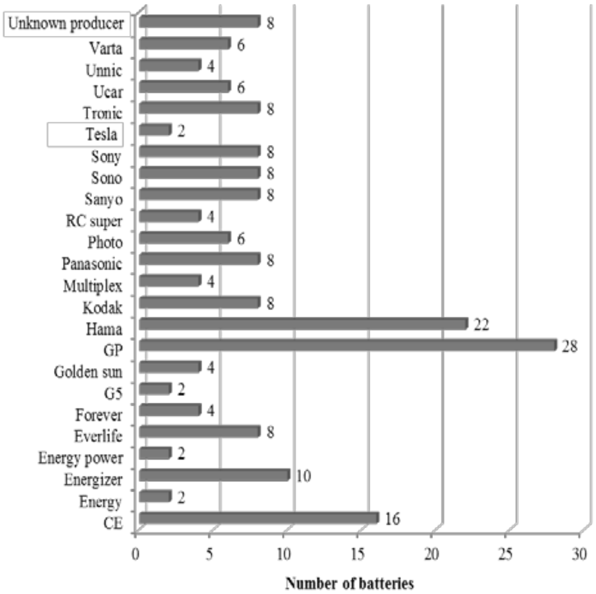


Fig. 1. Composition of the reference sample according to manufacturers, or commercial designation

Source: own

Graph on fig. 2 shows composition of the reference sample according to size (analyzed sizes were AAA, AA, C and unspecified for batteries its size did not match any of the usual categories, but whose was possible to connect to a charger, and work with them).

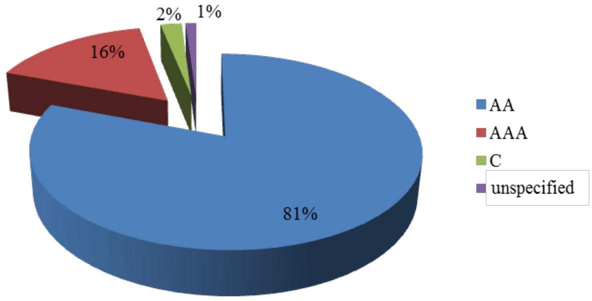


Fig. 2 Composition of the reference sample according to size

Source: own

Graph on fig. 3 shows composition of the reference sample according to capacity specified by the manufacturer. Researched batteries had very different capacities ranging from 250 to 2 800 mAh. According capacity can be approximately estimated the age of rechargeable batteries, ie. as smaller is the capacity, then will be probably older the battery.

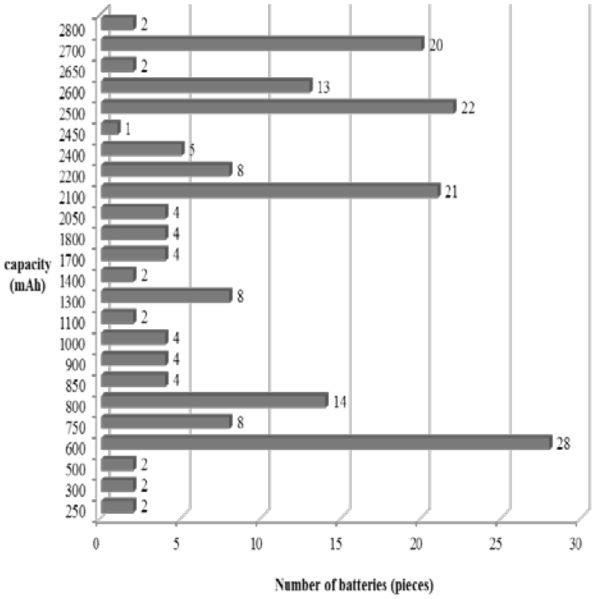


Fig. 3 Composition of the reference sample according to capacity

Source: own

Table 1 shows a sample of analyzed data, and in addition to the above mentioned characteristics of the batteries there is also newly acquired capacity after treatment, then there is column that indicates success of recovery, and a note explaining the status of a battery.

Table 1: The selected accumulators

| Producer | Capacity (mAh) | Size | Capacity after treatment (mAh) | Successful recovery yes (1) / no (0) | Type | Note |
|---|---|---|---|---|---|---|
| GP | 2050 | AA | 2178 | 1 | NiMH | |
| GP | 2050 | AA | 2306 | 1 | NiMH | |
| Tronic | 2100 | AA | 125 | 0 | NiMH | too low capacity |
| Tronic | 2100 | AA | 72 | 0 | NiMH | too low capacity |
| Hama | 2500 | AA | 376 | 0 | NiMH | too low capacity |
| Hama | 2500 | AA | 1273 | 1 | NiMH | |
| Energizer | 2500 | AA | 0 | 0 | NiMH | not possible to charge |
| Hama | 2500 | AA | 1350 | 1 | NiMH | |
| Ucar | 750 | AA | 0 | 0 | NiCd | not possible to charge |
| CE | 600 | AAA | 595 | 1 | NiMH | |
| Multiplex | 600 | AA | 244 | 1 | NiCd | |
| Sono | 800 | AA | 950 | 1 | NiCd | |

Source: own

Research has shown that 18% (34 pcs) of accumulators were not possible to revive, but 82% of the used accumulators can be reused (see Fig. 3), i.e. 152 accumulators from a total amount of 186 units. This means that consumers hand into the take back still usable cells. This situation is mainly caused by ignorance of users by producers and of course by inexpensive chargers that are marketed and widely used by consumers. Compared special charger that is able to charge the battery as 1,000 times, inappropriate chargers cause after about 100-150 charging cycles, the inapplicability of the cells.

It should also be noted, that this analysis is based on data from only one formatting cycle. But it can be expected that due to the re-formatting of batteries, these results can be further improved by re-formatting with more formatting cycles. This assumption was tested on a very small sample (35 cells) yet, the improvement of the characteristics of these batteries was confirmed. Because of a very small selection, we cannot make general conclusions.

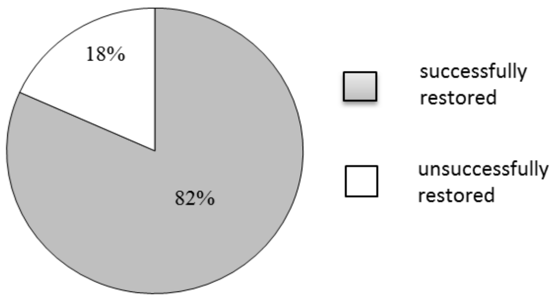


Fig. 3: Success in restoring used accumulators

Source: own

Fig. 4 divides the entire sample into three groups. Batteries were divided by new capacity, measured by Charger Charge Manager 2015 after recovery.

The first group includes batteries, which amounted to 0-69% of the capacity after the recovery, this group represents 51 pieces. The second group includes batteries with new capacity from 70 to 99% of the capacity stated by the producer, which includes 56 pieces. Finally, the last group, which reached even above 100% of its original capacity. This group represents 79 pieces of the cells that were given in take-back by the consumers. Batteries charged over 70% of their original capacity are further normally usable, actually some of them exceeded their reported capacity of over 100%. It is very surprising that despite of this fact, they were thrown away by their users, this indicates a huge profusion of the batteries and accumulators.

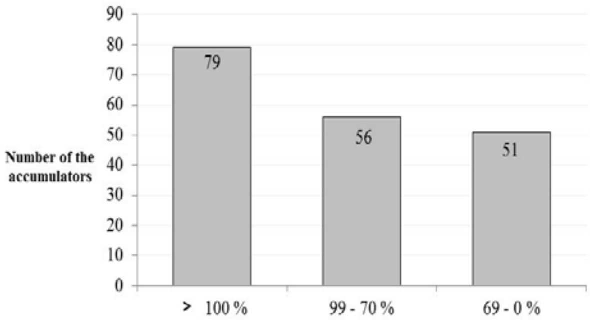


Fig. 4 Accumulators according to the new capacity after recovery.

Source: own

The next two figures complement the previous Fig. 4. Batteries charged over 70% are recorded in multiple groups so as to clearly see this unexpected result. The largest parts of both graphs represent the batteries, which have reached new capacity in percentage terms from 91 to 110%. This is an excellent result, however, it requires to ensure that users are really informed about this fact. This would subsequently reduce the impact on the environment and limit the production of this type of waste.

Fig. 5 shows a group of batteries charged to 100% of their original capacity. 10 cells received 70-80% of their original capacity, there are 11 pieces of the cells which are ranging from 81 to 90% of their original capacity and the largest group comprising 35 batteries, includes all cells, which reached new capacity from 91 to 99% of original producer's reported capacity.

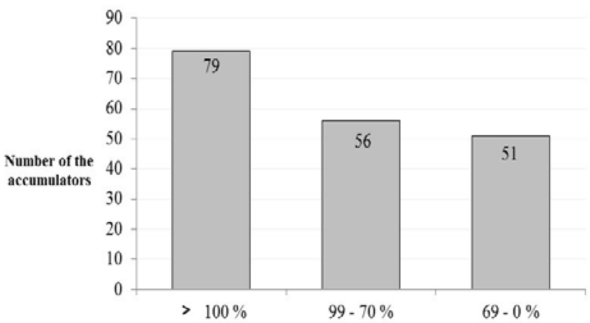


Fig. 5 - Chargeable at 70-99% of the original capacity

Source: own

The results for the group of batteries with best recovery results from chosen sample can be seen in Fig. 6. Here are included all batteries, which got over 100% of their original capacity after being restored by the special charger. 56 pieces ranged from 100 to 110% of the capacity, 18 pieces achieved capacity from 111 to 120% and even 5 batteries are between 121 to 150% of their capacity reported by the producer.

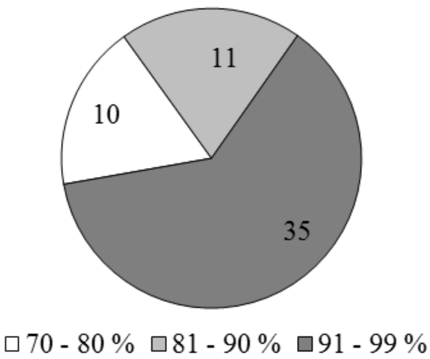


Fig. 6 – Charging at 100 – 150 % of the original capacity

Source: own

Furthermore, the batteries were divided into 4 groups according to their original capacity, which can be seen in Fig. 7. The first group includes the batteries with a capacity of 0 to 700 mAh, this group is 34 units (18%). The second group includes 46 batteries (25%), which have a capacity between 701 and 1400 mAh. The third group with a capacity of 1 401-2 100 mAh includes 33 batteries, which means 18%. Finally, the fourth group with the largest capacity (from 2 101 to 2 800 mAh) contains 73 recovered batteries, which is 39% of the total.

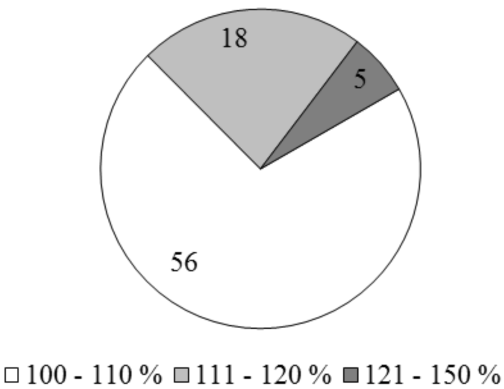


Fig. 7 – Number of accumulators in each capacity group in mAh

Source: own

## 3.2 Characteristic of used equipment and the way of disposal

Used batteries were charged by a special charger Charge Manager 2015 in the mode called alive, to determine which can be re-used and what capacity can be restored.

There is basic description according Voltcraft manual [17]: Accumulators consist of two electrodes put into an electrolyte; thus, a battery is a chemical element. Chemical processes are running inside this element. Since these processes are reversible it is possible to recharge batteries. The so-called charge voltage is required for recharging batteries. This voltage must be higher than the cell voltage. Moreover, the energy (mAh) supplied for the charging process must be higher than the one that can be drawn afterwards. This ratio of the energy supplied to the energy drawn is called efficiency. The capacity that can be taken mainly depends on the discharge current; it is decisive for the condition of the battery. The supplied charge cannot be used as a measure, because a proportion of it will be lost (for example converted into heat). The capacity data given by the manufacturer is the maximum theoretic quantity of current which can be delivered by the battery. That means that for example a battery of 2000mAh can theoretically deliver a current of 1000mA (= 1 ampere) for two hours. This value considerably depends on many factors (condition of the battery, discharge current, temperature, etc.). The term C-rate is very common for charging devices. The C-rate is the amount of current usually indicated for the charging and discharging processes. This current value given in ampere corresponds to the nominal capacity given in ampere-hours; that means that 1C = 2.0A for a battery of 2000mAh. Please note that the battery capacity which can be drawn mainly depends on the discharge current: The lower the discharge current the higher the capacity that can be drawn. A discharge current of 850mA fließen circulate with this charging device at the start of the discharge procedure: for a battery with 850mAh, 850mA are already 1C, while for a battery with 1700mAh only C/2. This is why the 1700mAh battery reaches its 1700 mAh easier than the 850mAh battery reaches its 850mAh. Nowadays, noted manufacturers indicate C/5 for the capacity of an accumulator. That means that for example a battery of 4000mAh achieves these 4000mAh for a discharge current of 850mA (= approx. C/5). But if a manufacturer indicates a discharge current of C/10 (= 400mA) for a battery of 4000mAh you can take it for granted that this accumulator cannot deliver 4000mAh for a discharge current of 850mA. Therefore, the battery provided with the indication C/10 is the worse battery. Batteries discharge themselves in the course of time. This property is known as self-discharge. The microcomputer-controlled charging process charges the batteries to 100%. 100% means up to 115% of the capacity indicated for new batteries and less than 100% of the capacity indicated for older ones. For batteris with a capacty of less than 800mAh the discharge capacity (D) may not reach 100%; this discharge value, however, must be greater than 80%, otherwise the battery is broken (preferably test with the ALIVE program). This charging device does not require a discharge before starting the recharge process. Based on its current charge status the battery is recharged to its currently possible 100%. The recharging and discharging cycle is controlled independently of the charge status of the battery. The charge and discharge current is micro computer-controlled. The discharge current of the charging device is selected at 16mA to 850mA in line with the practice. The charging device is provided with automatic charge conservation. The charging device has an automatic battery monitoring system (charge current and charge amount). The automatic battery detection registers if a battery is inserted or removed. No memory effect occurs (charge and discharge current are clocked). Thus, a high internal resistance of the battery decreases and its current carrying capacity increases. The efficiency of the battery is improved (ratio of the required quantity of current to the capacity that can be delivered). The charging device does not have a memory backup. In the event of a power outage, the data of the battery and the current functions remain stored for up to two days. If the charging device is again connected to the mains, this results in a continuation of the programme. To this end, the charging device must previously be connected to the mains and switched for at least two hours.

ALV (ALIVE) means that the battery will be charged and discharged, then recharged and discharged again and finally recharged. The ALIVE programme is used for activating new batteries and such which have been stored over a longer period of time.

There are remaining four groups according to their original capacity. From Fig. 6 it is clear that the groups are not significantly different. For the first group, which contains batteries with capacity from 0 to 700 mAh, we can say that the slightly lesser status (65%) can be justified by the fact, that in this category, there are some very old cells, for which have failed their restoration. For other groups, the average capacity of recovered accumulators moves to 80% of their original value. The best was the group with the capacity of 1 401 to 2 100 mAh, which charged at 84% of the original capacity in average.

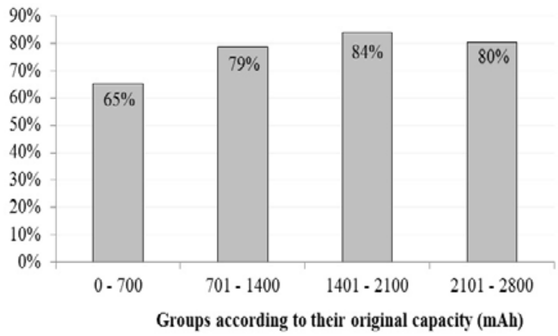


Fig. 8 – The average charge after the recovery according capacity

Source: own.

Graph on the fig. 9 shows the distribution by manufacturers and battery parameters after treatment. Selected were those, for which the analysis was examined at least 5 pieces of batteries. Evaluated is the success according to the average charge for the new capacity by manufacturer. It includes 15 groups, with success rate of charge over 100% of their capacities (Kodak, Panasonic, Photo, Sanyo and Sony). The best of them were with 119% of original recharging capacity Kodak and Photo.

On the other hand, the worst position occupied Tronic with 6% and Ucar with 26%.

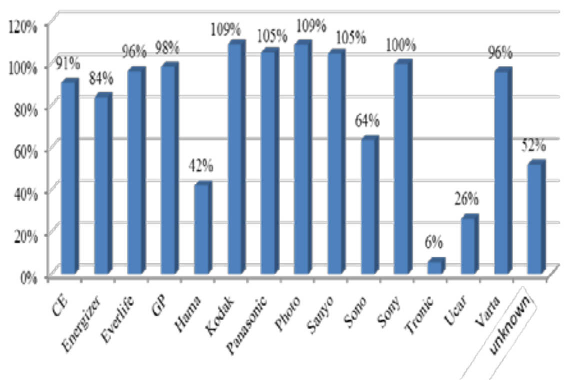


Fig. 9 The distribution by manufacturers and battery parameters after treatment

Source: own

In summary it can be said that in addition to 5 groups, which includes Hama, Sono, Tronic, Ucar and unknown manufacturers, other manufacturers have achieved excellent results, ie. new capacity of at least 80% of the original capacity. Due to the uneven representation of different brands in the sample analyzed a small number of batteries in each group, however, these results must be understood only in relation to the reference sample.

## 3.3 Calculation of savings potential

In 2011, the retail network of the Czech Republic sold nearly 100 millions of new batteries. In every household in the Czech Republic at the moment is an average of 10 used batteries. In the Czech Republic in 2012 921 tons of batteries were given back for recycling. The quantity of batteries placed on the market in the years 2010 - 2012 is shown in Table 2.

Table 2 The amount of batteries placed on the market

| The amount of batteries placed on the market in | 2010 | 2011 | 2012 |
|---|---|---|---|
| Type | Weight (t) | Weight (t) | Weight (t) |
| Alkaline | 998,888 | 1085,813 | 1322,997 |
| Zinc | 1068,407 | 928,007 | 956,62 |
| Lithium | 18,357 | 21,718 | 21,277 |
| Button cells | 20,31 | 20,877 | 24,164 |
| Nickel-cadmium | 187,517 | 153,724 | 158,092 |
| Nickel-metal hydride | 218,569 | 186,864 | 170,209 |
| Li-Ion/Li-Pol | 233,181 | 246,939 | 252,542 |
| Leaden | 320,479 | 430,931 | 480,593 |
| Alkaline accumulators | 2,045 | 3,826 | 2,387 |
| *Sum* | *3067,753* | *3078,699* | *3388,881* |

Source: [2]

It is more favorable for the environment if the battery can be used repeatedly. Disposable batteries pollute the environment more particularly because of considerably greater volume of waste produced.

It is evident from the graph in fig. 10 that the sale of conventional rechargeable cells shows a decreasing trend, especially for battery Nickel-metlahydrid while, as shown in the graph in fig. 11, the sale of disposable batteries, especially alkaline shows a growing trend.

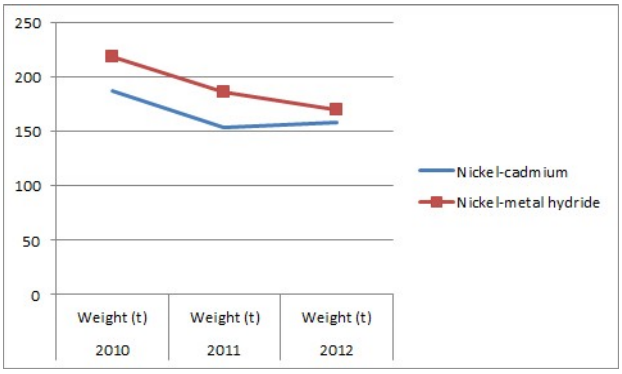


Fig. 10: The sale of conventional rechargeable cells in 2010 - 2012

Source: [2]

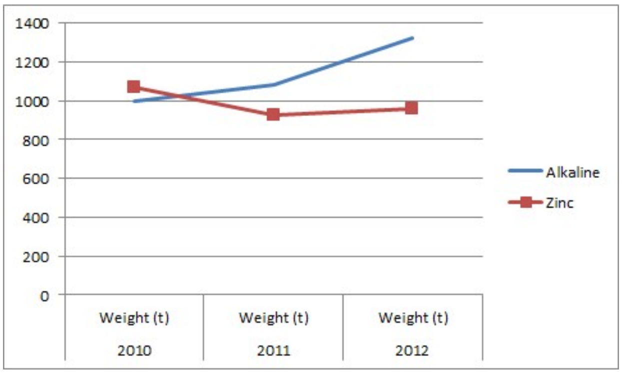


Fig. 11: The sale of disposable batteries in 2010 - 2012

Source: [2]

This may be caused, among others, by dissatisfaction with the characteristics of rechargeable batteries. Firstly, they are relatively expensive and require a battery charger, secondly, they are not able to last, as mentioned above, the number of charge cycles featured by the manufacturer. If we build on the results for the analyzed sample and apply them on the global data, it is possible to make the assumption that at least 82% of the accumulators purchased each year were not necessary to produce as they could have been replaced by reformatted, earlier produced accumulators.

Let us further consider that using a normal charger, the battery becomes unusable after app. 200 charging cycles, while by charging in pulse mode and correct treatment it increases to 1000 charging cycles. This relationship could be described mathematically by formula:

$$Q=(A \times 0{,}18)/5 \qquad (1)$$

Where

Q is the maximum number of accumulators needed in case of proper handling in t/year,

A is the number of batteries placed on the market in a given year in t

Similarly, can be expressed the achievable savings in t batteries, which did not need to be made as:

$$S = A-Q \qquad (2)$$

where S are the savings expresed in t/year.

Substituting the values from Table 2 to the formula (1) and (2) we obtain the values shown in Table 3.

Table 3 The Saving Potential

| The amount of batteries realy needed on the market | 2010 | 2011 | 2012 |
|---|---|---|---|
| Type | Weight (t) | Weight (t) | Weight (t) |
| Nickel-cadmium | 6,750612 | 5,534064 | 5,691312 |
| Nickel-metal hydride | 7,868484 | 6,727104 | 6,127524 |
| Saving potential | | | |
| Nickel-cadmium | 180,766388 | 148,189936 | 152,400688 |
| Nickel-metal hydride | 210,700516 | 180,136896 | 164,081476 |

Source: own, according [2]

From the above it is clear that many of the accumulators were probably produced because of incorrect dealing with these types of accumulators. The sample selected due to their size, of course, may not be fully representative and it is certainly the question of the extent to which the analysis can show the whole. The overall ratio of successfully renewed accumulators in a larger sample may not as favorable as in the sample chosen. On the other hand, it is possible that a part of the 18% longer unusable accumulators were damaged by improper handling. In conclusion, the analysis showed that there is probably a great potential for possible savings. This can present a challenge for the subsidy policy in the field of public administration [12].

As a measure to solve this problem an information campaign could be conducted or chargers more appropriate for a particular type of accumulators could be made more price favorable.

At the same time, it should be stated on the packaging that if the accumulators will not be charged by the attached charger, the number of cycles will not be 1000, but only e.g. 200.

## 4 Conclusion

To determine whether the batteries are really useless or just damaged by improper use (or improper charging), batteries were chosen which had been already located in the collection boxes for the take-back.

The results confirmed the assumption. It can be said, that an excessive amount of new batteries is produced and a lot of them is wasted. It should be noted that the accumulators get in large numbers into the mixed waste cans and bins, instead of recycling.

From the analysis it was found that 82% of cells from the sample are able to recover.

Total 135 accumulators get at least compliant state (at least 70% of the original capacity) after the recovery, which means that it is possible to continue using them. Due to the low quality chargers, the accumulators probably devaluate, their capacity and durability decreases. Special charger Charge Manager 2015 was able not only to recover the majority of the batteries, but also counteract the memory effect and self-discharge of the cells. Even 42% of the total battery selection (i.e. 79 cells) reached over 100% of their capacity reported by the producer after the recovery, which is an excellent result.

Finally, it must be emphasized, how little attention is paid to this problem. People are little aware of the fact that concerns the whole issue of waste, and often do not realize what happens to the accumulators which are thrown away just as unsorted municipal waste. Suggestions for improving the situation may be to increase of the public awareness through a variety of media devices or projects that are carried out by companies that deal with the take-back of batteries and accumulators. Important now and especially for the future is to recognize this fact and adjust the behavior of consumers, so that batteries would be used as efficiently and quality chargers would reduce the production of this type of waste.

*References:*

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