The flow of rechargeable batteries in the economy.

The case study of portable nickel-cadmium batteries in Germany.

Questions and Answers

FINAL DRAFT

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Brussels
November 2004

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INTRODUCTION

A review of CollectNiCad's arguments in favour of an efficient Collection and Recycling program as a policy option for the future Battery Directive.

The use of cadmium in Nickel-Cadmium (Ni-Cd) rechargeable batteries has been considered by Industry and answers to the many question raised on the presence of cadmium in our economy and environment are discussed in this document.

The absence of information being at the source of many misunderstandings the Ni-Cd battery industry has delivered for more than six years a transparent message based on observable and measurable data. It has shown its willingness to develop an efficient collection and recycling policy in all countries where Ni-Cd batteries are used and particularly in each and all Member States (MS) of the European Union.

Rechargeable batteries are made of metals, chemicals and synthetic materials. All rechargeable battery systems contain classified chemicals. Consequently, it is the opinion of the rechargeable battery industry that all rechargeable battery systems should receive the same attention when their end of life is considered.

The analysis supplied below focuses on portable rechargeable Ni-Cd batteries. It will be illustrated by data collected in a country where information is available. The case of Germany is used as a basis for this analysis due to the many reliable sources of available data in this country.

One of the objectives of RECHARGE's program is to extend the availability of such data to all MS in order to increase progressively the level of knowledge on the life cycle of portable rechargeable batteries in our economy.

1. What are the objectives of the 1988 Council Resolution ?

1.1. This decision was based on data of cadmium emissions during the 60's and 70's. These emissions have been reduced significantly during the last twenty years (§ 13.1 and § 13.2.).
1.2. The Council Resolution recommends substitution as one of the tools to reduce cadmium emissions **and it also recommends** to increase collection and recycling of cadmium containing products among others batteries.
1.3. At the time where the resolution was adopted, there were no specific data on the contribution of batteries to total cadmium emissions. The 1988 resolution was also adopted at a time when the Ni-Cd portable battery markets was in an early development stage and batteries were not of a particular concern at that time.

An extract of the text of the 1988 Council resolution is supplied below.

31988Y0204(03)
Council Resolution of 25 January 1988 on a Community action programme to combat environmental pollution by cadmium
Official Journal C 030 , 04/02/1988 p. 0001 - 0001

…/.
Welcomes the initiative of the Commission proposing an action program as an additional step forward to control environmental pollution by cadmium and agrees that such control should be pursued through an integrated approach taking into account all the various sources of cadmium pollution, including diffuse sources,

Invites the Commission to pursue without delay the development of specific measures of the kind identified in the action program, taking into account relevant Community provisions,
Stresses that, in the light of the result of scientific and technical studies, the major elements of the strategy for cadmium control in the interests of the protection of human health and the environment should be the following:

- limitation of the uses of cadmium to cases where suitable alternatives do not exist;

-stimulation of research and development of substitutes and technological derivatives, in particular, encouragement to the development of further alternatives to the use of cadmium in pigments, stabilizers and plating;

-related to the cadmium content of the raw materials used for the production of phosphate fertilizers;

-of varieties of tobacco and food plants with a lower cadmium content;

-collection and recycling of products containing cadmium, for example batteries;

-development of a strategy designed to reduce cadmium input in soil, for example by appropriate control measures for the cadmium content of phosphate fertilizers based on suitable technology not entailing excessive costs, taking into account environmental conditions in the different regions of the Community; -combating significant sources of airborne and water pollution.

2. Are Ni-Cd batteries sales the source of significant quantities of cadmium in the environment?

The refining of zinc and the use of phosphates fertilizers introduce in the economy significant amount of cadmium. The Nickel-Cadmium battery is using a majority of the refined cadmium produced at zinc refineries. Typically in Europe, the annual quantity of metallic cadmium used in batteries reaches 1’920 Tonnes. It does not mean that this quantity of cadmium is emitted to the Environment.

The first source of cadmium introduction to the Economy is the refining of zinc concentrates to produce primary zinc. This industrial activity will not be stopped if cadmium applications will be restricted and cadmium will be produced in any case under the form of unrefined cadmium cake containing zinc, lead, cadmium, mercury, copper…. Zinc and lead refineries produce more than 6400 Tonnes/year of un-refined cadmium and introduce more than 4’000 Tonnes of refined cadmium to the economy in Europe: a large ratio being exported.

Between the introduction of cadmium into the economy and emissions of cadmium to the environment, there is a complex situation that needs to be clarified in full transparency whereby several critical parameters needs to be quantified and communicated in the most appropriate way.

Indeed, there is no direct proportional correlation between the sales quantity of batteries and the cadmium quantity emitted to the environment. This report will explain the reasons of this absence of direct correlation.

3. Is it a substitute to the Ni-Cd portable rechargeable battery on the market?

During the last 15 years, the Portable Rechargeable Battery industry has been the most innovative of this industrial sector, responding to the suggestion of the 1988 Council Resolution.

New portable rechargeable battery chemistries (Ni-MH, Li-Ion, Li-Polymer in addition to Lead-acid and Ni-Cd) are found on the market satisfying an increasing demand for powering a larger variety of Electrical and Electronic Equipment. The development of a new battery technology is at first a market driven process.

The Nickel-Cadmium battery produced in 2004 has better performances than the Ni-Cd battery produced in 1990. It is one of the reason that makes it the preferred choice on a cost/performances ratio criteria in several applications where high current drain is requested.

Most comments made on the battery directive proposal by the Commission focus their concerns on metals like mercury, lead and cadmium. Nevertheless other battery systems contain chemicals and metals; this is ignored systematically.

Competitive technologies to portable Ni-Cd batteries are lead-acid, nickel-metal hydride, lithium-ion, lithium-polymer and new chemistries that my appear to-morrow on the market.

One of the objective of an Extended Producer Responsibility principle is to care about the end of life of all these batteries and their chemical content. This will also be governed by the future Chemicals policy in preparation.

The principles that will be developed below are cadmium oriented for historical reasons. In the framework of the future chemicals policy they will be applicable to all classified metals and chemicals used to manufacture a battery.

The mass flow of Ni-Cd batteries in Germany will be use as an example to justify a policy based on traceability, collection and recycling.

4. Is Cadmium mined for its own specific applications.

In 2001, the production of unrefined primary cadmium in Europe reached 6'462 Metric Tonnes (Table 1).

From this unrefined cadmium production, the European industry produces approximately 4’952 Tonnes of refined primary cadmium from which a significant fraction is exported from the EU to China, Japan and North America either as a metal or as an oxide (more than 3000 Tonnes).

Ni-Cd battery production in Europe currently requires the equivalent of 2’166 Tonnes of refined cadmium. This requirement is satisfied by the use of 1’620 Tonnes of primary refined cadmium and 540 Tonnes of recycled refined cadmium.
For the production of recycled refined cadmium, the main parameter is the collection efficiency of spent batteries: the sources of recycled cadmium are almost exclusively battery manufacturing by-products and collected spent Ni-Cd batteries.

Consequently, the recovered cadmium weight is directly proportional to the quantities of collected spent batteries that are processed for recycling. Cadmium from Ni-Cd batteries can be used in a closed loop lifecycle because cadmium recycled out of spent batteries can be re-used indefinitely for new batteries.

TABLE 1 Current and future production of cadmium in EU MS.
Current and future uses of cadmium in Ni-Cd batteries.

Cadmium Production In EU MS (Tonnes / Year)	2001	Five years scenario	Ten years scenario
Unrefined Cadmium	6462	6400	6400
Refined Cadmium (primary and recycled) Consumption by EU Battery Industry	2166	2200	2200
Recycled Refined Cadmium (Produced from in Batteries)	540	900	1100

The collection of spent industrial Ni-Cd batteries reached 3100 Tonnes in 2001 leading to the recovery of 248 Tonnes of recycled cadmium re-used in the production of new Ni-Cd batteries by European producers.

The collection of spent portable Ni-Cd batteries reached 2140 Tonnes in 2001 leading to the recovery of 295 Tonnes of cadmium mainly re-used in the manufacture of new Ni-Cd batteries.

From the processing of spent industrial and portable Ni-Cd spent batteries, a total of 540 Tonnes of cadmium was recycled in 2001.

5. What are the potential routes of humans exposure to cadmium?

Potential humans exposure to cadmium is not at the use stage of a battery but at the manufacturing (exposure of workers controlled by health and safety at workplace regulations) and at the end of life stage (exposure of humans emissions from waste treatment plants and waste deposits (landfills).

The Targeted Risk Assessment Report (TRAR) on the use of cadmium in batteries is the first official report from the EU institution that address the issue of emissions to the environment and of human exposure to cadmium at the end of life of a battery.

The first TRAR has been performed according to the best knowledge available at the time and was peer reviewed by experts of Member States on a regular basis. Experts from MS have accepted the results presented by The Rapporteur which has communicated the final draft document to the European Chemical Bureau for final publication.

The final draft has been reviewed by the highest scientific authority CSTEE (Scientific Committee for Toxicology and Eco-toxicology) of the EU institutions.

This work may require adjustments and improvements, but the basic results are publicly known and can be analysed objectively.

This analysis will use the TRAR as a reliable source of data for two reasons:

- The TRAR offers the most comprehensive and up-dated data available on the subject of cadmium emissions to air, water and soil.
- The data have been supplied by Member States that cannot ignore this work to which their national expert has contributed.

Consequently, we will refer to these data in the analysis presented below.

The EU's scientific experts (the CSTEE[1]) have issued their opinion on the EU Risk Assessment for Cadmium and the Targeted Risk Assessment Report (TRAR) on the use of cadmium in nickel-cadmium rechargeable batteries in June 2004.

[1] The CSTEE, the Scientific Committee for Toxicology, Eco-toxicology and Environment is an independent scientific body requested by the Commission to produce opinions on the risk assessment reports conducted in the context of council regulation 793/93 (existing substances regulation).

The CSTEE opinion

- states that “the contribution of cadmium exposure from sources other than nickel-cadmium batteries represents the main component in the overall exposure level for most estimations”.
- describes the contribution of nickel-cadmium batteries to the overall exposure of cadmium to the environment as ‘negligible’.
- further states that 90 to 100% of cadmium in the environment is related to other sources.

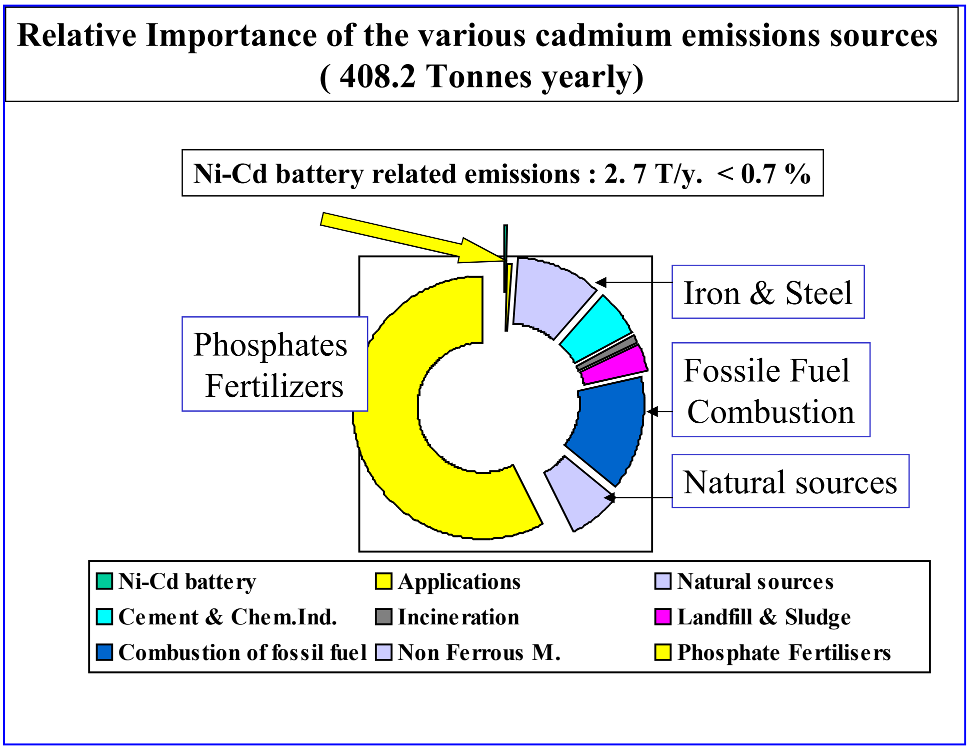

Figure 1 Relative importance of the various cadmium emissions sources to the environment (EU 15 MS + N).

The analysis of the data presented in the TRAR and summarised in the Figure 1 above confirms that Ni-Cd batteries do not represent the major source of cadmium emission to the environment.

6. What is the flow of rechargeable Ni-Cd batteries in the economy?

Rechargeable Ni-Cd batteries have a long life in the economic sphere: this contribute to a growing stock in the economy. When portable rechargeable batteries are sold , they are introduced in the economy. As these rechargeable batteries are sold with durable goods, they will not be available for collection before many years. Consequently, there is no reason to compare the production of spent batteries with the sales of new portable batteries on a year to year basis (Figure 2 A).

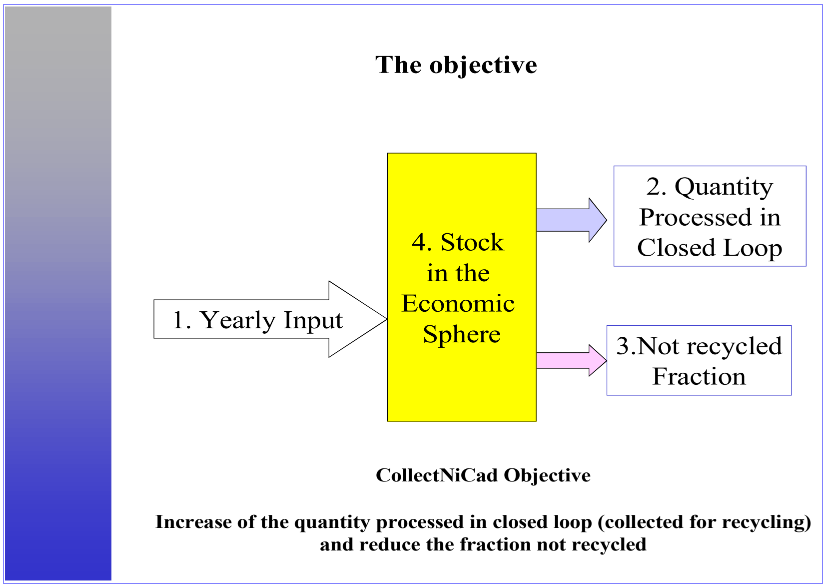

FIGURE 2.A. Batteries in the economy

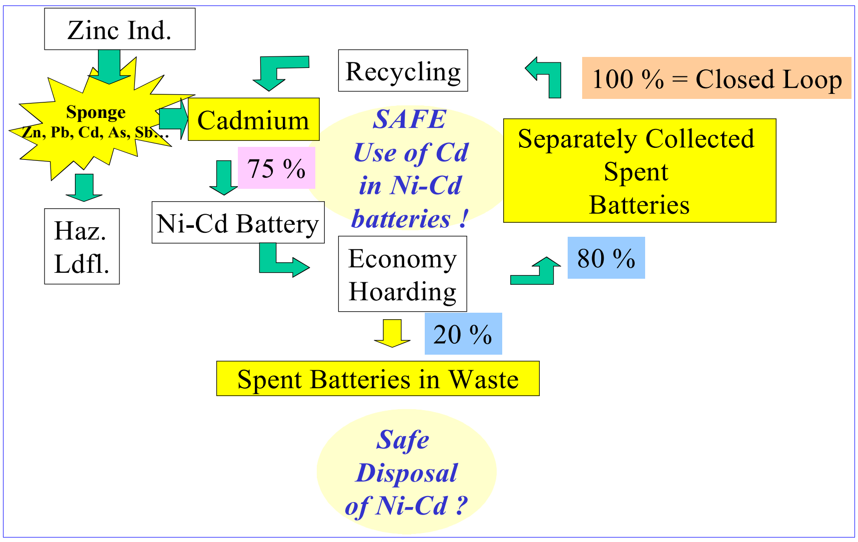

FIGURE 2.B. The Closed Loop on separately collected spent batteries

As shown in Figure 2.B. the objective of Industry is the long term management of the stock of batteries in the economic sphere and of the yearly production of spent batteries by implementing an efficient collection and recycling policy while maintaining a developing economic activity at the European and International level.

As shown in Figure 2, the Closed Loop applies to the collected batteries and their materials content. All spent batteries separately collected by dedicated programs or separated from WEEE should be processed for recycling and their materials content re-used in new applications.

7. What are the yearly sales of portable rechargeable batteries in Germany?

Due to the participation of producers to the GRS, Bosch Recycling and VfW programs, the data of Ni-Cd batteries sold in Germany are regularly registered together with other Portable Rechargeable Battery systems. Respectively 2785 tonnes, 2608 Tonnes and 3184 Tonnes have been registered by the Bosch and GRS systems in 2001, 2002 and 2003. (Figure 3).

Figure 3. Portable Rechargeable Battery Sales in Germany

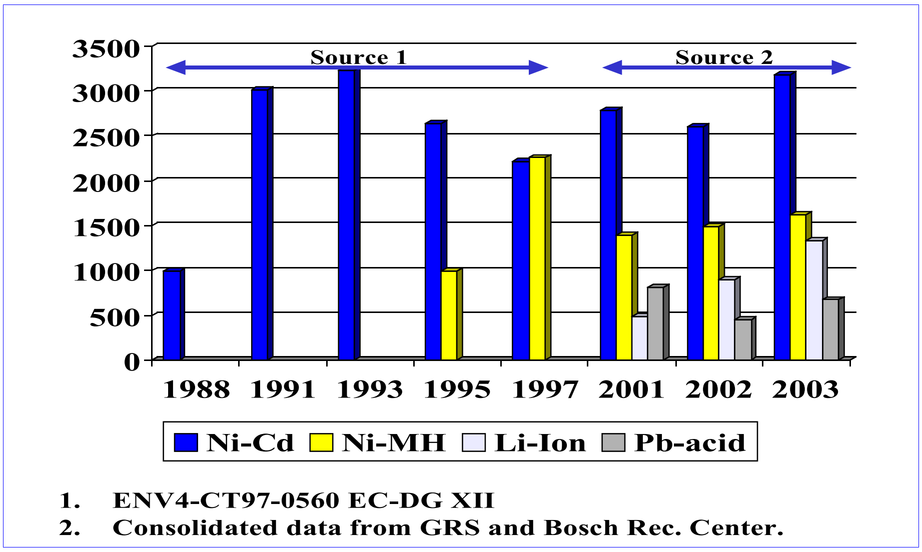

Figure 3. Portable Rechargeable Battery Sales in Germany

Figure 3 gives an historical review of information available on portable rechargeable batteries sales in Germany for the last 15 years.

8. What are the market segments for portable Ni-Cd batteries in Germany?

For portable Ni-Cd batteries, the market shares are the following: Cordless Power Tools (60-65 % by weight), other EEE equipment (20 % by w.), replacement cells for packs (10 to 15 % by w.), and single cells sales (<5% by weight).

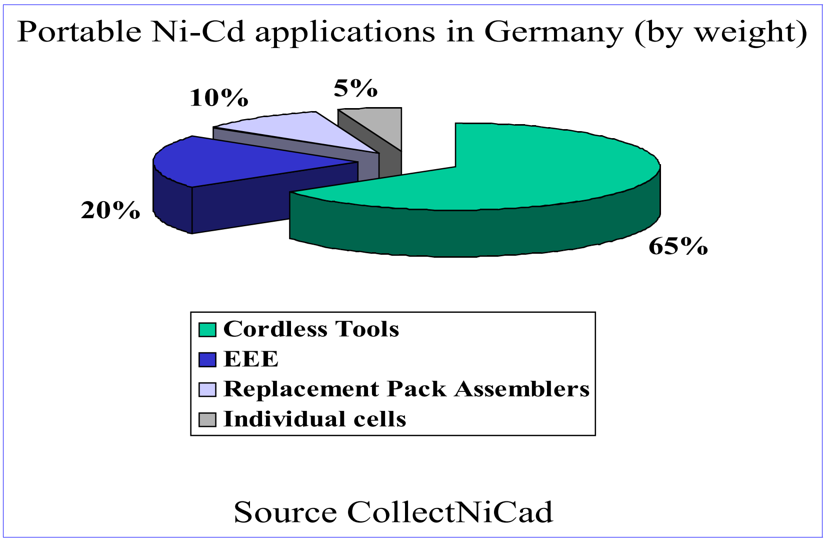

Figure 4. Market share for portable Ni-Cd batteries.

9. What are the collected quantities of Spent Portable Rechargeable Batteries in Germany?

The data on collection are also obtained by consolidation from the GRS, Bosch and VfW schemes and by checking quantities processed by recyclers. It is the role of CollectNiCad to consolidate data at the recyclers level. Regarding Ni-Cd portable batteries, the following quantities have been collected in 2001, 2002 and 2003: respectively, 966, 1090 and 1254 Tonnes.

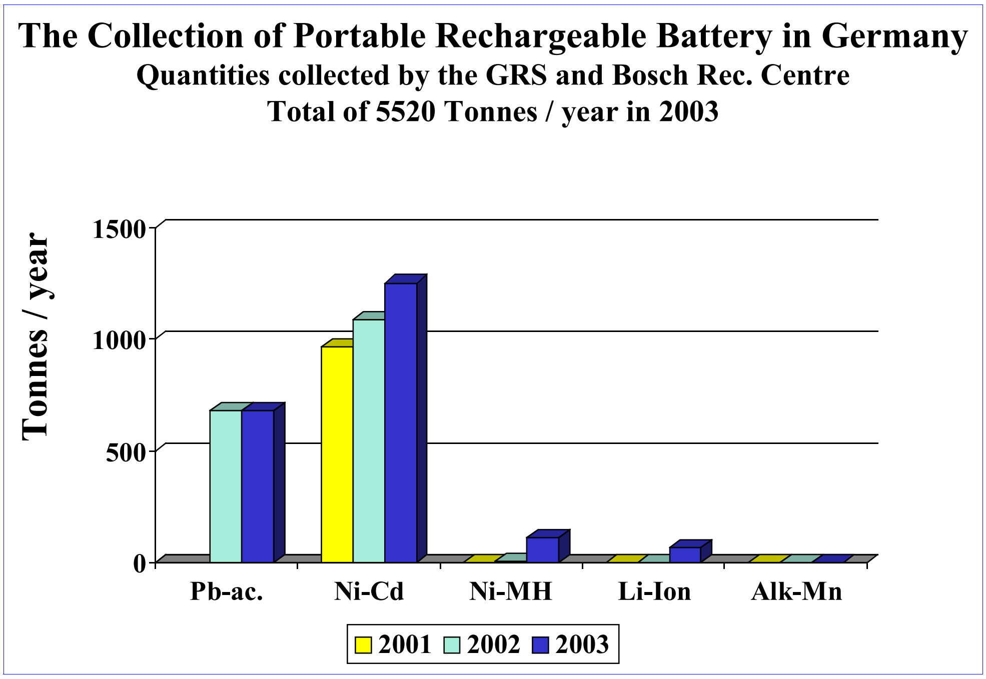

Figure 5. Consolidated data on spent portable rechargeable batteries collection in Germany.

For the year 2003, the following quantities were collected as reported in Figure 5.

Sealed Lead-acid, 600 Tonnes, Nickel-Cadmium, 1’200 Tonnes, Nickel-Metal Hydrides , 200 Tonnes and Lithium-Ion, 100 Tonnes.

10. Collection: are single cells collected efficiently ?

From the analysis of a sample of 600 Tonnes of spent portable Ni-Cd batteries received from Germany at a recycler’s plant location, the data indicates that 45 % of them are power packs from cordless power tools and 45 % are individual cells where the label allows to identify the manufacturer.

It shows that individual cells sold several years ago are collected efficiently. Indeed, single cells represent less than 5 % of current sales but 45 % of quantities collected. This is illustrated in Figure 6.

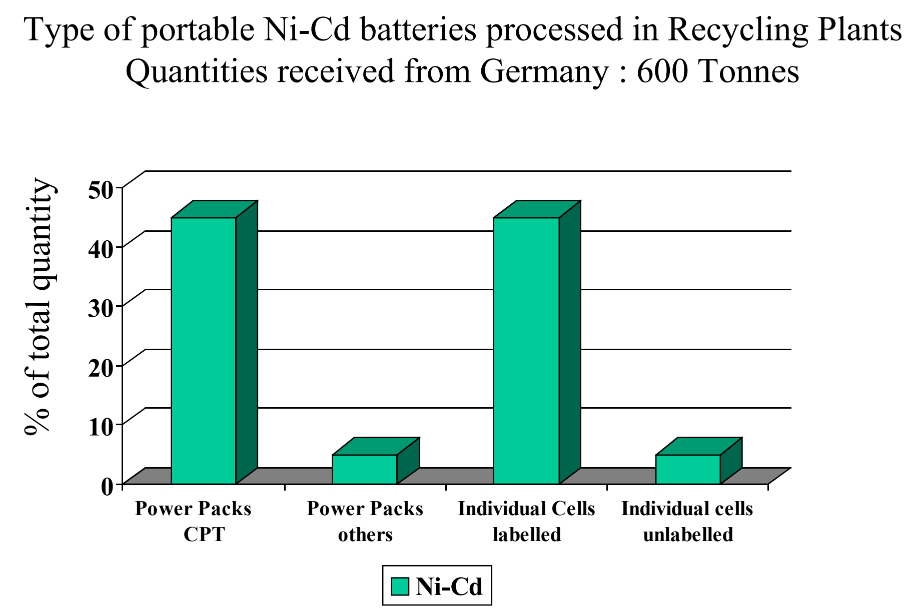

Figure 6. Weight distribution among the various types of spent Ni-Cd batteries collected. Germany : 600 Tonnes sample 2003.

11. What is the importance of the Hoarding effect for portable rechargeable batteries?

The large majority of Portable Ni-Cd batteries (> 95 % of sales by weight) are sold with durable equipment goods (EEE) and not on the consumer market. The equipment where Ni-Cd are incorporated has a long life time. In Figure 7, the data relative to sales vs collection of spent portable rechargeable batteries are indicated for Germany for 2003. It shows the lack of correlation between both information as already mentioned in § 4.

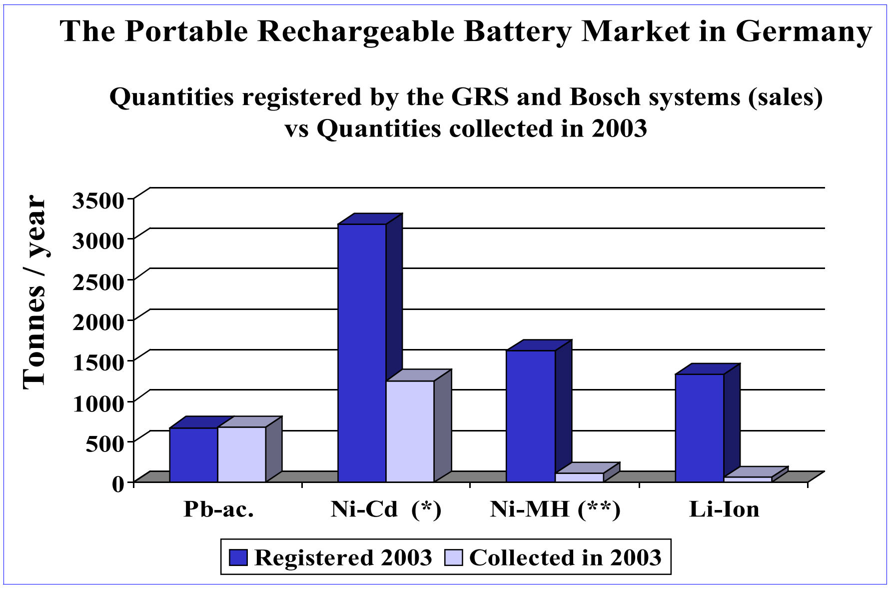

Figure 7. Data on the sales and collection of spent portable rechargeable batteries in Germany (year 2003).

In order to understand the large difference between the quantities sold and those collected on the same year basis, CollectNiCad has realized several "date coding" campaigns on batteries collected either in separate collection or together with Municipal Solid Waste (MSW).

For batteries returned as packs from durable goods such as Cordless Power Tools, the average life is between 6 to 10 years (Packs source : Germany) as shown in Fig.8.. It must be mentioned that date coding reveals the lifetime of returned batteries but is not representative of the real life of the majority of equipment which stays in home. It is estimated that the result of "date coding" are representative of less than one half of the quantities sold in a given year.

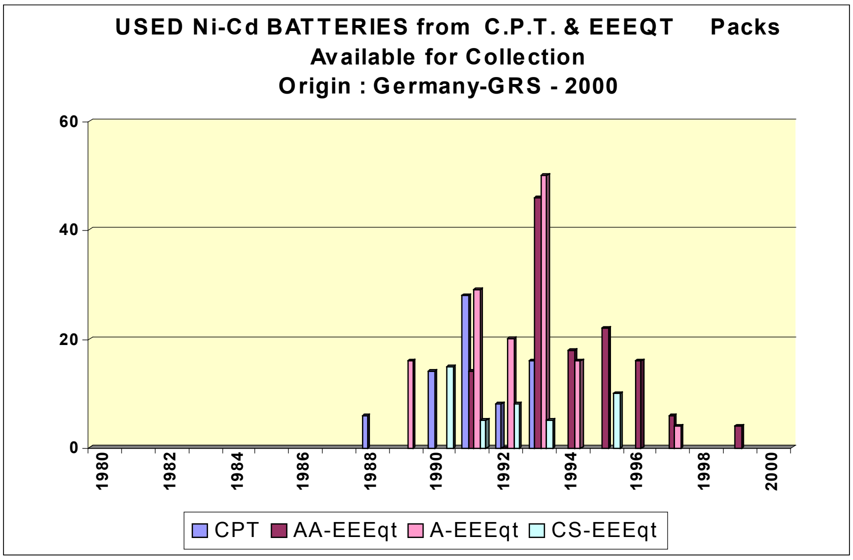

Figure 8 Date coding of returned batteries to collection points in Germany

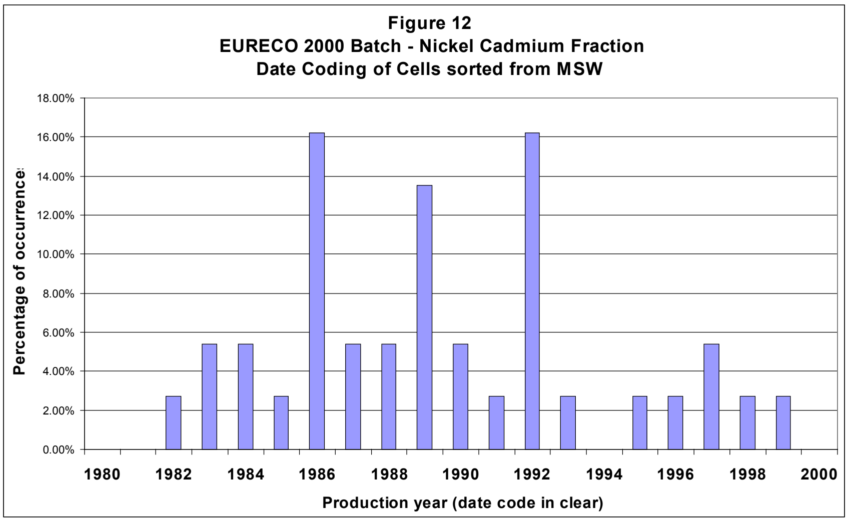

Figure 9. Date coding on Ni-Cd portable batteries identified in MSW in The Netherlands.

Date coding of identified packs and cells in MSW in The Netherlands, show an even longer average lifetime well above ten years (Figure 9).

12. What quantity of spent portable batteries are present in Municipal Solid Waste (MSW).

Statistical evaluation of the presence of batteries in MSW were performed in various MS and particularly in Germany. The results obtained in the 2001 campaign performed by the Witzenhausen Institut for GRS reveals the presence of 6.9 g/inhbt. of spent portable Ni-Cd batteries in MSW. This has to be compared with a collection of 12 g/inhbt.year 2001. In 2003, 14g./inhbt.y. were collected. The collection efficiency for portable Ni.-Cd batteries in Germany is of the order of 63 % when the three following parameters are considered: sales, collection via NCRO and MSW studies. Data are reported in Table 2.

TABLE 2. Results of the statistical evaluation of spent portable Ni-Cd batteries in MSW. Germany 2001.

Campaign performed for GRS by the Witzenhausen Institut (2001)			
	Unit	**Data**	**Units**
Sampling	1 m3	486	
Representativity	20 - 30 individuals	10000	individuals
Results	Grams / inhbt.	115	g/inhbt
	Number of inhabitants	82.4	Millions
	Total battery content	9476	Tonnes
Ni-Cd results	Weight ratio in %	6	%
	Grams/inhbt	6.9	g/inhbt
	Total Ni-Cd content (A)	569	Tonnes
Collected in 2001	GRS + Bosch (B)	966	Tonnes
Total Spent Batteries Production	(A + B)	1535	Tonnes
Collection Efficiency	**(A) / (A + B)**	**63**	**in %**

Por. Ni-Cd sales in 2001		2785	Tonnes
		34	g/inhbt
Port. Ni-Cd in MSW (2001 Campaign)	(A)	569	Tonnes
		6.9	g/inhbt.
Ratio in MSW vs sales		20	%
Quantity collected (2001)	(B)	966	Tonnes
		12	g/inhbt.
Ratio collected vs sales		35	%
Collection efficiency	**(A) / (A) + (B)**	**63**	**%**

13. Can we quantify emissions to the environment of cadmium from batteries?

An intriguing question is the following:
How is it that 75 % of cadmium being used in batteries, and only 1-2 % of cadmium emissions to the environment comes from batteries?

As mentioned by BMU, the nickel-cadmium battery sales in Germany accounts for the use of approximately of 450 Tonnes of cadmium. They are not emitted to the environment but, certainly, they enter the economy.

The aim of this chapter is to review the emissions of cadmium to the environment.

13.1. What is the level of atmospheric emissions of cadmium from batteries?

Atmospheric emissions of cadmium from spent Ni-Cd batteries will arise mainly at Municipal Waste Incinerators sites.

In the Targeted Risk Assessment report, Germany has declared a total emission of 300 kg / year 2001 to atmosphere from MSW Incinerators. As a conservative value, 50 % of these emissions can be attributed to spent Ni-Cd batteries or 150 kg (Table 3.1.22 in TRAR).

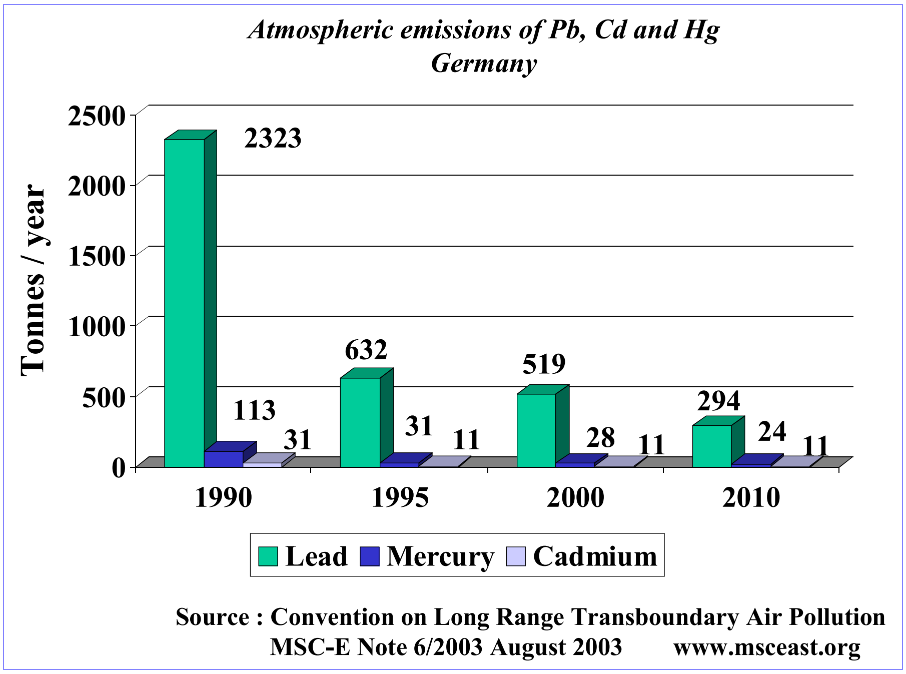

Figure 10. Atmospheric emissions of various metals in Germany. (Web site of BMU)

A recent report on total cadmium atmospheric emissions indicates that a total quantity of 11.0 Tonnes of cadmium are emitted to air in Germany.

By comparison with data reported by Germany to the TRAR, the emissions of cadmium from spent Ni-Cd batteries represent less than 1.5 % of total cadmium atmospheric emissions in Germany. Indeed, the major sources of cadmium emissions are the production of steel in Electric Arc Furnaces, non-ferrous metals production, coal and oil burning plants, residential energy production, transportation and chemical industries.

Conclusion 1.
Heavy metals emissions are not directly proportional to the use of metals in batteries or the use of cadmium in Ni-Cd batteries cannot be directly correlated to atmospheric emissions of cadmium.

A market restriction on portable Ni-Cd battery will have a minor impact on the reduction of total cadmium atmospheric emissions in Germany.

13.2. What is the volume of cadmium emissions to surface water ?

In the Targeted Risk Assessment Report on the use of cadmium in Ni-Cd batteries, it is reported that

1.cadmium emissions to surface water from MSW incinerators, reaches 108 kg /year from which 50 % can be accounted for batteries contribution or 54 kg/y. (Table 3.1.25 TRAR).
2.cadmium emissions from landfills reaches 75 kg Cd per year (Table 3.1.50)
3. The total represents 129 kg of cadmium /year.
In the literature, it is reported that total cadmium emissions to water reached a plateau around 12 Tonnes / y. in Germany.

Consequently, the emissions of cadmium from batteries to surface water represents only 129 kg out of 12'000 kg or just above 1.0 % of total emissions as shown in Figure 11.

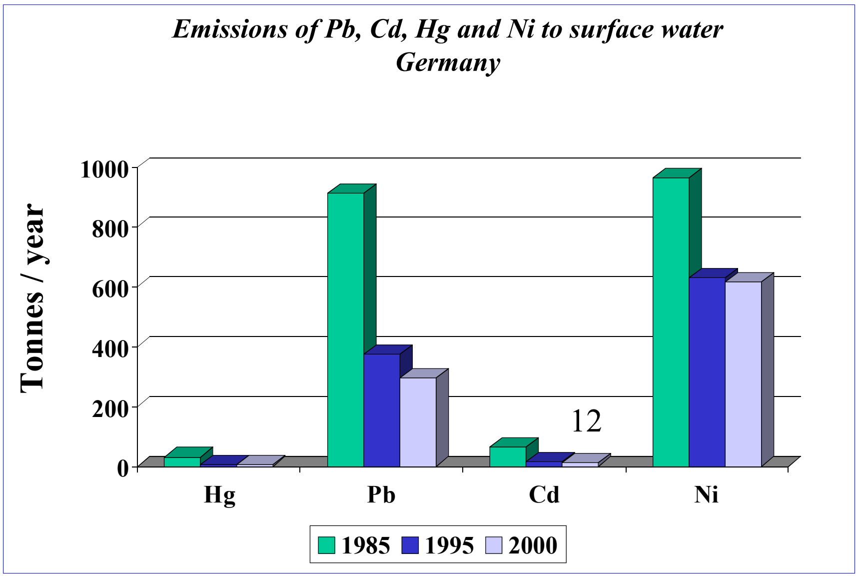

Figure 11. Surface water emissions of various metals in Germany. (Web site of BMU)

13.3. What is the level of emissions of cadmium to (under)ground water?

A review of cadmium concentration in more than 2000 landfills in Europe has been performed recently and is referred to in the TRAR.

The direct contamination of groundwater, surface water and soil by leachates from MSW residuals represents a potential route of exposure to the cadmium found in the ashes. As is stated in the TGD revised document, concerns related to leaching from incineration residues are more a general waste management issue rather than belonging to a substance specific risk assessment. (§ TRAR on future emissions)

These values have been considered in the TRAR and accounted for in the Figures 3.1.2. and follows. It confirms that the quantity of such emissions remain minor versus total cadmium release to water. Reference is made also to Table 3.1.54.

Regarding Fly Ash from MSW Incinerators, they are classified as hazardous waste and needs to be considered as such not only for their cadmium content (which is a minor constituent by weight) but for the overall content of other materials such as As, Sb, Hg, Pb, Zn,Ni. Co …and dioxins…Their end of life management is a general waste management issue rather than belonging to a substance specific risk assessment.

When treated as hazardous waste, they are treated such as impure cadmium cements extracted from the zinc purification route which is also an inevitable hazardous waste when cadmium is not used in batteries (refer to § 4.).!

Extract from TRAR.

The data compiled by Eggenberger and Waber (2000) from 71 investigated landfills in Switzerland, Italy, Japan and France indicate that about 80 % of the leachates have Cd concentrations below 5 µg/L and 75 % below 3 µg/L. A similar distribution of Cd-concentrations in landfill leachates and contaminated ground water is obtained for old landfills (closed 15-25 years ago) in Germany. The results of 1,422 analyses from leachates of mainly old landfills (186) in Germany and more recent landfills (closed 10 years or still in use) in Switzerland and some data from France, Italy and Japan, revealed that roughly 90 % of the investigated leachates Cd-concentrations laid below 5 µg/L. It has to be mentioned that the Cd background concentrations as measured in uncontaminated shallow groundwater are very low, being generally below 1 µg/L. Flyhammer (1995) reported different cadmium concentrations in leachates from landfills in different countries and suggested to use 5 µg Cd/L as an average concentration in leachate from landfills (active and closed landfills) in Nordic countries. Similar values were reported in the Netherlands, Finland, US and France (see Table 3.1.40).

14. Are they any other by-products/waste production containing cadmium from Ni-Cd batteries.

The major part of the cadmium present in Municipal Solid Waste will be shared according to the following paths.

14.1. **In the incineration process**, the majority of the cadmium (27.6 Tonnes) will be contained in 336'000 Tonnes of Fly Ash that are classified as Hazardous waste and will end up in a hazardous waste landfill like cadmium cements from the zinc purification process.
A quantity of 3.8 Tonnes of cadmium present in Metal hydroxide sludges will be treated with the Fly ash in hazardous waste landfills.

Another fraction of the cadmium ((4.1 Tonnes) will be present in 2'556'000 Tonnes of bottom slag that will either be landfilled or used in road construction according to leaching tests performed on more than 10 constituents from which cadmium is a minor one by weight..

Table 3. Mass balance of cadmium in MSW treatment and landfilling in Germany

PORTABLE Ni-Cd BATTERIES IN MSW				**Cd Ratio in %**
	Tonnes/year		Tonnes/year	
Cadmium in MSW from batteries				
Estimation by CollectNiCad	**84.000**		**600.00**	**14.00**
Incineration 43 % (12 Million T / y)	**36.120**	**Total Cd**	**0.43**	
Atmospheric Emissions				
from MSW Incinerators Total)	**0.300**		TRAR Data	
Slag Content (Total) 2'556'000 T	**4.137**		Submitted to leaching test	
M(OH)x Sludge	**3.824**		Hazardous waste	
Fly Ash 336'000 T	**27.686**		Hazardous waste	
Water Emissions	**0.110**		TRAR Data	
Total from MSWI Tonnes/y	**36.057**			
Landfill 57 % (16 Millions T / y)	**47.880**	**Total Cd**	**0.57**	
Water Emissions from Leachates	**0.235**		TRAR Data	
Direct to surface water	**0.024**		TRAR Data	
To groundwater	**0.024**		TRAR Data	
After STP to surface water	**0.075**		TRAR Data	
To sludge STP	**0.115**		TRAR Data	
Cumulated Quantity in Landfill				
Not emitted to air & water	**47.65**			

14.2. **In landfilling of waste**, cadmium from batteries will be stored in the landfill for ever. According to the FES Institut (*), due to the high alkali content of a battery, the transformation of the cadmium content into cadmium carbonate will happen during the ageing of a landfill. The cadmium carbonate formed will then be mineralized as an insoluble species.

The impact of acid rains on the ageing of landfills has also been considered by this Institute and the conclusion are the following.

Inorganic material:

Landfills normally have a basic environment for most wastes disposed. As shown for hazardous waste landfills this buffer is very high and can neutralize acid rainfall of about 100,000 years to maintain a pH value of 7 in the landfill. To dissolve the complete carbonate buffer in the investigated hazardous waste landfills a time period of 600,000 years with acid rainfall would be necessary [1, 2]. Landfills containing slags from municipal solid waste incineration have a comparable acid neutralization capacity than that of hazardous waste landfills.

These calculations show that within the landfill over a very long period of time, even with the effect of acid rainfall or leachate, a neutral or weak basic environment is given. It should be remarked that acid rainfall over such long periods of time cannot be expected since the carbon, gas and oil reservoir on earth, whose burning causes the acid rainfall, will only last some hundreds of years at maximum. Therefore the permanent weak basic environment within a mainly inorganic landfill offers many paths for the fixation of nickel and cadmium.

(*) Reference:

Behavior of Ni-Cd batteries in waste and landfills.
A study prepared by
Research and Development Centre of Hazardous Wastes
P.O. Box 1469
D-91124 Schwabach
E-Mail: kontakt@fes-schwabach.de

15. What will be the impact of a ban on total Cd emissions from anthropogenic sources

The next Tables 4 and 5 illustrates the impact of of a ban on portable Ni-Cd batteries on atmospheric and surface water emissions of cadmium from anthropogenic sources. The data presented in these Tables confirm the fact that such a market restriction will have an impact on 1 to 2 % of the overall cadmium emissions.

Table 4.

Water Emissions. **Source Final Draft TRAR May 2003**

	Cadmium Emissions in Tonnes / year	Curent emissions level	Contribution of batteries	Emissions after market restriction
1	Coal Firing Plants	0.1	0	0.1
2	Steel Production (BOF and EAF)	15.6	0	15.6
3	Non-Ferrous Metallurgy (Zn, Cu, Pb)	9.7	0	9.7
4	Trafic, Cement, Chemicals,…	1.2	0	1.2
5	Cd to CdO conversion (Export 75%)*	1.2	0.3	0.9
6	Cd alloys	0.2	0	0.2
7	Batteries production and recycling	0.66	0.66	0
8	MSW incineration	0.176	0.088	0.088
9	Landfilling	0.275	0.138	0.138
10	Mining	1.1	0	1.1
11	Fertilizers	9.1	0	9.1
12	Total	39.311	1.186	38.126

Table 5.

Atmospheric Emissions. **Source Final Draft TRAR May 2003**

	Cadmium Emissions in Tonnes / year	Curent emissions level	Contribution of batteries	Emissions after market restriction
1	Coal Firing Plants	54	0	54
2	Steel Production (BOF and EAF)	31	0	31
3	Non-Ferrous Metallurgy (Zn, Cu, Pb)	9.7	0	9.7
4	Trafic, Cement, Chemicals,…	19	0	19
5	Cd to CdO conversion (Export 75%)*	3.9	0.75	3.1
6	Cd alloys	0.8	0	0.8
7	Batteries production and recycling	0.05	0.05	0
8	MSW incineration	3.2	1.6	1.6
9	Fertilizers	0.7	0	0.7
10	**Total**	**122.35**	**2.4**	**119.9**

16. What is the objective of the Environmental Agreement proposed by Industry?

CollectNiCad 2003 proposal for an Environmental agreement.

An Environmental Agreement to ensure the Sound Environmental Management of Spent Nickel-Cadmium Accumulators was proposed to the German Ministry of Environment and the German Ministry of Economic Affairs and Labour.

The aim of this agreement is to initiate without delay a development of the collection of spent rechargeable Ni-Cd under the control of German authorities.

It would be initiated in addition to currently operated programs by enhancing the promotion of the return, take back of spent nickel-cadmium batteries via commercial and waste management routes.

It will allow German authorities to obtain from Industry regular annual reports on the flow of cadmium in Nickel-Cadmium batteries in Germany and on the way to control it.

The Environmental Agreement is aimed at :

- Increasing the collection of spent batteries to reach a minimum of 75 % of collection efficiency (e.g. instead of 63 % to-day in Germany).
- Reducing the quantity of spent batteries in non recycled waste streams.
- Controlling cadmium emissions from spent nickel-cadmium battery sources.
- Maintaining an economic and social activity in the portable rechargeable battery field while controlling any source of potential risk.