

IMPACT ASSESSMENT ON SELECTED POLICY OPTIONS FOR REVISION OF THE BATTERY DIRECTIVE

FINAL REPORT
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A2 - Consumption, Production & Waste

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FOREWORDS

The purpose of the study is to perform an analysis of economic, environmental and social impacts of different policy options about batteries and accumulators, in the framework of an extended impact assessment. The methodology developed is based on the guidelines recently published by the EC about extended impact assessment. But considering the time constraint of the present study which had to be performed in less than 3 months, we do not pretend having covered all the issues.

However, a considerable work was performed and trends and orders of magnitude presented in the report can be considered with good confidence.

We are grateful to the many experts who provided us with their help and comments at different key steps of the report's preparation and for their reactivity and availability within a very short time period.

1 EXECUTIVE SUMMARY

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1.1 CONTEXT AND OBJECTIVES OF THE PROJECT

■ Directive 91/157/EEC on batteries and accumulators containing dangerous substances amended by Commission Directive 98/101/EC, as well as Commission Directive 93/86/EEC, harmonise the national laws of the Member States in the field of waste management and spent batteries and accumulators containing certain heavy metals.

In practice the Battery Directives have not fully realised these objectives, since:

- The Battery Directives only cover the collection of batteries containing certain quantities of cadmium, mercury or lead, and this limited scope tends to reduce the effectiveness of waste management of batteries and has caused implementation problems within the Member States.
- The Battery Directives only prohibit the marketing of batteries and accumulators containing more than 0.0005% mercury as from 1 January 2001. However, other spent batteries and accumulators are an important source of heavy metals (particularly lead and cadmium), which may constitute a significant source of environmental damage and risk to human health.
- There is a significant disparity between the laws and administrative measures adopted by the Member States with regard to the collection and recycling systems as well as the results yielded by such systems.
- In order to contribute to a proper functioning of the internal market and to establish a high level of environmental protection in the field of waste management of spent batteries and accumulators, the European Commission commissioned BIO Intelligence Service to analyse the positive and negative impacts of different policy options in view of revising the Battery directives.

An extended impact assessment was performed. The methodology developed in this study is based on recent guidelines published by the EC: 'A Handbook for Impact Assessment in the Commission – How to Do an Impact Assessment'.

Remark: It should be noted that this impact assessment had to be performed in a very short time compared to the wide scope of the issue under consideration. The methodology had thus to be defined considering this time schedule constraint.

Different policy options are evaluated regarding their feasibility (from a practical point of view) as well as their economic, environmental and social impacts:

- Different ranges of collection and recycling targets were studied for small, automotive and industrial batteries and accumulators.
- A part of the study focused on the use of cadmium in batteries and its economic and environmental impacts.
- All considerations were made taking into account the two following possible principles: producer responsibility or shared responsibility.

1.2 CURRENT SITUATION

1.2.1 Batteries Segmentation

- Batteries can be divided into primary (non rechargeable) and secondary (rechargeable) types. They can also be divided into 3 categories that we will keep all along the project:
- portable batteries (used by households or professional users),
- starter batteries for vehicles (large batteries used by households or professional users),
- industrial batteries (large batteries used in the industry).

Users Type of batteries Technology **Typical Uses** General Purpose (alkaline Clocks, portable audio and devices, manganese AlMn and zinc carbon torches, toys and cameras ZnC) Non Photographic equipment, remote rechargeable Lithium (Li) controls and electronics (primary) Button cells (zinc air, silver oxide, Watches, hearing aids, calculators manganese oxide and lithium) Households Portable Cordless phones, power tools and & Professional Nickel Cadmium (NiCd) (<1 kg) emergency lighting users Nickel Metal Hydride (NiMH) Cellular and cordless phones Lithium Ion (Li-ion) Cellular phones, laptops and palms Lead Acid Hobby applications Automotive/Motorcycle Starter Lead Acid Starter, Lighting and Ignition (SLI) batteries Rechargeable Alarm systems, emergency back-up (secondary) Lead Acid Standby systems, e.g.rail and telecommunications applications Motive power sources, e.g. forklift Industrial Lead Acid Traction Large trucks, milk floats batteries (> 1 kg) Motive and standby applications, Industrial Nickel Cadmium (NiCd) standby e.g.satellite and rail applications Nickel Cadmium (NiCd) motive Electrical vehicles power Nickel Metal Hydride (NiMH) Hybrid vehicles

Batteries Segmentation

In this report, the term 'starter batteries' stands for 'starter lighting and ignition (SLI) batteries', which are lead acid automotive batteries.

1.2.2 Definitions About Collection and Recycling Rates

- Spent batteries are split between:
- Spent batteries available for collection,
- Spent batteries not available for collection (because hoarded by end users, exported with equipments in which they are contained...).

Collection rates (CR)

Because no definition is yet established about collection rates, we systematically assessed three collection rates in the study:

- Collection rate as % of sales.
- Collection rate as % of spent batteries, where spent batteries year N can be roughly estimated from sales for previous years by considering an appropriate hypothesis about lifespan for each applications.
- Collection rate as % of spent batteries available for collection, where spent batteries available
 for collection = spent batteries x (1 X%), X% depending on segment specificities (hoarding,
 exports...).

For instance in the case of portable batteries:

Remark: The higher the quantities collected, the higher the difference between these two collection rates. And the higher the % hoarded, the higher the difference between collection rates.

In case of markets where sales evolved regularly over the last years with a certain average growth rate, spent batteries year N can be roughly estimated from previous years sales:

and thus

CR as % of spent batteries = CR as % of sales x (1 + average growth rate) lifespan

■ Regarding recycling, the same ratio was assessed for all the batteries segment considered in the study: the **recycling plant input**, as the % of collected batteries sent to recycling.

1.2.3 Starter Batteries

Definition about spent batteries available for collection

Two main categories of starter batteries are sold:

- OEM (Original Equipment Manufacturer's) batteries, sold in cars;
- AM (After Market) batteries, sold to replace spent batteries.

A significant part of the OEM batteries are exported with cars and will then not become spent batteries in the country. Remaining OEM batteries, when spent, are replaced by the after market batteries, until the car is scrapped. Thus, the total sales, OEM + AM, does reflect the real quantities of spent batteries.

Spent starter batteries available for collection in 2002 = After market sales in 1997 + Batteries in scrapped cars in 2002

Starter batteries market and waste stream

In Western Europe in 2002, about 860 kt of starter batteries are estimated to be sold and 610 kt of spent batteries available for collection to arise, among which 15% from scrapped end-of-life vehicles (respectively 140 kt and 110 kt in Eastern and Central Europe).

Collection and recycling results for starter batteries

80-95% of spent starter batteries available for collection are believed to be collected and sent to recycling. No statistic exist at the EU level to confirm that situation.

Collection and recycling economics of starter batteries

Revenues from recycling (mostly sale of recovered lead and also of plastics) are generally sufficient to cover all of the collection and re-processing costs involved in the sector. However, lead batteries recycling economics is sensitive to the lead market price (LME) which can fluctuate significantly over years. But the industry has shown in the past that they can deal with that lead market fluctuation, using intermediate temporary storage as a hedging effect. This may explain that 5-10% of spent starter batteries available for collection are actually not collected.

We found no information during the study which would indicate that this recycling activity is not durable at the European level. This may need some restructuring and collection optimisation, in some regions at least.

1.2.4 Industrial Batteries

Definition about spent batteries available for collection

Two main categories of industrial batteries can be distinguished:

- NiCd batteries, which are covered by the battery directive, for which statistics are available at both the EU and national levels,
- Other industrial batteries, mostly lead acid batteries, for which statistics are available neither at the European level nor at the national level.

Spent batteries, which can theoretically be derived from sales of previous years by considering lifespans, are all collectable. However, spent batteries have very long lifespans which vary significantly with applications. And some hoarding behaviours by end users exist. Contrary to portable batteries, no data are available to assess the level of hoarding. As a consequence, spent batteries derived from sales and considered available for collection give a rough approximation of actual waste streams, without being able to quantify the uncertainty.

Industrial batteries market and waste stream

About 200 kt of batteries have been put on the market in 2002, 97% being lead acid batteries. This estimation about the total industrial batteries market is very uncertain. It is derived from 1995 data with an average 1% growth rate till 2002.

3.6 kt of large NiCd batteries have been sold in 2002, among which 83% for standby applications (3 kt) and 16% for electrical vehicles (0.6 kt).

Considering average lifespans, spent batteries available for collection are assessed to amount at 187 kt in 2002, among which 3.1 kt of NiCd.

Collection and recycling results for industrial batteries

No statistics are available about large lead acid batteries. Considering the well established recycling market of lead acid batteries, it is quite certain that all collected batteries are sent to a recycling plant.

As for NiCd, 2.8 kt were collected in 2002 at the EU level, representing 78% of 2002 sales and 90% of the spent batteries available for collection. 98% of NiCd batteries collected at the European level are declared to be sent to recycling.

Between 80-90% of total industrial batteries are then believed to be collected and sent to recycling.

From the nature of the product and their application, their collection and recycling is regulated by established industrial practices and supplier-customer regimes.

Collection and recycling economics of industrial batteries

For lead acid batteries, see starter batteries above.

For NiCd batteries sent to dedicated plants, recyclers bill between 0 to 300 Euros / t entering the plant depending on the proportion of metals recovered and metal market prices (nickel, cadmium and steel).

According to recyclers, NiCd recycling cost could decrease to a range of 0 - 200 Euros / t in the future (even positive value in some cases), in particular by increasing the recovery of ferro nickel by 10-15%.

1.2.5 Portable Batteries

Definition about spent batteries available for collection

Spent batteries available for collection = spent batteries x (1 -% hoarded).

In countries where data are available about batteries contained in municipal solid waste (MSW), we assessed the % of hoarding and obtained a very large range: from 27% to 62% according to countries.

At the EU level, we considered that 30% of non rechargeable batteries and 60% of rechargeable batteries are hoarded by households and professional users, resulting in an average of 37% all portable batteries together.

Beside, the equivalence formula with collection rate as % of sale is as follows:

CR as % of spent batteries = CR as % of sales + 1 or 2 points for 1% average growth rate over last yrs CR as % of spent batteries = CR as % of sales + 2 or 3 points for 5% average growth rate over last yrs

Portable batteries market and waste stream

About 160 kt of batteries are sold in the EU in 2002, i.e. an average of 410 g / capita / year. The discrepancy between countries is important: between 250 and 425 g / capita / year according to country.

About 75% of portable batteries sold are non rechargeable batteries (general purpose, button cells and lithium), mainly general purpose batteries (alkaline manganese and zinc carbone). Button cells

(containing high mercury content) only represent 0.2%. NiCd technology represents one third of portable rechargeable batteries (7% of all portable batteries sold).

About 30% of portable batteries (45 kt) are estimated being sold in electric and electronic equipment (EEE). This concerns about 90% of rechargeable batteries and 10% of non rechargeable batteries.

About 150 kt of spent batteries are estimated to arise in the EU, i.e. an average of 380 g / capita / year (with an important discrepancy between countries as for sales: between 245 and 400 g / capita / year according to country). Spent NiCd batteries amounts to about 10.5 kt.

Only about 97 kt of spent batteries are estimated to be collectable in 2002 (i.e. available for collection), that is an average of 235 g / capita / year (between 140 and 285 g / capita / year according to country). Spent NiCd batteries available for collection are estimated at 4.1 kt.

An average of about 20% of spent batteries available for collection are estimated to be contained in WEEE.

Collection and recycling results for portable batteries

Separate collection of portable batteries is well or quite well developed in 8 MSs:

- Separate collection focusing on NiCd (or all rechargeable according to country) batteries: Dk, Nw (other portable batteries remain in the MSW flow),
- Separate collection of all portable batteries: A, B, F, D, NL and Sw.

According to information provided to BIO in the framework of the study, separate collection would not be well developed in accession countries.

About 27 kt of spent batteries are separately collected in the EU:

- 17% of current sales,
- 18% of spent batteries,
- 28% of spent batteries available for collection,
- an average of 70 g / capita / year.

More than 80% of portable batteries collected are non rechargeable general purpose batteries and 8% are rechargeable NiCd batteries (2.1 kt).

The situation is very different from one country to another. Three categories of countries can be distinguished:

- Countries where separate collection of all portable batteries is well developed (A, B, F, D, NL, Sw):
 45 to about 85% of portable batteries available for collection are estimated to be collected according to countries.
- Countries where separate collection of NiCd batteries is well developed (Dk, Nw): 40 to 50% of spent NiCd are collected.
- Countries where separate collection is not developed: 0 to 15% of portable batteries available for collection are estimated to be collected according to countries.

Differences in the results reached in MSs may be explained by several parameters which differ among countries:

• Starting date of separate collection: in some MSs, the system is more than 10 year old thus at a steady stage rather than in others, it is 2 year old, so still at a development stage.

- Type and level of legal collection objectives set up at national level: from high mandatory targets to no quantified targets.
- Collection schemes and communication programmes implemented: depending on the objectives
 to be reached (and the level of penalties included), more or less collection points have been
 setting up and more or less extensive communication and promotion programmes have been
 developed to encourage end users to first participate and secondly reduce their hoarding
 behaviours.

About 90% of total portable batteries collected is estimated to be recycled. This percentage aggregates different situations according to battery segments and countries:

- NiCd batteries: about 100% of NiCd batteries collected are recycled.
- General purpose batteries: the situation is very different among countries:
 - Most of them send all portable collected batteries to a recycling plant.
 - Others send 60-65% of portable collected batteries to a recycling plant (D, UK, Sw).
 - Others have no estimation of quantities sent to recycling.

The limitation of recycling rate of general purpose batteries in some countries is motivated by different reasons according to countries:

- Relatively high Hg-content general purpose batteries, put on the market before legislation entered into force in the EU¹, are not all recycled in some countries, due to specific costly recycling processes².
- Non hazardous general purpose batteries (i.e. containing no Hg) are disposed of in landfill in some other countries.

Portable batteries are recycled in dedicated plants, smelting plants or electrical arc furnaces (EAF). About 32 dedicated recycling plants exist in the EU and are concentrated in certain countries (mainly France and Germany). Several plants dedicated to batteries recycling are still under used (up to half of their capacity seems to be available) thus there is an overcapacity of recycling. After collection, spent batteries are transported from countries where no recycling plant exist to over-capacity countries.

Collected batteries which are not recycled are disposed of in landfill, as hazardous waste or non hazardous waste according to their type.

■ Collection and recycling economics of portable batteries

Case studies were performed to gather updated cost data about existing collection and organisation schemes in countries where they are well or quite well developed. From these data, we were able to define ranges for the different cost items and discuss with experts about expected economies of scale.

Portable NiCd batteries recycling costs

They vary depending on the recycling technology. In dedicated plants, recyclers bill 0 Euros / t in case of individual cells and around 300 Euros / t in case of power packs because the latest require to be dismantled (in both cases, revenues amount at about 1 000 Euros / t). As a consequence, the recycling cost of a batch constituted of about 50% of individual cells and 50% of power packs amounts to about 150 Euros / t of NiCd batteries.

In the future, according to recyclers, economies of scale can be expected mostly for the packs preparation costs. Total recycling cost could be at 0 Euros / t for both individual cells and power packs.

Restriction concerning the marketing of batteries other than button cells containing Hg.

In Germany, main collector GRS estimates that the average Hg content of the ZnC + AlMn mixture was ca. 60 ppm in 1998, 100 ppm in 2002 and will be 10 ppm in 2005.

In metal plants, recycling costs amounts to approximately 100 Euros / t of batteries. No major economies of scale can be expected in the future.

Portable NiCd batteries collection and recycling economics

Danish scheme concerns NiCd batteries collection and recycling. Total collection and recycling costs are estimated at about 2 830 Euros / t of NiCd collected.

For collection circuits dedicated to power tools containing NiCd batteries, collection and recycling costs vary between 1 300 and 1 750 Euros / t collected.

In both cases, collection rates reach about 40-50% of spent NiCd.

All portable batteries recycling costs

The average recycling cost (all types of portable flows together) vary in a quite large range: 400 to 900 Euros / t entering a recycling plants according to country.

Portable Batteries - Recycling Costs Inventoried

Euros / t entering a recycling plant

	Large t entering a recycling plant
	about 900-1000 Euros / t in dedicated plants whatever Hg content (B, F) 180 to 700 Euros / t in metal plants for limited Hg content (D)
Small lead acid batteries	1000 Euros / t (F) 0 even negative costs (B)
	2600 Euros / t (F) 4000 Euros / t (B)
NiMH batteries	0 Euros / t (B, F)
Li batteries	2000 Euros / t (F)
Li-ion batteries	1000 Euros / t (F)

Further investigation would be required to explain differences between different countries for portable lead acid and button cells batteries.

All portable batteries collection and recycling economics

The compilation of the different costs obtained in our analysis results in the following ranges.

Portable Batteries - Costs Ranges For Existing Schemes

Euros / t of portable batteries collected

Variable costs	
Collection points (equipment)	50 - 150
Collection (logistic)	250 - 550
Sorting	150 - 250
Transport & Recycling (excl. disposal)	400 - 900
Fixed costs	
Public relations & communication	50 - 1 700
Administration	125 - 900
Total	1 115 – 3 765

Portable Batteries - Collection and Recycling Costs in MSs Collecting All Portable Batteries

Detailed data presented in fact-sheets - See appendix 2

		AUSTRIA	BELGIUM	FRANCE	GERMANY	NETHERLANDS
Scope		UBF	BEBAT	SCRELEC	GRS	STIBAT
Main characteristics			•			
Financial responsibility		Shared	Consumers (via producers)	Partial shared	Producers	Partial shared
Mandatory collection targets		Only quite recently	Yes	Only from 2003	No	Yes
Starting date		1991	1996	2001	1998	1995
Collection system			Bring back to different types of collection points	Bring back to sale and municipal collection points	Bring back system mainly to sale points	Bring back system with small chemical waste
Nb of inhab/ collection point		1100	500	2000 - 2500	410	1500
Main general purpose batteries	recycling		Dedicated plants of all ZnC and Alk batteries	Dedicated plants	Mostly metal plants (except higher Hg- content batteries which are disposed of)	Metal plants + dedicated plants
Results			1			
Quantities collected	kt / yr	1 440 t	2 368 t	4 139 t	11 256 t	1 876 t
Collection rate	% of sales	44%	60%	16%	38%	32%
0/ of anont bottorics as	% of spent batteries	45% 80%	63% 90%	17% 45%	39% 64%	33% 82%
% of spent batteries av	g / inhab / yr	80% 179	228	45% 69	137	116
Recycling plant input	% of collected	100%	100%	96%	67%	100%
Costs paid for by producers						
Variable costs	Euros / t collected		1 205	1 610	6 98	(1 550
Collection points (equipment)	Euros / t collected		56	1010	150	۱ ۱ ۲
Collection (logistic)	Euros / t collected		250	457	1 -	1 450
Sorting	Euros / t collected		ر	ر	assum { 150	BIO
Transport	Euros / t collected	n.a.	{246	{ 152	ption {	assum 200
Treatment	Euros / t collected		653	1 000	for split { 298	for split 900
Fixed costs	Euros / t collected		2 529	790	517	1 968
PR & communication	Euros / t collected		1 658	290	267	1 568
Administration	Euros / t collected		870	500	250	400
Total	Euros / t collected	1 113	3 733 (3)	2 400	1 115	3 518
Total	Cents / unit sold	2,0	11,3	1,6	1,7	4,5
Total	Cents / kg sold (2)	49	283	39	42	112
Food paid for by producers	(2)					
Fees paid for by producers Total portable batteries	Cents / kg sold (1)	90	428	46 - 175	24 - 78	65
Portable NiCd batteries	Cents / kg sold (1)	90	138	175	51	65
. Ortable 1410a batteries	30iu (2)		100	173		

- (1) According to battery type
- (2) Hypothesis: 40 g / unit
- (3) Marking costs not included

The highest costs are in Belgium and the Netherlands, in particular due to very high communication costs. Despite these high costs, collection rates stagnate and proportion of batteries hoarded are still high (around 30% or more).

1.2.6 Summary of the Current Situation in Europe

Summary of the Current Situation in Europe – Portable Batteries³

	Current Situation - Total Portable Batteries					
			ion rates		Recycling plant input	
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of sales	% of collected
Countries where	e all small batterie		ollected - 2001			
Austria	44%	45%	80%	179 g	44%	100%
Belgium	60%	62%	85%	230 g	60%	100%
France	16%	17%	45%	69 g	16%	96%
Germany	39%	40%	56%	157 g	17%	44%
Netherlands	32%	33%	82%	116 g	32%	100%
Sweden	55%	56%	81%	193 g		
Average	33%	34%	59%	132 g		60%
	e small NiCd (or re	· · · · · · · · · · · · · · · · · · ·				
Denmark	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Norway	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Countries where Average	e separate collection 0 to 15%	on is not develope 0 to 15%	e d - 2002 n.a.	0 to 60 g		10 to 100%
Total EU-15 + C Total portable batteries	h + N - 2002	18%	28%	70 g	15%	90%
		Curr	ent Situation - Po	rtable NiCd Batt	eries	
		Collect	ion rates		Recycling plant input	
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of sales	% of collected
Countries where	e all small batterie	s are separately co	ollected - 2001	_		
Austria	34%	35%	70%	10 g	34%	100%
Belgium	92%	96%		34 g	92%	100%
France	17%	17%	64%	4 g	17%	100%
Germany	45%	46%	67%	16 g	45%	100%
Netherlands	31%	32%	69%	10 g	31%	100%
Sweden	84%	87%		19 g	84%	100%
Average	40%	42%		12 g		100%
	e small NiCd (or re					
Denmark	98%	43%	n.a.	20 g	98%	100%
Norway	47%	49%	n.a.	27 g	47%	100%
Average	62%	46%	n.a.	24 g		100%
Countries where Average	e separate collecti 0 to 7%	on is not develope n.a.	n.a.	0 to 2 g		100%
Total EU-15 + C	h + N - 2002					
Total portable NiCd batteries	19%	20%	51%	5 g	19%	100%

Collection rate as % of spent batteries available for collection is assessed with the current level of hoarding estimated at about 37% of all small spent batteries (average between 30% for non rechargeable batteries and 60% for rechargeable batteries)

Summary of the Current Situation in Europe – All Segments

Spent batteries	Current situation 2002 - Collection rates			
kt of spent batteries and collection rates as % of spent batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment	
Starter Batteries	611 kt			
	80-95% (1) (4)	i	-	
NiCd Batteries		3,1 kt	10,5 kt	
	-	80-90%	15-20%	
		14 kt		
		30-35%		
Other batteries		184 kt	142 kt	
	-	80-90% (2)	15-20%	
Total batteries	611 kt	187 kt	153 kt	
	80-95%	80-90%	15-20%	
		950 kt		
		70-85%		

Spent batteries available for collection	Current situation 2002 - Collection rates				
kt of spent batteries available for collection	Starter batteries	Industrial batteries	Portable batteries		
rates as % of spent batteries	segment	segment	segment		
available for collection					
Starter Batteries	611 kt				
	80-95% (1)(4)	-	-		
NiCd Batteries		3 kt	4 kt (3)		
	-	80-90%	45-55%		
		7 kt			
		60-70%			
Other batteries		184 kt	92 kt (3)		
	-	80-90% (2)	25-30%		
Total batteries	611 kt	187 kt	97 kt		
	80-95%	80-90%	25-30%		
	894 kt				
		75-90%			

Current situation 2002 - Recycling plant inputs			
Starter batteries segment	Industrial batteries segment	Portable batteries segment	
490-590 kt			
95-100%	-	-	
	2,8 kt	2,1 kt	
-	98%	100%	
	4,9	9 kt	
	10	0%	
	145-165 kt	25 kt	
-	95-100%	90%	
490-590 kt	148-168 kt	27 kt	
95-100	95-100%	90%	
	665-800 kt		
	95-100%		
	Starter batteries segment 490-590 kt 95-100% - 490-590 kt	Starter batteries segment 490-590 kt 95-100% - 2,8 kt 98% - 4,5 10 145-165 kt 95-100% 490-590 kt 95-100% 665-800 kt	

⁽¹⁾ Hypothesis because no statistics available at the EU level; countries where data are available, 90% to 97% of spent batteries are collected and recycled

⁽²⁾ No statistics available at the EU level; in France, more than 90% of sales are collected; as an hypothesis, the same collection rate range as for industrial NiCd batteries is considered

⁽³⁾ Hypothesis about hoarding: 30% of spent non rechargeable batteries and 60% of rechargeable ones are considered being hoarded by households and professional users

⁽⁴⁾ It is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared. In that case, this difference in scope of stakeholders would result in an overestimation of collection rate.
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1.3 BASELINE SCENARIO

The baseline scenario aims at describing 2007 situation without any revision of the Batteries directives. The policy options to be analysed are compared to this baseline scenario.

Compared to the current situation, 2 main elements were taken into account:

- For all segments: the assumption that existing separate collection systems dedicated to batteries will still exist and maybe develop.
- For portable batteries: a 5 point increase in taken into account for collection rates following the WEEE directive implementation.

No major impacts are expected from the ELV directive since first most starter batteries are believed already collected and recycled and secondly ELV directive sets up no collection target; targets concern the % of each scrapped car which has to be recycled and batteries are one of spare parts already well recycled.

Summary of the Baseline Scenario 2007 – Portable Batteries

	Baseline Scenario 2007 - Total Portable Batter				ies
	Collection rates				Recycling plant input
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of collected
Countries where al	l portable batteries	are separately co	llected in 2002		
A, B, F, D, NL, Sw	30-65%	30-65%	60-85%	120-230 g	70-100%
Countries where po	ortable NiCd (or re	chargeable) batter	ies are separately	collected in 2002	
Dk, Nw	low?	low?	low?	low?	
Countries where se	parate collection i	s not developed i	n 2002		
Other countries	5-20%	5-20%	n.a.	20-80 g	10-100%
		Baseline Scena		ole NiCd Batteri	es Recycling plant input
	% of sales	% of spent	% of spent batteries available for	g / capita / yr	% of collected
			collection		
Countries where al	l portable batteries	are separately co			
A, B, F, D, NL, Sw	I portable batteries	are separately co		10-35 g	100%
	35-95%	35-95%	about 70%	, , ,	100%
A, B, F, D, NL, Sw	35-95%	35-95%	about 70%	, , ,	100%
A, B, F, D, NL, Sw Countries where po	35-95%	35-95%	about 70% ies are separately	collected in 2002	
A, B, F, D, NL, Sw Countries where po	35-95% ortable NiCd (or reconstruction 98% (1) 47%	35-95% chargeable) batter 43% (1) 49%	about 70% ies are separately n.a. n.a.	collected in 2002	100%

⁽¹⁾ Sales are radically decreasing since 1996

Summary of the Baseline Scenario 2007 – All Segments

Spent batteries	Baseline scenario 2007 - Collection rates			
kt of spent batteries and collection rates as % of spent batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment	
Starter Batteries	642 kt			
	80-95% (8)	-	-	
NiCd Batteries		3,3 kt	11,0 kt (1)	
	-	80-90%	20-25% (6)	
		14	kt	
		35-	40%	
Other batteries		193 kt	150 kt (1)	
	-	80-90%	20-25% (6)	
Total batteries	642 kt	196 kt	161 kt (1)	
	80-95%	80-90%	20-25%	
		1 000 kt		
		70-85%		

Spent batteries available for collection	Baseline scenario 2007 - Collection rates			
kt of spent batteries available for collection and collection rates as % of spent batteries available for collection	Starter batteries segment	Industrial batteries segment	Portable batteries segment	
Starter Batteries	642 kt			
	80-95% (8)	-	-	
NiCd Batteries		3,3 kt	4,4 kt (1)	
	-	80-90%	50-60% (6)	
		8	kt	
		60-	70%	
Other batteries		193 kt	97 kt (1)	
	-	80-90%	30-35% (6)	
Total batteries	642 kt	196 kt	102 kt	
	80-97%	80-90%	30-35%	
		940 kt		
		75-90%		

Recycling plant inputs (7)	Baseline scenario 2007 - Recycling plant inputs			
kt of collected batteries and recycling plant input as % of collected batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment	
Starter Batteries	510-610 kt			
	95-100%	-	-	
NiCd Batteries		2,5-3 kt	2,2-2,8 kt	
	-	98%	100%	
		4,7-	5,8 kt	
		10	0%	
Other batteries		155-175 kt	30-37 kt	
	-	95-100%	90%	
Total batteries	510-610 kt	157,5-178 kt	32-40 kt	
	95-100%	95-100%	90%	
		700-850 kt		
		95-98%		

Footnotes can be found in the report

1.4 SUMMARY OF THE IMPACTS OF POLICY OPTIONS

1.4.1 Quantitative Policy Options About Total Batteries

- When considering the baseline scenario for 2007, the highest policy options to be studied for all spent batteries, a collection rate of 70-80% and a recycling plant input of 90%, are already reached due to the fact that:
- 80 to 95% of spent starter batteries, which represent about 65% of all spent batteries, are believed to be collected and more than 95% of them sent to a recycling plant,
- 80 to 90% of spent industrial batteries, which represent about 20% of all spent batteries, are believed to be collected and more than 95% of them sent to a recycling plant.
- No major additional environmental impacts are thus expected for policy options about all batteries.
- Regarding economic impacts, the setting up of mandatory targets will require to implement monitoring systems for all types of batteries, in particular starter batteries and industrial batteries where statistics do not exist at all in most countries today. This will generate costs, without being certain of the reliability of the measurements considering the high levels already reached.
- As for social impacts, job would be created with the implementation of monitoring systems.

1.4.2 Quantitative Policy Options About Starter Batteries

■ In the baseline scenario for 2007, 80-95% of spent starter batteries are believed to be collected and more than 95% of them sent to a recycling plant. We would be between the 80-90% and 90-100% policy options to be studied for collection rate and above the highest policy options for recycling.

It should be noted that no statistics exist at the European level and in most countries. But where data are available, the highest values of the range are reached⁴. The lowest values are assumed to reflect the situation in countries where starter batteries collection would be less developed.

- Economic impacts
- Baseline scenario: lead recycling is financially self sufficient.
- Economic impacts are mostly independent from the level of collection rate (for the recycling plant input considered 75%⁵). They are rather linked to their mandatory aspect: having mandatory targets will involve costs to monitor, without being certain of measurement reliability (because high results are believed to be already achieved).
- Other additional costs are likely to be not significant, even for countries where starter batteries recycling is less developed (because lead recycling is financially balanced).

It is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared. In that case, this difference in scope would result in an overestimation of collection rate.

If recycling targets higher than 90-95% of collection (i.e. higher than those considered here) would be considered, market efficiency could be hurt. As a matter of fact, this could oblige the industry to reduce the temporary storages they use as a hedging effect, which could affect their capacity to adjust when facing low lead prices. The risk is that lead recycling could become no more financially self sufficient, which would oblige producers to create a collective system to finance recycling.

- Environmental impacts
- Baseline scenario:
 - Positive consequences of recycling: most of lead (heavy metal) is already diverted from waste.
 - Negative consequences of recycling: environmental damages linked to collection, transport and re-processing (in particular to air) are higher than benefits brought by virgin material savings.
- Positive consequences of recycling increase with collection and recycling targets increase (the higher the collection and recycling targets, the higher the lead diverted from waste).
- Negative consequences of recycling decrease with recycling targets increase (for a given collection target, the higher recycling target, the lower negative consequences of recycling: recycling benefits increase more than transport negative impacts).
- Social impacts
- As for economic impacts, social impacts are mostly independent from the level of collection rate.
 They are rather linked to their mandatory aspect: having mandatory targets will involve the creation of a monitoring system, with new jobs.

1.4.3 Policy Options About NiCd Batteries

1.4.3.1 Quantitative Options About NiCd Batteries

■ In the baseline scenario, industrial NiCd batteries already reach the highest collection target (80-90% of spent batteries).

But they only represent 1/5th of total spent NiCd batteries and collection rate of portable NiCd batteries is estimated at 20-25% in the baseline scenario.

To reach the total targets contemplated for NiCd batteries (60-70% or 70-80% or 80-90%), targets 10 points lower than for total spent NiCd batteries would be necessary for portable NiCd batteries (50-60%, 60-70%, 70-80%).

This is technically possible, but will require both:

- current domestic hoarding behaviours to be reduced significantly,
- refractory persons to participate to separate collection.

As a matter of fact, with current level of domestic hoarding (estimated at 60% of spent rechargeable batteries), collecting 50-60% of spent portable NiCd batteries means collecting more than what is assessed being available for collection.

■ In view of collecting portable NiCd batteries, the directive could either adopt collection and recycling targets focusing on portable NiCd batteries or on all portable batteries.

It is not easy to compare these scope options in terms of collection efficiency because results vary in a large range on the ground. Most of member states who launched a collection system following the current directive implementation decided to collect all portable batteries (A, B, D, F, NL, Sw). 17% to 62% of all spent portable batteries are collected according to country (systems more or less

developed, different stakeholders responsibility, different equipments...). Two others (Dk, Nw) focused on portable NiCd and collect 40-50% of spent portable NiCd batteries.

The question should be asked if schemes focusing on portable NiCd batteries can reach policy targets under consideration. As a matter of fact, despite very high financial incentives for collectors to collect since 1996, only 43% are collected in Denmark.

Economic, environmental and social impacts are worthwhile to assess for both scope options.

It is even necessary to distinguish between 3 schemes, because for a given scope option, countries have still different possibilities to implement the directive which will generate different impacts.

Possible Scope Options for the Directive and Possible Schemes at National Level

•	Po	ssible schemes at nationa	ıl level
Possible scope options for the directive	Scheme 1 – Collection and recycling of portable NiCd batteries	Scheme 2 – Collection and recycling of all portable batteries	Scheme 3 – Collection of all portable batteries and recycling of portable NiCd
Collection and recycling targets focusing on portable NiCd batteries or on all portable batteries	x	x	x
Collection and recycling targets covering all portable batteries		x	

Economic impacts

Scheme 1 – Collection and recycling of portable NiCd batteries:

- For countries which have already adopted this scheme (Dk, Nw) and for countries which have developed no scheme till now, it is not relevant to assess the additional costs because it is possible that this scheme does not allow to reach policy targets under consideration.
- For countries which have already adopted scheme 2 (A, B, F, NL, Sw) or 3 (D⁶),
 - Some of them already reached the highest option (70-80% of spent batteries): no impacts are expected.
 - For others, collection could develop with no major additional costs.

Scheme 2 – Collection and recycling of all portable batteries:

• For countries which have already adopted this scheme, several of them are expected to reach the lowest target contemplated (50-60% - maybe some could be between 60-70%) (for some of them, the implementation of the WEEE directive which would give about 5 additional points could help).

For the others, they may still be at about 30% of spent batteries, with high domestic hoarding.

For countries which have adopted scheme 1 or no scheme, very low collection rate will be reached in 2007.

⁶ Germany is actually between scheme 2 and 3 since not only NiCd is recycled but also other small batteries, those whose recycling cost is judged not being too high (67% of what is collected in 2003 is recycled)

- The economics of collection and recycling of all portable batteries is impacted by the following parameters:
 - Choice of collection scheme (without being able to associate a type of collection to a level of cost) and recycling technologies (higher cost in dedicated plants compared to other technologies): our calculation were based on ranges to take these variations into consideration.
 - Economies of scale which were considered to affect recycling cost (for dedicated plants only) and administration costs (for administration cost, a step function was considered with economies of scale in between).
 - Important increase of communication expenses with the collection rate (in order to encourage households and professional users to reduce hoarding behaviors and participate to separate collection).

The economic model built results in the following shape:

- Up to a certain level of collection rate estimated near 40-50% of spent batteries, the costs remain quite constant, due to compensation of communication costs increase and economies of scale of both administration and recycling costs.
- After this threshold, a step of increase of administration costs is assumed, so the still increasing communication costs would not be compensated any more: the costs would increase faster with collection rate.
- Remark: the threshold appears to be near a collection rate of 40-50% of spent batteries, which correspond to about 60-75% of spent batteries available for collection when considering the current hoarding behaviors. Such level of collection rate is reach today in Belgium and Netherlands with no significant collection rate increase over the last years although already relatively high costs. Considering a high cost increase above that level seems then to be coherent with the situation on the ground.

Cost per tonne collected:

- A 10 point increase of recycling plant input (e.g. from 50-60% to 60-70%) results in an increase of 10 to 55 € / t collected, due to the fact that additional tons recycled are recycled at an average cost of 300-700 € / t of portable batteries entering a recycling plant (depending on the type of recycling technology and the economies of scale) instead of 90 € / t of batteries disposed of.
- For a constant recycling input plant, a 10 point increase of collection rate results in an increase of about 100-150 € / t collected for relatively low collection rates (e.g. 30 to 50% of spent batteries), and more than 1000 € / t collected for high collection rates (from 50 to 100%)⁷.

Overall budget concerned

In the baseline scenario 2007, a budget of 60 to 75 million Euros is already dedicated to separate collection and recycling of about 32-40 kt of portable batteries (collection rate of 20-25% of spent batteries).

A target of 50-60% of spent batteries in the directive would require a budget of 215-285 million Euros, i.e. additional costs of 140-225 million Euros (extra costs are assessed at 345-420 million Euros in case of a 60-70% target and 475-570 million Euros for 70-80%).

This is because of both communication and administration costs:

⁻ communication costs regularly increase as collection rate increases. For example, to double collection rate from 30 to 60% of spent batteries (45% to 85% of spent batteries available for collection with current level of hoarding), PR and communication budgets are estimated to be multiplied by 10 to avoid domestic hoarding (i.e. from 250 to 2500 € / t collected).

⁻ As for administration costs, economies of scale are observed until about 50 – 60% of collection rate, then a step of increase is considered being needed to ensure collection of higher quantities.

- Euros cents per unit sold:
 - The collection and recycling cost in € cent / unit sold does not vary much function of recycling plant input rate, for a given collection rate (maximum 0.8 € cent / unit sold).
 - For a given recycling plant input, costs vary from about 2 € cents / unit sold (30-40% collection rate) to 11 € cents / unit sold (60-70% collection rate) and about 17 € cents / unit sold (80-90% collection rate).
 - In case of producers' responsibility, these costs would be paid for by producers.
 - They are likely to be transferred to consumers.
 - Sale prices vary a lot for a same type of battery: from 60 to 150 € cents / unit for an alkaline battery for instance
 - Collection and recycling costs thus represent 1.5 to 25% of the sale price depending on the level of collection objective.
 - In case of shared responsibility⁸, collection equipment and communication costs are considered being paid for by public authorities and / or retailers. Costs paid for by producers would then vary from about 1.5 € cents / unit sold (30-40% collection rate) to about 4.5 € cents / unit sold (60-70% collection rate) and about 5.5 € cents / unit sold (80-90% collection rate)..
 - They would represent 1 to 9% of the sale price depending on the level of collection objective.
- Cost per tonne of all portable spent batteries

For countries where no separate collection exist (cost of 120 Euros / t of batteries collected with MSW and disposed of), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is 10-15 times higher for 50-60% collection rate to about 30 times for 70-80% collection rate.

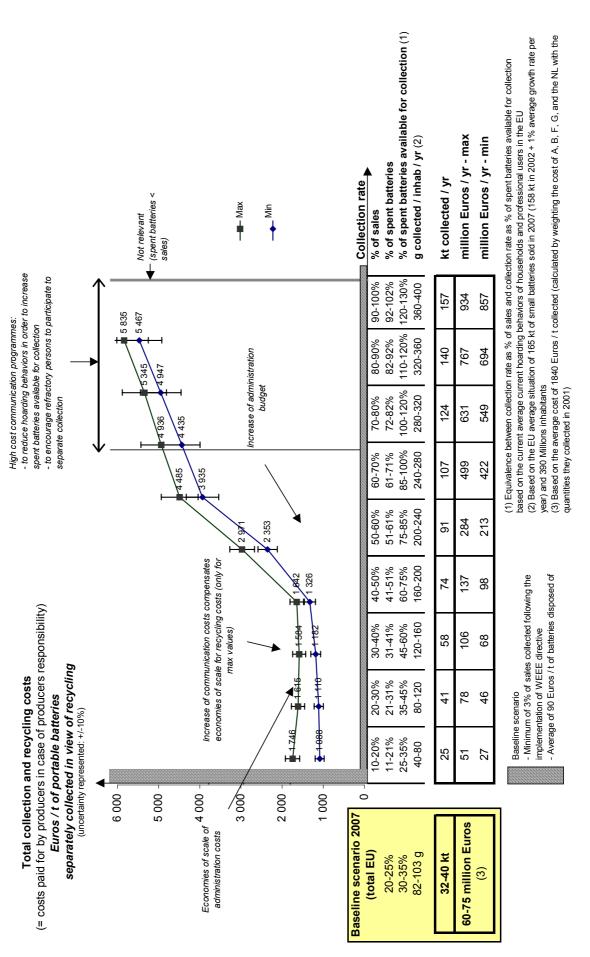
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The cost quantified here corresponds more to a partial shared responsibility because logistics is accounted for producers and only collection equipments and communication are deduced from what producers would have to pay. In cases where logistics is paid for by municipalities, costs covered by producers could be lower.

Portable Batteries - Total Collection and Recycling Costs Function of Collection Rate (orders of magnitudes)

Euros / tonne collected

Collected batteries sent to recycling: 90 - 100%



Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- The difference considered here compared to scheme 2 is that only NiCd (and other batteries which can be recycled at a low cost, even a 0 cost) are recycled.
 - It is considered that 15% of collected portable batteries are sent to recycling, at an average cost of $100 \text{ Euros} / t^9$.
 - Scheme 3 presents costs which are lower than scheme 2 of about 100-250 Euros /t collected.
- For countries where no separate collection exist (cost of 120 Euros / t of batteries collected with MSW and disposed of), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is about 11 times higher for 50-60% collection rate to 25 times for 70-80% collection rate.

Environmental impacts

Scheme 1 – Collection and recycling of portable NiCd batteries:

- The separate collection and recycling of portable NiCd batteries has positive environmental consequences for all the environmental indicators examined (dissipative losses of Cd, CO2 emissions, SOx emissions, NOx emissions, primary energy consumption), irrespective of the collection and recycling rates. As collection and recycling rates increase, the predicted environmental benefits are maximised.
- Remark: no data were available to assess the environmental consequences of other NiCd recycling technologies (metal plants, electric arc furnace...). They are likely to significantly differ from recycling in dedicated plants (different proportions of metals recovered, specific environmental advantages or disadvantages...).

Scheme 2 – Collection and recycling of all portable batteries:

• It was not possible to assess the overall environmental balance of this scheme since there is no LCA data available to conclude if the environmental consequences of collection and recycling of portable batteries other than NiCd are positive or negative.

Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- The separate collection of portable batteries in view of recycling portable NiCd batteries only (other portable batteries are disposed of) has positive environmental consequences for all the environmental indicators examined except NOx emissions, irrespective of the collection and recycling rates.
- For NOx emissions, the higher the collection rate and recycling plant input, the lower the damage (the environmental benefit of recycling increasing more than the NOx emissions due to transport).
- Remark: no data were available to assess the environmental consequences of other NiCd recycling technologies (metal plants, electric arc furnace...) as mentioned above.

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with economies of scale (recycling cost = 0 Euros / t for 50-60% collection rate and above)

Social impacts

Two indicators have the same tendencies whatever the scheme is:

- Gender employment: waste management are not unfavorable to equal gender employment.
- Modification of end users behaviors: the higher the collection objectives, the higher necessary hoarding decrease.

Scheme 1 – Collection and recycling of portable NiCd batteries:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 140-160 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: potential negative impact on the perception of batteries by consumers ('some would be dangerous others not').
- Perception of waste management by end users: possible confusing message with other waste management policies¹⁰.

Scheme 2 – Collection and recycling of all portable batteries:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 2000-2400 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: No difference between batteries in the perception by users.
- Perception of waste management by end users: Messages homogeneous with other waste management instructions to citizens¹¹.

Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 1600-2000 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: No difference between batteries in the perception by users.
- Perception of waste management by end users: Messages homogeneous with other waste management instructions to citizens. But high risk to discourage end users from participating to waste separation¹².

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Contrary to other waste, in the battery sector, recycling would be justified only by level of hazard.

Similarly to other waste, in the battery sector, separate collection is promoted independently of the hazardous content of waste.

when they realise that most of separately collected waste are disposed of instead of being recycled

1.4.3.2 NiCd Batteries Ban Option

Environmental impacts

- From a global risks point of view, a ban of NiCd batteries is not relevant to reduce total human cadmium exposure because NiCd batteries do not represent a significant source of cadmium emissions to the environment (Cd emissions come mainly from other anthropogenic emission sources: fertilizers, fossil fuels, iron and steel...). (TRAR conclusion)
- As for local risks, there is no strong argument to support a ban on industrial NiCd batteries, because they do not represent a significant source of Cd emissions to the environment (local risks are primarily linked to incineration and landfilling and most of industrial NiCd batteries are believed to be collected and sent to recycling). (BIO conclusions from TRAR data)
- On the contrary, as far as portable NiCd batteries and local risks are concerned, BIO calculation of characterisation risk factors from TRAR data does not permit to exclude the relevance of a ban on portable NiCd batteries (BIO conclusions from TRAR data):
 - no risk assessment has been performed regarding air emissions,
 - no conclusion can be drawn for additional risk in sediment compartment because existing cadmium concentration has already eco-toxicological effect,
 - for the other compartments, the existence or absence of local risk depend on local characteristics: in particular, incineration and landfill facilities in conformity with EU regulations and applying existing risk reduction measures have no local risk whereas others have local risks for fresh water ecosystems.

On the other hand, a ban option will not necessarily result in a no risk situation because two flows of spent NiCd batteries will still have to be treated after the ban is into force: batteries which will become waste after the ban and batteries discarded after having been hoarded¹³.

High rate collection and recycling of portable NiCd batteries and / or enforcement of existing regulations about incinerators and landfill facilities are likely to be good alternatives to a ban with a view to reduce local risks.

 Other environmental impacts of a ban can be mentioned. Because the life expectancy of NiMH batteries in terms of number of cycles is between one third and one half that of NiCd, the number of cells for disposal would double or triple. And for domestic tools, it is often necessary to replace the entire tool because it is a sealed unit and the battery cannot be removed.

Feasibility

A ban on batteries containing cadmium could be feasible for one market segment: households applications, except cordless power tools where significant negative technical impacts are expected. Other segments do not have viable substitutes other than lead-acid batteries.

Households applications other that cordless power tools represented 3 600 tonnes in 1999, i.e. about 30% (weight) of portable NiCd batteries and about 20% of total NiCd batteries.

¹³ 60% of rechargeable batteries are assumed being hoarded today by end users.

Other impacts

Economic and social impacts are difficult to assess because first no factual information were available and secondly the effect of a ban on the market structure (mainly the four industrial stakeholders: producers, assemblers, incorporators, retailers) is difficult to predict:

Risk of side effect for the whole portable NiCd batteries industry

A ban on only one segment of NiCd rechargeable batteries is likely to be generalized to other NiCd segments, even if not required legally. Some actors may decide to anticipate a possible extension of the regulation or may simply misunderstand the actual scope of existing regulation. However, the existence of alternative technologies is a prerequisite for this generalization to arise.

Risk of domino effect

Through a domino effect, importers, assemblers and incorporators will be affected too. SMEs may be more sensitive to a ban, in case they can not switch to other technologies (if any).

Risk of market distortion

The difficulty to implement an efficient and reliable control system (to guarantee that no NiCd batteries are imported with household equipments other than power tools for instance) could benefit to non EU producers and result in competition distortion.

As for macroeconomic impacts:

- Some of them were roughly quantified:
 - Costs due to higher pricing of substitutes: based on current prices, a substitution by more expensive Ni-MH batteries could result in additional costs for consumers of 825 to 1 995 million Euros (this large range reflects two elements: first, NiMH selling price is today 10 to 30% higher than NiCd¹⁴ and NiMH life expectancy is one third to one half that of NiCd). Most likely, the market will adjust to a lower equilibrium.
 - Costs due to more waste to be treated: the doubling or tripling of the number of cells for disposal¹⁵ would result in additional costs between 0 Euros (if enough recycling capacities exist with a zero cost as today) to 1.3 million Euros (in case of disposal of 10 800 tonnes at 120 Euros / t).
- Others can be qualitatively mentioned, mostly:
 - Costs due to more frequent equipment replacement: for domestic tools, it is often necessary to replace the entire tool when the battery is over because it is a sealed unit and the battery cannot be removed. The shorter life expectancy of NiMH batteries would then generate higher costs related to equipment purchase and WEEE management.
 - Costs to implement and monitor a control system, in particular for importations of equipment containing rechargeable batteries (without being certain of its expected efficiency and reliability).

Concerning social impacts:

- Employment:
 - Jobs are likely to be created, first at the production stage since 2 to 3 times more substitutes are today necessary to replace NiCd (due to lower life expectancy) and also to control the system.
 - Others could disappear at the different stages (production, assembling, incorporation, distribution) due to possible reorganisation of industrial and commercial activities.

Depending in particular on the country where it is produced; a 10% difference in selling price would be for NiMH produced in China.

¹⁵ The life expectancy of NiMH batteries is between one third and one half that of NiCd as mentioned above for environmental impacts.

- Indirect jobs are generally considered being impacted in the same proportion as direct jobs.
- As for new jobs location, the possibility of a foreign outsourcing for production, in favor to countries with lower labor costs (in particular China), at least for part of the jobs created, can not be excluded from information available.
- Acceptability (homogeneity with other European policies): a ban on NiCd batteries in the Battery
 directive would be consistent with other recent directives (end-of life vehicles directives and
 directive on the use of certain hazardous substances in electrical and electronic equipment).
- Perception by stakeholders: a ban on only one segment of NiCd rechargeable batteries would possibly constitute a confusing message for downstream industrial stakeholders (assemblers, incorporators, importers, retailers), who could easily generalized to other NiCd segments, even if not required legally.

1.4.4 Policy Options About Stakeholders' Responsibility

- If the directive defines only legal responsibilities, no major differences can be expected between producers' and shared responsibility for the three categories of impacts considered (economic, environmental, social). As a matter of fact, impacts are more related to the financial responsibilities or the organisational responsibilities.
- Compared to a producers' organisational responsibility, a shared organisational responsibility:
- is likely to allow more easily an optimisation of waste collection by municipalities and thus a reduction of total costs and of environmental impacts.
 - However, in case of partial shared financial responsibility where producers reimburse partly municipalities expenses, municipalities may have less incentive to optimise their costs and these benefits of shared responsibility principle may not exist.
- is more favourable to local jobs creation (proximity principle).
- Compared to a producers' financial responsibility, a shared financial responsibility:
- from the economic point of view, is more favourable to producers and less to municipalities and retailers of course, and more favourable to end users and less to tax payers (because all tax payers may pay, not only end users as consumers).
- is more favourable to local jobs creation (proximity principle).

And a producers' financial responsibility:

- has no major economic impact on municipalities and on tax payers and is thus more favourable to the polluter-pays principle (end users will pay total costs as consumers),
- is likely to be more favourable to the design of products more environmentally friendly because producers may try to design product integrating end-of-life considerations in view of reducing endof-life costs),
- is more favourable to the internalisation of waste management costs in purchasing price of products, as the integrated product policy developed at the EU level may give priority in the future.

1.5 LIMITS OF THE STUDY AND FURTHER RESEARCH WORK TO BE PERFORMED

■ We encountered an important lack of statistics (sales, quantities collected, quantities recycled) mostly for starter batteries and industrial batteries other than NiCd.

Besides, choice between collection rate definitions still need to be made. The elaboration of methodologies to estimate them and monitor quantities arising may help to make the decision.

- According to information provided to BIO in the framework of the study, separate collection would not be well developed in accession countries. But information received is very partial at that stage. Further investigation would be necessary in order to describe more accurately the situation in accession countries.
- No system to accredit battery recycling facilities exists today. The analysis of the advantages and disadvantages of systems based on best available technology (BAT) principles and systems based on best available technology not entailing excessive costs (BATNEEC) principles would be necessary given that the different recycling technologies (mostly dedicated plants, metal plants, EAF) are likely to present different profile in terms of Recovery rate (proportion of metals which can be recovered), costs and environmental impacts and benefits.
- Regarding environment impact assessment, the lack of LCA data about portable batteries other than NiCd do not allow to conclude about the environmental consequences of their recycling. LCA study has to be carried out.

For NiCd, LCA are only available for their recycling in dedicated plants. No data are available for other recycling technologies (metal plants, electric arc furnaces...) whose environmental profiles are likely to significantly differ from dedicated plants.

■ Monetarisation of environmental impacts

In this study, no monetarisation of environmental impacts was performed:

- First, existing results from ERM study can not be used directly in the present study since we recalculated environmental impacts.
- Secondly, to monetarise environmental impacts, we should have had to select a set of cost-factors (no ready-for-use database about external cost factors exist today in such a macro-economic and LCA-context) and carry out calculation for the different battery segments and policy options under consideration (collection and recycling rates). This was not compatible with the short duration of the study.
- Most importantly, the benefit to reduce cadmium dissipative losses through the implementation of a collection and recycling system would not have been monetarised by lack of data. A considerable biais would have been introduced and as a result, it would not have been of great help for decision makers.

Further research work are necessary in that area.

■ The conclusions we were able to draw from the TRAR encountered the same limits as those mentioned in the TRAR, in particular the lack of data about atmospheric toxicity of cadmium.

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1 CONTEXT AND OBJECTIVES OF THE PROJECT

■ Directive 91/157/EEC on batteries and accumulators containing dangerous substances amended by Commission Directive 98/101/EC, as well as Commission Directive 93/86/EEC, harmonise the national laws of the Member States in the field of waste management and spent batteries and accumulators containing certain heavy metals.

In practice the Battery Directives have not fully realised these objectives, since:

- The Battery Directives only cover the collection of batteries containing certain quantities of cadmium, mercury or lead, and this limited scope tends to reduce the effectiveness of waste management of batteries and has caused implementation problems within the Member States.
- The Battery Directives only prohibit the marketing of batteries and accumulators containing more than 0.0005% mercury as from 1 January 2001. However, other spent batteries and accumulators are an important source of heavy metals (particularly lead and cadmium), which may constitute a significant source of environmental damage and risk to human health.
- There is a significant disparity between the laws and administrative measures adopted by the Member States with regard to the collection and recycling systems as well as the results yielded by such systems.
- In order to contribute to a proper functioning of the internal market and to establish a high level of environmental protection in the field of waste management of spent batteries and accumulators, the European Commission commissioned BIO Intelligence Service to analyse the positive and negative impacts of different policy options in view of revising the Battery directives.

An extended impact assessment was performed. The methodology developed in this study is based on recent guidelines published by the EC: 'A Handbook for Impact Assessment in the Commission – How to Do an Impact Assessment'.

Remark: It should be noted that this impact assessment had to be performed in a very short time compared to the wide scope of the issue under consideration. The methodology had thus to be defined considering this time schedule constraint.

Different policy options are evaluated regarding their feasibility (from a practical point of view) as well as their economic, environmental and social impacts:

- Different ranges of collection and recycling targets were studied for small, automotive and industrial batteries and accumulators.
- A part of the study focused on the use of cadmium in batteries and its economic and environmental impacts.
- All considerations were made taking into account the two following possible principles: producer responsibility or shared responsibility.

2 CURRENT SITUATION IN EUROPE

2.1 BATTERIES SEGMENTATION

- Batteries can be divided into primary (non rechargeable) and secondary (rechargeable) types. They can also be divided into 3 categories that we will keep all along the project:
- portable batteries (used by households or professional users),
- starter batteries for vehicles (large batteries used by households or professional users),
- industrial batteries (large batteries used in the industry).

Users Type of batteries Technology **Typical Uses** General Purpose (alkaline Clocks, portable audio and devices manganese AlMn and zinc carbon torches, toys and cameras ZnC) Non Photographic equipment, remote rechargeable Lithium (Li) controls and electronics (primary) Button cells (zinc air, silver oxide, Watches, hearing aids, calculators manganese oxide and lithium) Households Portable & Professional Cordless phones, power tools and Nickel Cadmium (NiCd) (<1 kg) emergency lighting users Nickel Metal Hydride (NiMH) Cellular and cordless phones Lithium Ion (Li-ion) Cellular phones, laptops and palms Lead Acid Hobby applications Automotive/Motorcycle Starter Lead Acid Starter, Lighting and Ignition (SLI) batteries Rechargeable Alarm systems, emergency back-up (secondary) Lead Acid Standby systems, e.g.rail and telecommunications applications Industrial Motive power sources, e.g. forklift Lead Acid Traction Large trucks, milk floats batteries (> 1 kg) Motive and standby applications, Industrial Nickel Cadmium (NiCd) standby e.g.satellite and rail applications Nickel Cadmium (NiCd) motive Electrical vehicles power Nickel Metal Hydride (NiMH) Hybrid vehicles

Batteries Segmentation

Remark: It has been decided to separate starter batteries from NiCd batteries for electrical vehicles (instead of having an 'automotive' category gathering both types of batteries). Starter batteries are usually considered by experts as a separate category because of the existence of very specific collection routes. NiCd batteries for electrical vehicles are much heavier than starter batteries and will join other collection routes, close to industrial ones.

In this report, the term 'starter batteries' stands for 'starter lighting and ignition (SLI) batteries', which are lead acid automotive batteries.

■ In the following sections, we describe the current situation of successively the 3 segments, beginning with starter batteries, which represent 65% of total sales, then industrial batteries (20%) to finish with portable batteries (15%).

2.2 STARTER BATTERIES SEGMENT

2.2.1 Discussion About Collection Rates For Starter Batteries Segment

- Two main categories of starter batteries are sold:
- OEM (Original Equipment Manufacturer's) batteries, sold in cars;
- AM (After Market) batteries, sold to replace spent batteries.

A significant part of the OEM batteries are exported with cars and will then not become spent batteries in the country.

Remaining OEM batteries, when spent, are replaced by the after market batteries, until the car is scrapped.

Thus, the total sales, OEM + AM, does reflect the real quantities of spent batteries.

- Spent starter batteries which can be collected can better be assessed from two sources:
- After-market batteries which become spent during the year under consideration (they can be roughly estimated from AM batteries sold in the past, considering average lifespan);
- · Batteries removed from scrapped cars.

NB: a distinction has to be made between end-of-life vehicles (ELV) and scrapped cars, because only a part of ELV is actually sent to scrapping. Most of the remaining ELV are exported for a secondary use.

Spent batteries available for collection are thus only those contained in cars scrapped, and not in all ELV. An evaluation of batteries contained in scrapped cars has been made and is presented in table 'Starter Batteries – Evaluation of batteries contained in scrapped passengers cars' hereafter.

- Two different collection rates are thus assessed in this report:
- Collection rate as % of sales;
- Collection rate as % of spent batteries available for collection where

Spent starter batteries available for collection in 2002 = AM sales in 1997 + Batteries in scrapped cars in 2002

2.2.2 Broad Overview of Starter Batteries Segment

The detailed table, 'Starter Batteries – Current situation in Europe', presents the overall picture of the starter batteries segment (sales, waste stream, collection and recycling). Comments are provided in following sections.

Starter Batteries - Evaluation of Batteries Contained in Scrapped Passenger Cars

				End-of-live Vehicles	ehicles			Starter E	atteries from	Starter Batteries from End-of-live Vehicles	ehicles
	Number of ELV per 1 000 inhab.	Number of ELV per 1 000 inhab.	Population	Total number of ELV	ber of ELV	Total number of ELV scrapped	per of ELV	Tons of batteries contained in ELV	atteries d in ELV	Tons of batteries contained in scrapped ELV (2)	oatteries n scrapped (2)
	1999	2005		1999	2005	1999	2005	1999	2005	1999	2005
I	elv1	elv2	드	ELV1 = elv1 x 1000 / In	ELV2 = elv2 x 1000 / In	C1 = ELV1 x %sc	C1 = ELV2 x %sc	B1 = ELV1 x w / 1000	B2 = ELV2 x w / 1000	D1 = C1 x w / 1000	$D2 = C2 \times w /$ 1000
					(1) hyp:	(1) hyp: %sc = % of ELV scrapped =	45%	Hyp: w = kg / _ battery unit	15		
Fotal EU -15			377 887 445	12 934 047	14 367 587	5 820 321	6 465 414	194 011	215 514	908 28	96 981
	26	32	8 032 926	208 856	257 054	93 985	115 674	3 133	3 856	1 410	1 735
	20	54	10 309 725	515 486	556 725	231 969	250 526	7 732	8 351	3 480	3 7 5 8
Denmark	21	22	5 330 020	111 930	117 260	698 09	52 767	1 679	1 759	952	792
	26	26	5 171 302	134 454	134 454	60 504	60 504	2 017	2 017	806	806
	32	37	59 625 919	2 086 907	2 206 159	939 108	992 772	31 304	33 092	14 087	14 892
Germany	37	43	82 441 365	3 050 331	3 544 979	1 372 649	1 595 240	45 755	53 175	20 290	23 929
	9	6	10 964 020	65 784	98 676	29 603	44 404	286	1 480	444	999
	24	28	3 917 336	94 016	109 685	42 307	49 358	1 410	1 645	989	740
	39	43	56 305 568	2 195 917	2 421 139	988 163	1 089 513	32 939	36 317	14 822	16 343
-uxembourg	19	29	437 389	26 681	29 305	12 006	13 187	400	440	180	198
he Netherlands	43	44	16 146 123	694 283	710 429	312 427	319 693	10 414	10 656	4 686	4 795
	8	12	10 355 824	82 847	124 270	37 281	55 921	1 243	1 864	699	839
	29	34	41 116 842	1 192 388	1 397 973	229 222	629 088	17 886	20 970	8 049	9 436
	40	41	8 943 892	357 756	366 700	160 990	165 015	2 366	5 500	2 415	2 475
United Kingdom	36	39	58 789 194	2 116 411	2 292 779	952 385	1 031 750	31 746	34 392	14 286	15 476

www.populati ondata.net TERM 2002 11a EU Agency Indicator factsheet European Environment Source

(WMF13) -Generation of waste from end-of-life vehicles

(2) Most of ELVs not scrapped are exported

(1) Hypothesis (45% of ELV are scrapped) based on the German and Swedish situation where statistics are available (source: Eurobat & FV Batterien for D, June 2003 and EEA for Sw)

BIO Intelligence Service

Starter Batteries		Sales (1)				Waste stream	3am		Separ	Separate collection	tion		Recy	Recycling	
Current Situation in Europe	Units		Tonnes		Spent	Spent batteries = Spent batteries available for collection	ies = ailable for ກ	Ousmitting	Collec	Collection rates	Means of	Means of collection	Quantities	Recycling plant input	sling
	Total AM OEM	Total	AM (9)	OEM (9)	АМ	Scrapped ELV batteries	Total	separately collected	% of sales	% of spent batteries available for collection	Batteries alone	Through scrapped ELV	ecycled (entering a recycling plant)	% of sales	% of collect ed
Legend: n.a. = not assessed by MS	M units	tons	tons	tons	tons	tons	tons	tons	%	%	%	%	tons	%	%
n.d. = no data available	ם	a=uxw	AM = a x 70%	OEM = a x 30%	$d = a/$ $(1+g)^{\dagger}$	e (11)	f = d + e	ح	i = h / a	k=h/f	d/f	e/f	-	m=/ a/	n = 1/h
	(4) hyp: w = average weight kg / unit = 15	eight kg / unit :	= 15		(2) hyp: g = 3%	. 3%									
Western Europe - 2002					t (years) = 5	. 5				•	•				E
Total lead acid starter batteries	57,3 70% 30% (3)	859 500 t	601 500 t	258 000 t	518 859 t	92 143 t	611 002 t	n.d.			85%	15%	n.d.		95- 100%
Central and Eastern Europe - 2002						(14)									
Total lead acid starter batteries	9,4 82% 18% (3)	3) 141 000 t	115 500 t	25 500 t	99 631 t	9 107 t	108 738 t	n.d.			%76	%8	n.d.		
Per Member State (13) Year	0.7	(10) (18)	(16)					(10) (18)	(42)				(10)	1E20/	400%
	+	0000							()[.)				10000	0/ 761	8
Denmark		n.a.	_					n.a.					n.a.		
Finland		n.a.						n.a.					n.a.		
France 2001								91 411 t	%16				90 222 t	%06	%66
Germany (12) 2001	1999	99 235 304 t			148 109 t	27 248 t	175 357 t	169 809 t	72%	%26			161 319 t (8)	%69	%36
Ireland		n.a.	_					n.a.					n.a.		
Netherlands		n.a.	_					n.a.					n.a.		
Norway 2002		15 260 t						14 689 t	%96				14 689 t	%96	100%
		n.a.						n.a.					n.a.		
Sweden 2001		42 000 t						32 000 t	%92	95-100%	(3)		32 000 t		100%
United Kingdom 2000		2002 111 853 t	_				108 000 t (6)	97 200 t (7)	%28	%06			97 200 t (7)	%28	100%
Day Accession Country (49)		(1)						(0.5)					(10)		
r		28 500 t	_					22 500 t	%62				22 500 t	%62	100%
	_	n.a.	_					n.a.					n.a.		Τ
	7		7										5		

(1) Sales = production + imports - exports

From 2.2 to 6.2 year lifespan according to countries (source: Eurobat, June 2003) 3%

t = average lifetime = years

g = average sales growth rate over last 5 yrs = 3%
(3) Eurobat, June 2003
(4) starter battery weight = between 0.5 and 25 kg (source: ERM - 1997)
(5) Sw declares collection rate = 95-100% of average of sales over the last 5 years
(6) UK declares 108 000 tons for 2003, using BATMOD (ecroment model) to predict waste arisings from battery sales
(7) UK declares recycling rate = 90%, quantities collected then assessed as 90% of spent batteries available for collection
(8) D declares approximately 95% for recycling rate
(9) AM = after market (replacement batteries), OEM = original equipment manufacturer's batteries (sold in cars)

(10) Declared by MSs in the scope of a short inquiry carried out in the framework of this project
(11) See Table 'Starter Batteries - Evaluation of Batteries Contained in Scrapped Passenger Cars' - Average value between 1999 and 2005
(12) For Germany, all data regarding waste stream come from Eurobat calculation, June 2003, carried out from different data sources (FV Baterien, KfBundesamt, ARGE Altauto, WVM, Stat. Bundesamt)
(13) For Germany, all data regarding waste stream come from Eurobat calculation, June 2003, carried out from different data sources (FV Baterien, KfBundesamt, ARGE Altauto, WVM, Stat. Bundesamt)
(14) Fypothesis: same proportion of scrapped ELV batteries compared to CEM batteries as in Western Europe
(15) About 4 600 t out of 16 000 t are imported
(16) This figure only includes baterries sold in Austria which participate (pay) to the Austrian system. A lot of importers do no.

(17) Not calculated because sales and quantities collected declared by Austrian governement do not cover the same scope.

(18) It is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cans but also from 2 and 3 wheel vehicles as weel as from professional and industrial vehicles (agricultural vehicles, trucks, buses, mitte that the quantit when which are not necessarily included in batteries sales declared. In that case, this difference in scope of stakeholders would result in an overestimation of collection rate.

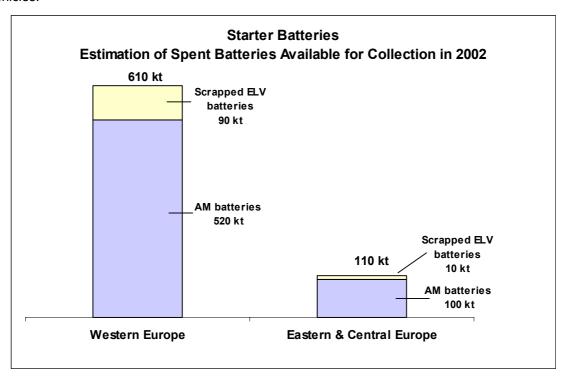
2.2.3 European Market of Starter Batteries

■ About 860 kt of starter batteries are estimated to be sold in Western Europe in 2002, among which 70% (about 600 kt) for the after market (AM) and 30% (about 260 kt) as OEM batteries.

140 kt are estimated to be sold in Eastern and Central Europe in 2002.

2.2.4 Waste Stream of Starter Batteries

■ 610 kt of spent batteries available for collection are estimated to arise in Western Europe in 2002. 85% are estimated coming from the "after market" segment and 15% from scrapped end-of-life vehicles.



■ Compared to 2002 sales (even if the comparison has no real signification because sales and waste arising the same year have no empirical relationship), spent batteries available for collection represent only 60% of sales.

This will introduce a significant difference between levels of collection rate assessed depending on the definition considered for collection rate (see next section).

2.2.5 Collection of Spent Starter Batteries

- Battery collection is carried out by players belonging to two categories:
- Collecting resulting from work by dealers: the dealers collect used starter batteries and supply a circuit of recyclers and wholesalers.
- Unbilled organised collecting and organised collecting with billing for services: multi-waste collectors, certain refiners and certain manufacturers collect starter batteries.
- Regarding collected quantities and collection rates, no statistics are available at the European level and for most of the European countries.

When considering countries where statistics are available (D,F, Sw, UK, Cz for instance), 90 to 97% of spent batteries available for collection are collected, representing at least 70 to 90% of the same year sales.

Remark: It is possible that the collected quantities declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared. In that case, this difference in scope of stakeholders would result in an overestimation of collection rate.

Because the collection and recycling of starter batteries is economically self sufficient and market driven (see § 2.2.7 page 38), it is likely that the situation in these countries above mentioned reflect a much more generalised situation, without being able to quantify it.

2.2.6 Recycling of Spent Starter Batteries

Starter batteries are recycled in lead smelting plants, located in most of European countries (a list of EU secondary lead smelters is provided in appendix 3 on page 204).

About 0.58 t of lead is recovered from 1 tonne of battery smelted (58% recovery rate).

2.2.7 Economics of Starter Batteries Collection and Recycling

- The revenues from recycling (mostly sale of recovered lead and also of plastics) are generally sufficient to cover all of the collection and re-processing costs involved in the sector.
- However, lead batteries recycling economics is sensitive to the lead market price (LME London Metal Exchange) which can fluctuate significantly over years.

The following table and curves present the detail of the cost and revenues involved. They are based on a French study performed for ADEME where several collectors and all French smelters were audited in 2001.

The collection cost varies between 40 and 120 €/t of battery collected, and the recycling cost is evaluated at 230 €/t collected. Revenues from lead sale varied in a 265-355 €/t collected range over the 1995-1999 period. With certain expensive collection systems, net revenues may then be negative certain years.

■ But the industry has shown in the past that they can deal with that lead market fluctuation, using intermediate temporary storage as a hedging effect. This may explain that 5-10% of spent starter batteries available for collection are actually not collected.

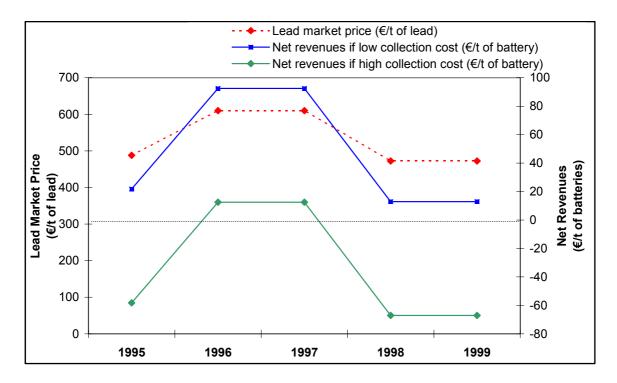
We found no information during the study which would indicate that this recycling activity is not durable at the European level. This may need some restructuring and collection optimisation, in some regions at least.

Starter Batteries - Economics of Lead Acid Starter Batteries Collection and Recycling

		Euros / t of lead recovered	Euros / t of batteries collected (1)	
Costs (1999 data)				
Collection (logistics / storage)	а		40 to 120	according to collection system (3)
Lead smelting cost (2)	b	395	229	
Raw material purchase (other than Ld)		47		
Grinding		40		
Reduction		122		
Waste treatment		35		
Smelting Waste water treatment		49 11		
Security-Health-Environment		9		
S&G		83		
Total cost	C = a + b		270 to 350	
Revenues (lead sale)				
Lead sale	r1	460 to 610	265 to 355	fluctuation with lead market price (LME)
Polypropylene sale	r2	14	8	
Total revenues	R = r1 + r2		273 to 363	
Net revenues	R - C		- 77 to + 93	

- (1) Ratio: 0.58 tonne of lead recovered from 1 tonne of battery (58% recovery rate)
- (2) Average cost data for 4 refiners representing the entire refining capacity in France
- (3) Data derived from a sample of 11 collectors

Source: Figures presented here result from BIO IS calculation based on data from 'Economic audit of lead batteries' gathering and recycling', carried out by Arthur Andersen for ADEME, 2001



2.3 INDUSTRIAL BATTERIES SEGMENT

2.3.1 Broad Overview of Industrial Batteries Segment

- Two main categories can be distinguished:
- NiCd batteries, which are covered by the battery directive, for which statistics are available at both the EU and national levels;
- Other industrial batteries, mostly lead acid batteries, for which statistics are available neither at the European level nor at the national level.
- Spent batteries, which can theoretically be derived from sales of previous years by considering lifespans, are all collectable.

However, spent batteries have very long lifespans which vary significantly with applications. And some hoarding behaviours by end users exist. Contrary to portable batteries, no data are available to assess the level of hoarding.

As a consequence, spent batteries derived from sales and considered available for collection will give a rough approximation of actual waste streams, without being able to quantify the uncertainty.

■ Table 'Industrial Batteries - Current Situation in Europe' next page presents the overall picture of the industrial batteries segment (sales, waste stream, collection and recycling). Comments are provided in following sections.

2.3.2 European Market of Industrial Batteries

■ About 200 kt of batteries have been put on the market in 2002, 97% being lead acid batteries.

This estimation about the total industrial batteries market is very uncertain. It is derived from 1995 data with an average 1% growth rate till 2002

■ 3.6 kt of large NiCd batteries have been sold in 2002, among which 83% for standby applications (3 kt) and 16% for electrical vehicles (0.6 kt).

2.3.3 Waste Stream of Industrial Batteries

■ Considering average lifespans, spent batteries available for collection are assessed to amount at 187 kt in 2002, among which 3.1 kt of NiCd.

Hander Structure Structur	Industrial Batteries				Sales (00)		Waste stream	stream			oeba	Separate collection	lection			Recycling	ם
	Current Situation in	Europ	e		Total			batteries = Spe vailable for col	ent lection	Quantities	Collecti	on rates	Means	of collection	Quantitie recycled		rcling plant input
	Legend:			1195	2002			Contained C in WEEE (12) E	contain ed in LV (12)	separately collected	%of sales	% of spent batterie		hroug Thou h VEEE ELY			
	n.d. = no data available			tons	tons	years	tons]	tons	%	%	%	%	tons	%	%
				a ₁₉₉₅	$a = a_{1995} \times (1+g)^7$	+	d = a / (1 + g)	Ψ		ح	i = h / a	j = h / d			-	m=1/	_
						0)	(0) hyp: g =										
	Western Europe - 2002			(1)		L							ľ	ŀ		ŀ	
Control Cont	Lead Acid Traction			115 000 t			111 618 t			n.s.				ľ	n.s.		
NCA statistic NCA statisti	Nickel Cadmium			4000	(2)		3 101 t				%82	%06		ł		╄	%86
Figure Niction power (secritical setricies) Niction power (secritical setricies) Niction power (secritical setricies) Septent 10 to 500 (1 c) 2 to 3 to 4			NiCd standy		ot (2)					+			П		-	Н	
Control books Control book	NiCd motive pow	er (electr	ical vehicles)		(2)		(67)						T				
Accession Country Acce	Nickel Metal Hydride			2 000 +	50 t (11)		3 143 +			n.s.					n.s.		
Control Cont	Total industrial			189 490 t	16		186718+			- L					و ا	_	
Total Tota				100-001			3	7		11.5					9		
10 Nicd Ni	Per Member State (8)	Year	Segment	(10)			(4)		_	(10)(14)					(10) (14)	ļ	
Total Laboration Laborati	Austria	2001	Total NiCd	n.a. n.a.		(6) 8,2				n.a. 134 t					n.a. 134 t		100%
1	Belgium	2001	Total	n.a. n.a.		8,2				n.a. 104 t					n.a. 104 t		100%
g (1) Total n.a 8.2 67 550 1 n.a <	Denmark	2001	Total	n.a. n.a.		8,2			ı	n.a. 34 t					n.a. 34 t		100%
1	Finland	2001	Total	n.a. n.a.		8,2				n.a. 1 t					n.a. 1 t		100%
my 2001 Total 70 0000 t (5) 64 53 1 t n.a.	France	2001	Total	73 274 t 501 t		8,2	67 550 t			66 757 t 780 t	91% 156%	%66			65 941 t 780 t	90% 156%	
Indicate Total India I	Germany	2001	Total	70 000 t n.a.	(5)	8,2	64 531 t			n.a. 826 t					n.a. 826 t		
Find thick Total In a.	Ireland	2001	Total	n.a. n.a.		8,2			ı	n.a. 8 t					n.a. 8 t		100%
y Total n.a. 8,2 m.a. R4t 85% m.a. n.a.	Netherlands	2001	Total	n.a. n.a.		8,2				n.a. 124 t					n.a. 124 t		100%
In a. Total n.a. 8.2 m.a. n.a. n.a. 154 t n.a. 154 t n.a. 154 t n.a. 154 t n.a.	Norway	2001	Total	n.a. 99 t		8,2				n.a. 84 t	85%				n.a. 84 t	85%	100%
Indicator Total Indicator In	Spain	2001	Total	e, e,		8,2				n.a. 154 t					n.a. 154 t		100%
Kingdom 2002 Total 58 538 t R.2 53 965 t 22 800t (7) 39% 42%	Sweden	2001	Total	n.a. n.a.		8,2				n.a. 295 t					n.a. 295 t		100%
Accession Country Year Segment (10)<	United Kingdom	2002	Total	58 538 t n.a.		8,2	53 965 t				39%	42%			L.,		
Republic 2001 Total 650 t 8,2 599 t 604 t 93% 101% 604 t 93% n.a. n.a. n.a. 8,2 n.a. n.a. n.a. n.a. n.a. n.a.	Per Accession Country	Year	Segment	(10)					ı	(10)					(10)		
Total n.a. 8,2	Czech Republic	2001	Total	650 t n.a.		8,2	599 t			604 t n.a.	%86	101%			604 t n.a.	83%	
	Latvia		Total	n.a.		8,2				n.a.					n.a.		

- (00) Sales = production + imports exports
- (0) Hypotheses: t = average lifetime (source: ERM report 1997)

(source: ERM report 1997)

%

- g = average sales growth rate over last 3 yrs =
 - (1) ERM report 1997, 1995 data

- (2) Collectivificad, June 2003
 (3) Collectivificad, June 2003
 (4) Average lifetime considered (weighting of the different lifetimes) = 8,2 years
 (5) vague estimate for lead batteries only
 (6) 15-year lifetime considered
 (7) UK declares 110-130 kt of large batteries collected and recycled; industrial batteries collected is assessed as the difference between 120 kt and those assessed for starter batteries (97,2 kt see table Starter batteries)
 - (8) No answer obtained to the inquiry launched in the framework of this project for the other countries
 - (10) Declared by MSs in the scope of a short inquiry carried out in the framework of this project
 - (11) Saft, June 2003
- (12) only those concerned by the WEEE directive and the ELV directive
- (13) NiMH is used in hybride vehicles; one might not expect mgany to be avaiable for collection yet (source: Eurobat, June 2003)
- (14) Source fro NiCd data: TRAR, Risk Assessment Targeted Report Cadmium (oxide) as used in batteries Draft version of February 2003

2.3.4 Collection of Spent Industrial Batteries

No statistics are available about large lead acid batteries.

In France, where data are available, 91% of sales are declared being collected, which would represent 99% of spent batteries available for collection.

From the nature of the product and their application, their collection and recycling is regulated by established industrial practices and supplier-customer regimes.

As for NiCd, 2.8 kt were collected in 2002 at the EU level, representing 78% of 2002 sales.

It represents 90% of the spent batteries available for collection calculated from 1987 sales. The actual collection rate is likely to be a little bit lower, maybe somewhere between 80-90%, because landfilling still exist in some MSs.

Data about national situations can be derived from the TRAR (see table 'NiCd Batteries Market, Collection, Recycling' page 67).

2.3.5 Recycling of Spent Industrial Batteries

- Considering the well established recycling market of lead acid batteries, it is quite certain that all collected batteries are sent to a recycling plant, even if no statistics are available. This is the case in France, according to MSs declaration.
- As for NiCd, 98% of collected quantities at the European level are declared to be sent to recycling.

Most of industrial NiCd batteries are sent to dedicated recycling plants, as portable sealed NiCd batteries.

2.3.6 Economics of Industrial Batteries Collection and Recycling

- For lead acid batteries, see section 2.2.7 page 38.
- For NiCd batteries sent to dedicated plants, recyclers bill between 0 to 300 Euros / t entering the plant depending on the proportion of metals recovered and metal market prices (nickel, cadmium and steel). This is the same price range as for portable NiCd (see section 2.4.7.3.1 page 65).

According to recyclers, NiCd recycling cost could decrease to a range of 0 - 200 Euros / t in the future (even positive value in some cases), in particular by increasing the recovery of ferro nickel by 10-15%.

2.4 PORTABLE BATTERIES SEGMENT

2.4.1 Discussion About Collection Rates For Portable Batteries Segment and Equivalence Formulas

■ The notion of 'spent batteries' is difficult to define and quantify because in the portable batteries segment, a significant part of batteries, spent or not spent yet, are hoarded by end-users, mostly in electric and electronic equipment (EEE) in which they are contained.

A stock in the economic sphere is actually constituted of batteries still in use as well as batteries hoarded by households and professional users (batteries no more used, being spent batteries or not yet).

The spent batteries collectable (i.e. available for collection) are spent batteries which are not hoarded by end users. The less batteries hoarded, the more spent batteries available for collection.

■ In this study, it was possible to estimate the quantities available for collection in 2002 and the collection rates reached compared to spent batteries collectable, for the current situation of domestic hoarding.

To increase collection rates up to a certain point, it is necessary to have end users to put their spent batteries hoarded till now in the waste management circuits.

Specific communication programmes are necessary, whose corresponding costs are estimated in the economic analysis of policy options (see section 3.5.2 page 89).

■ Four definitions of collection rates are possible for portable batteries. These different collection rates were quantified for the current situation and are presented in the next sections.

Possible Collection Rates for Portable Batteries

Collection rate	Definition	Comments
% of sales	Quantities collected (kt) yr N	As for other segments, this collection rate is the easiest to calculate because statistics exist for both numerator and denominator. But there is
	Sales (kt) yr N	no empirical relationship between both of them so it does not reflect the efficiency of the collection scheme.
% of spent batteries	Quantities collected (kt) yr N	To reach high collection rate as % of spent batteries may be an objective which will need to
	Spent batteries (kt) yr N	have end users to cease or at least significantly reduce hoarding behaviours.
% of spent batteries	Quantities collected (kt) yr N	This collection rate takes into account actual domestic hoarding. The less hoarding, the
available for collection	Spent batteries available for collection (kt) yr N	closer % of spent batteries available for collection and % of spent batteries.
g collected /	Quantities collected (kt) yr N	This indicator reflects the actual level reached.
inhabitant / year	Inhabitants	

■ Equivalence formula between CR as % of sales and CR as % of spent batteries

The equivalence between these two collection rates is directly dependent on the level of sales year N and the level of spent batteries year N. If statistics were available about sales, spent batteries year N should have been estimated from sales for previous years by considering an appropriate hypothesis about lifespan for each segment. Because we were not provided with such data in the short time period of the study, we considered an average growth rate.

CR as % of spent batteries = CR as % of sales x (1 + average growth rate) lifespan

In this study, an average growth rate of 1% was considered. Then spent batteries 2002 = 96% of sales 2002 and

CR as % of spent batteries = CR as % of sales + 1-2 points

Remark: if a 5% growth rate would have been considered, spent batteries 2002 = 84% of sales 2002 and collection rates would appeared higher.

- 20% of spent batteries (instead of 18% with a 1% growth rate)
- 32% of spent batteries available for collection (instead of 28% with a 1% growth rate)

The collection rate as % of sales would of course stays at 17%.

So with a 5% growth rate, CR as % of spent batteries = CR as % of sales + about 3 points.

One can conclude that for portable batteries (where lifespans are lower than the other batteries segments), the difference between a collection rate as % of sales and a collection rate as % of spent batteries are not so different.

Important remark: an important biais would be introduced by assessing spent batteries from same year sales and average growth rate in the past for markets with important shrinking size (ex: portable NiCd market in Danemark following the introduction of high ecotax in 1996).

■ Equivalence formula between CR as % of spent batteries and CR as % of spent batteries available for collection

The difference between spent batteries available for collection and spent batteries are the quantities hoarded.

Spent batteries available for collection = Spent batteries x (1 - % hoarded)

As a consequence,

CR as % of spent batteries

CR as % of spent batteries

(1 - % hoarded)

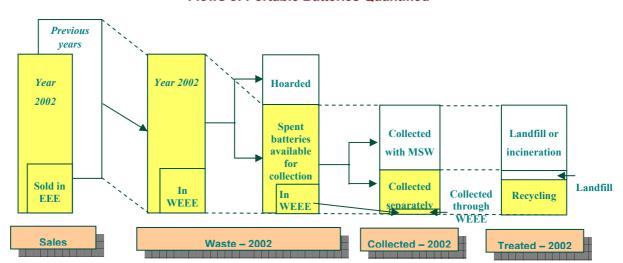
In this study, about 37% of portable batteries are assumed being hoarded, thus:

The higher the quantities collected, the higher the difference between collection rates. And the higher the % hoarded, the higher the difference between collection rates.

When considering the various situations in MSs, there is a 10-15 to 30 point difference between CR as % of spent batteries and CR as % of spent batteries available for collection, even a 50 point difference for some countries (see detailed data in section 2.4.5 page 55).

2.4.2 Broad Overview of Portable Batteries Segment

■ The following diagram describes the different flows of portable batteries quantified in this report.



Flows of Portable Batteries Quantified¹⁶

We combined different methods to assess batteries hoarded and batteries available for collection:

- At the EU level: upstream method, from sales.
 - Hypotheses about **% of hoarding** were used to assess batteries hoarded. Spent batteries available for collection are then the difference between spent batteries and hoarded batteries.
- For MSs where data were available (those where separate collection is developed): downstream method, by adding batteries collected separately and batteries contained in MSW (municipal solid waste).

The implementation of the upstream method as at the EU level with standardised hypotheses about % of hoarding proved to bring results incoherent at the national level. And indeed, from available data at national level, % of hoarding proved to be very different according to countries (see section 2.4.4 page 54).

In both cases, hypotheses about life spans were used to assess spent batteries.

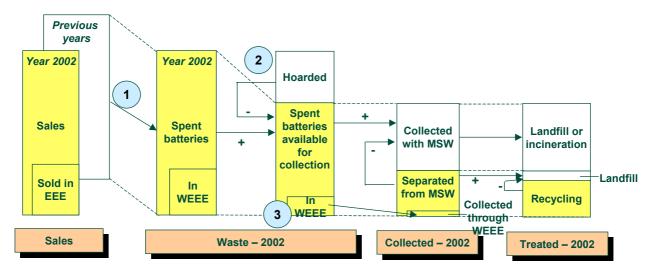
-

Quantities of small batteries collected through professional collection systems were not assessed; however, according to experts, only small quantities are concerned.

Methodology and hypotheses used to quantify flows at EU level

As mentioned above, the methodology used to assess batteries hoarded and then batteries available for collection is an upstream method, from sales.

Methodology and Hypotheses to Quantify Portable Batteries Flows at EU Level



The input data come from industry and concern:

- sales.
- quantities collected separately from MWS,
- quantities recycled (entering a recycling plants).

Several hypotheses had to be made:

- 1 Average portable batteries lifetime = 3 or 5 or 7 years according to battery type.
 - Spent batteries Year 2002 = Sales Year 1999 or 1997 or 1995 according to battery type.
- 2 Domestic hoarding = 30% for non rechargeable batteries and 60% for rechargeable batteries (i.e. 30 or 60% of spent batteries are hoarded by households and professional users), given an average of 37% all portable batteries together.

Remark: No statistics exist at the EU level. These hypotheses seemed acceptable to some experts, others were not able to refute or to confirm.

In countries where data are available about batteries contained in MSW, we assessed the % of hoarding and obtained a very large range.

% of Portable Spent Batteries Hoarded

Austria	Belgium	France	Germany	Netherlands	Sweden
43%	27%	62%	28%	60%	30%

Source: BIO calculation from data provided by CollectNiCad, June 2003 (original sources: various studies performed at national level) (see Table 'Portable Batteries – Current Situation in Some MSs')

Spent batteries available for collection = 60% of non rechargeable spent batteries and 30% of rechargeable spent batteries only

3 Spent batteries available for collection are either contained in WEEE or alone. Spent batteries 'alone' are mostly non rechargeable batteries after use collected separately from any EEE. Spent batteries contained in WEEE are mostly rechargeable batteries sold in EEE. Some of them are non rechargeable batteries: a part of those sold in EEE as well as batteries sold alone and used as safe batteries in EEE.

Hypotheses About Portable Batteries Contained in WEEE

Type of aport betteries	Нурс	otheses
Type of spent batteries contained in WEEE	Batteries sold in EEE in	Spent batteries contained in WEEE in
Contained in WELL	2002	2002
Rechargeable batteries sold in EEE	90 %	90%
	of rechargeable batteries sold	of rechargeable spent batteries
Non rechargeable batteries sold in EEE	10%	
	of non rechargeable batteries sold	10%
Non rechargeable batteries sold alone and	0%	of non rechargeable spent batteries
used in FFF as safe batteries	of non rechargeable batteries sold	of flori rechargeable sperit batteries

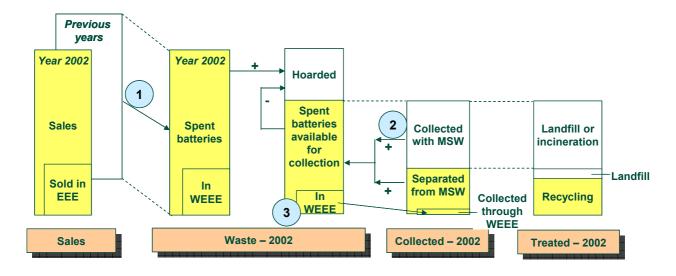
Remark: No statistics exist at the EU level. These hypotheses seemed acceptable to some experts, others were not able to refute or to confirm.

NB: these hypotheses do not affect the estimation of the current situation. They will be used in the baseline scenario to estimate the expected impact of the WEEE directive implementation (see section \Box page 76).

■ Methodology and hypotheses used to quantify flows at national level

As mentioned above, the methodology used to assess batteries available for collection and then batteries hoarded (for countries where data were available) is a downstream methodology, by adding batteries collected separately and batteries contained in MSW.

Methodology and Hypotheses to Quantify Portable Batteries Flows at national level



The input data come from industry, Member States and accession countries and concern:

- Sales.
- quantities collected separately from MSW,
- quantities recycled (entering a recycling plants),
- for MSs where data are available (countries where separate collection is developed): quantities contained in MSW.

Several hypotheses had to be made:

- 1 Same hypotheses as at the EU level for portable batteries lifetime and growth rates.
- 2 Hypothesis for MSs where data are available (countries where separate collection is developed): spent batteries remaining in MSW is extrapolated from national data about the content of batteries in MSW (between 100 and 370 ppm according to country) and the production of MSW per inhabitant (between 192 and 570 kg/capita/yr according to country).
- 3 Same hypotheses for batteries contained in WEEE as at the EU level.
- The detailed table, 'Portable Batteries Current situation in Europe', presents the overall picture of the portable batteries segment (sales, waste stream, collection and recycling).

The detailed table, 'Portable Batteries – Current situation in Some MSs', focuses on the 6 countries where separate collection of all portable batteries exist (see section 2.4.5 page 55).

Comments are provided in following sections.

- (0) Sales = production + imports exports
 - (1) EPBA, June 2003 Western Europe
- (2) CollectNiCad, June 2003
- (3) EBRA & EPBA, June 2003 (4) CollectNiCad, June 2003
 - (5) EBRA, May 2003
- (6) Source: TRAR, Risk Assessment Targeted Report Cadmium (oxide) as used in batteries Draft version of February 2003
 - (7) Pyrometallurgy in dedicated plants
- (8) Pyrometallurgy in metal plants
- (9) Included in 'Lithium ion (rechargeable)'
- (10) Declared by MSs in the scope of a short inquiry carried out in the framework of this project except when explicitely indicated
- (11) AIMn and ZnC batteries with relatively high mercury content (put on the market before legislation entered into force) are not all
- recycled because of recycling difficulties and high cost; general purpose batteries with no Hg are recycled
 - (12) decision not made yet regarding the exportation of collected quantities to be recycled abroac
- (13) see table 'Portable Batteries Current Situation in some MSs' where spent batteries available is assessed by adding batteries separately collected and batteries contained in MSW
- (14) No answer obtained to the inquiry launched in the framework of this project for the other MSs and accession countries.
 - (15) Recent implementation of take back obligation (since 23.02.2002) may explain collected quantities still very low
 - (16) Average growth rate for the last years Source: EPBA & CollectNiCad, June 2003
- (17) Including magnetic separation at incineration plants
- (18) 2700 kt according to EPBA, June 2003 (covering common organisations operating in Austria but not necessarily all), i.e. 336 g / inhab / yr; in this table, we decided to use CollectNiCad assumption, i.e. same sale per inhab in Austria as in Germany:
 - (20) Among general purpose batteries, Nw recycles those containing Hg and disposes of the non hazardous ones in landfill (19) Assumption: same sale per capita as France
 - (21) would be 950 kt according to CollectNiCad, when industrial NiCd is not accounted for
- (22) No statistics exist at the EU level; hypotheses seemed acceptable to some industrial experts, others were not able to refute or to confirm
- (23) 1396 kt according to EPBA, June 2003 (covering common organisations operating in Austria but not necessarily all)
- (25) 2002 data for France (STIBAT) according to EPBA, June 2003: sales = 22035 t; collected = 2105 t; recycled = 2100 t (99,8% of collected)
 - (26) data here are those declared by German government for 2001, covering GRS, REBAT and Bosch; 2002 data for Germany
 - covering GRS only) according to EPBA, June 2003: sales = 29982 t; collected = 11256 t; recycled = 7539 t (66% of collected
 - (27) same data given by EPBA, June 2003, for 2002
- (28) source: EPBA, June 2003, for 2002
- (29) Other data than those declared by national governments can be found in TRAR (Risk Assessment Targeted Report Cadmium (oxide) as used in batteries - Draft version of May 2003) for the following countries (without being able to explain differences):
- (30) Other data than those declared by national governments can be found in TRAR (Risk Assessment Targeted Report Cadmium (oxide) as used in batteries - Draft version of May 2003) for the following countries (without being able to explain differences):
- B 261 t: F 1768 t: D 1808 t: Nw 100 t
- 31) 44% is 2001 average between 54% for GRS, 15% for REBAT and 100% for Bosch; in 2002, GRS sent 67% of batteries collected to recycling
- introduction of a high tax paid for by producers aiming at encouraging collection but which discouraged sales as a side effect), spent batteries (32) Because Danish portable NiCd market has been declining radically since 1996 from 278 t in 1996 to 110 t in 2001 (see COWI report can not be assessed from 2001 sales without introducing a considerable biais. 1997 sales are considered instead, assessed at 250 t.

Portable Batteries			Sales	>	/aste stre	Waste stream (including stock in the economic sphere)	g stock in th	ne econon	ic sphere)						Collection
Current Situation in some MSs	ome l	MSs					Spent	ies Ses				des	Separate collection	_	
			Total	Average growth rate	Av erage lifetime	Spent	stock in the economic sphere)	economic re)	Spent batteries available for collection	s available			Collection rates	n rates	
Quantification of spent batteries available for collection from assessment of batteries contained in MSW	llection ries			years			Quantities	% of spent batteries			Quantities	% of sales	% of spent batteries available for collection	Inhab	g / capita / yr
			tons	% per yr	years	tons	tons	% of d	tons	kg/cap/ yr	tons	%	%	millions	g/cap/yr
			æ	D	+	$d = a / (1+g)^{t}$	e = d - f	p/ə	$f = h + B_{MSW}$	f/In	£	i = h/a	k = h / f	드	g _{in} = h / In
	Year	Segment	(3)	(3)	(3)						(9)				
Austria	2001	Total	3 251 t	1,0%	4	3 169 t	1375 t	43%	1 794 t	223 g	1 440 t	44%	%08	c	179 g
	2001	NiCd	247 t	1,0%	2	237 t	118 t	20%	119 t	15 g	84 t	34%	%02	0	10 g
Belgium	2002	Total	3 955 t	1,0%	4	3 817 t	1 024 t	27%	2 793 t	271 g	2 368 t	%09	85%	ç	230 g
	2001	NiCd	382 t	1,0%	2	367 t	(2)		(2)		350 t	%26		2	34 g
France	2001	Total	25 245 t	1,0%	4	24 609 t	15 370 t	62%	9 239 t	155 g	4 139 t	16,4%	45%	C	b 69
	2001	NiCd	1 456 t	1,0%	2	1 399 t	1 022 t	73%	377 t	б ₉	241 t	17%	64%	8	4 g
Germany	2001	Total	33 378 t	1,0%	4	32 538 t	9 239 t	28%	1 662 22	283 g	12 939 t	%68	%99	CB	157 g
	2001	NiCd	2 882 t	1,0%	2	2 770 t	842 t	30%	1 928 t	23 g	1 284 t	45%	%29	20	16 g
Netherlands	2001	Total	5 899 t	1,0%	4	5 751 t	3 475 t	%09	2 276 t	141 g	1876 t	%28	82%	97	116 g
	2001	NiCd	521 t	1,0%	2	501 t	269 t	24%	232 t	14 g	160 t	31%	%69	2	10 g
Sweden	2001	Total	3 100 t	1,0%	4	3 022 t	917 t	30%	2 105 t	239 g	1 700 t	%99	81%	c	193 g
	2001	NiCd	199 t	1,0%	2	191 t	(2)		(2)		167 t	84%		n .	19 g

132 g 12 g

185

%69

224 g

31 399 t

191 t 72 906 t 5 465 t

199 t 74 828 t 5 687 t

NiCd Total

Average situation among the 6 countries where separate collection system exist

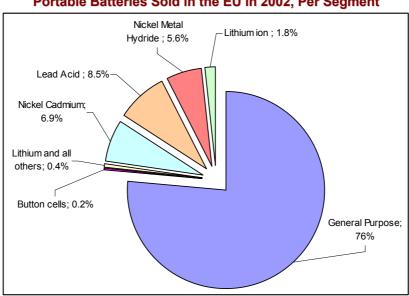
46%(5) 43%

84% 33% 40%

⁽¹⁾ CollectNiCad, June 2003 - Source: different studies performed at national level (2) may be overestimated at the national level; thus calculation results are not presented (quantities collected are higher than quantities available for collection resulting from calculation) (3) See Table Protected are higher than quantities available for collection resulting from calculation) (3) See Table Protected are higher than quantities available for collection resulting from the analysis performed in Belgium because according to BEBAT - June 2003, 0.010% would not be representative of the average Belgium situation (5) average for 4 countries

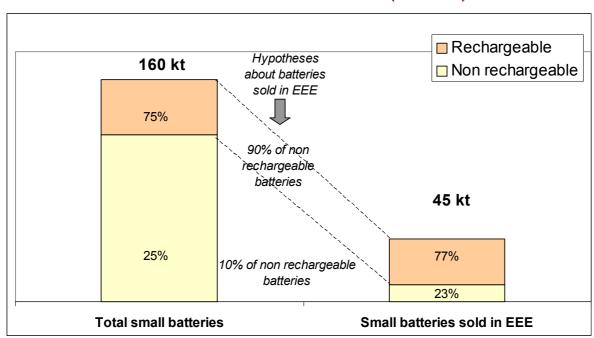
2.4.3 European Market of Portable Batteries

■ About 160 kt of batteries are sold in the EU in 2002, i.e. an average of 410 g / capita / year. The discrepancy between countries is important: between 250 and 425 g / capita / year according to country.



Portable Batteries Sold in the EU in 2002, Per Segment

About 75% of portable batteries sold are non rechargeable batteries (general purpose, button cells and lithium), mainly general purpose batteries (alkaline manganese and zinc carbone). Button cells (containing high mercury content) only represent 0.2%. NiCd technology represents one third of portable rechargeable batteries (7% of all portable batteries sold).



Portable Batteries Sold in EEE in 2002 (estimation)

About 30% of portable batteries (45 kt) are estimated being sold in EEE. This concerns about 90% of rechargeable batteries and 10% of non rechargeable batteries.

Remark: No statistics exist at the EU level. These hypotheses seemed acceptable to some experts, others were not able to refute or to confirm.

2.4.4 Waste Stream of Portable Batteries

- The quantification of waste streams is based on several assumptions (lifespan, domestic hoarding, proportion contained in WEEE) described above in section □ page 45. Figures regarding batteries waste streams are thus approximate estimates. This exercise (although time-consuming) proved to be very useful to be able to quantify collection rates according to more accurate definitions rather than collected quantities compared to sales.
- About 150 kt of spent batteries are estimated to arise in the EU, i.e. an average of 380 g / capita / year (with an important discrepancy between countries as for sales: between 245 and 400 g / capita / year according to country).

Spent NiCd batteries amounts to about 10.5 kt.

- Domestic hoarding is estimated at
- 30% for non rechargeable batteries (i.e. 30% of non rechargeable spent batteries are hoarded by households),
- 60% for rechargeable batteries.

Thus only about 97 kt of spent batteries are estimated to be collectable in 2002 (i.e. available for collection), that is an average of 235 g / capita / year (between 140 and 285 g / capita / year according to country).

Spent NiCd batteries available for collection are estimated at 4.1 kt.

■ An average of about 20% of spent batteries available for collection are estimated to be contained in WEEE.

Estimation of Waste Stream of Portable Batteries in 2002

	(includ		stream he economic sphere	e)
Spent batteries	(stock in th	ries hoarded ne economic nere)	Spent batteries collec	
Datteries	% of spent batteries	Quantities	Total	Contained in WEEE

EU-15 + Ch + N - 2002

117 405
362 t
700 t
118 466
10 460
12 845
8 301 t
2 697 t
34 304
152 770

117 405 t	30%	35 221 t	82 183 t	85%	10%	8 218 t
362 t	30%	109 t	253 t	0%	10%	25 t
700 t	30%	210 t	490 t	1%	10%	49 t
118 466 t	30%	35 540 t	82 926 t	86%	10%	8 293 t
10 460 t	60%	6 276 t	4 184 t	4%	90%	3 766 t
12 845 t	60%	7 707 t	5 138 t	5%	90%	4 624 t
8 301 t	60%	4 981 t	3 320 t	3%	90%	2 988 t
2 697 t	60%	1 618 t	1 079 t	1%	90%	971 t
34 304 t	60%	20 582 t	13 722 t	14%	90%	12 349 t
152 770 t	37%	56 122 t	96 648 t	100%	21%	20 642 t

See detailed table 'Portable Batteries - Current Situation in Europe' for further explanations.

2.4.5 Collection of Spent Portable Batteries

- Several collection schemes are possible to collect portable batteries in view of recycling:
- separate collection of batteries 'alone', which is the most widespread scheme in countries where separate collection and recycling exist,
- separate collection of WEEE containing batteries, which is not developed yet,
- separate collection in professional circuits, which concerns only a small proportion of portable batteries separately collected according to experts,
- collection mixed with MSW and magnetic separation in incineration plants, which is not developed
 yet but is under study in several MSs (e.g. NL and D). This solution presents low collection costs.
 On going R&D programmes includes the improvement of the efficiency of the magnetic
 separation.

As for separate collection of portable batteries 'alone', it is well or quite well developed in 8 MSs, which can be split into 2 categories according to the choice made in terms of flows collected:

- Separate collection focusing on NiCd (or all rechargeable according to country) batteries: Dk, Nw (other portable batteries remain in the MSW flow),
- Separate collection of all portable batteries: A, B, F, D, NL and Sw.

According to information provided to BIO in the framework of the study, separate collection would not be well developed in accession countries. But information received is very partial at that stage. Further investigation would be necessary in order to describe more accurately the situation in accession countries.

■ This quantification of quantities collected is based on the different data provided by European industry associations as well as MSs.

About 27 kt of spent batteries are separately collected in the EU, i.e. the collection rate reaches:

- 17% of current sales.
- 18% of spent batteries,
- 28% of spent batteries available for collection,
- an average of 70 g / capita / year.

More than 80% of portable batteries collected are non rechargeable general purpose batteries and 8% are rechargeable NiCd batteries (2.1 kt).

- The situation is very different from one country to another. Three categories of countries can be distinguished:
- Countries where separate collection of all portable batteries is well developed (A, B, F, D, NL, Sw):
 45 to about 85% of portable batteries available for collection are estimated to be collected according to countries.
- Countries where separate collection of NiCd batteries is well developed (Dk, Nw): 40 to 50% of spent NiCd are collected.
- Countries where separate collection is not developed: 0 to 15% of portable batteries available for collection are estimated to be collected according to countries.

A table in section 2.5 summarises the current situation.

Differences in the results reached in MSs may be explained by several parameters which differ among countries:

- Starting date of separate collection: in some MSs, the system is more than 10 year old thus at a steady stage rather than in others, it is 2 year old, so still at a development stage.
- Type and level of legal collection objectives set up at national level: from high mandatory targets to no quantified targets.
- Collection schemes and communication programmes implemented: depending on the objectives
 to be reached (and the level of penalties included), more or less collection points have been
 setting up and more or less extensive communication and promotion programmes have been
 developed to encourage end users to first participate and secondly reduce their hoarding
 behaviours.

Fact sheets are presented in appendix 2 for each main collection scheme. A summary is included in section 2.4.7 page 60 with related costs as well.

2.4.6 Recycling of Spent Portable Batteries

- About 90% of total portable batteries collected is estimated to be recycled. This percentage aggregates different situations according to battery segments and countries:
- NiCd batteries: about 100% of NiCd batteries collected are recycled.
- General purpose batteries: the situation is very different among countries:
 - Most of them send all portable collected batteries to a recycling plant.
 - Others send 60-65% of portable collected batteries to a recycling plant (D, UK, Sw).
 - Others have no estimation of quantities sent to recycling.

The limitation of recycling rate of general purpose batteries in some countries is motivated by different reasons according to countries:

- Relatively high Hg-content general purpose batteries, put on the market before legislation entered into force in the EU¹⁷, are not all recycled in some countries, due to specific costly recycling processes¹⁸.
 - Smelting plants (not dedicated to batteries) can accept batches containing up to 5 ppm of mercury (even 500 ppm in certain cases according to experts).
 - As for the plants dedicated to batteries, a demercurisation step must take place prior to the recycling process.
- Non hazardous general purpose batteries (i.e. containing no Hg) are disposed of in landfill in some other countries.

Button cells and batteries containing up to 30% of Hg are recycled in specific plants (some of spent button cells have a positive market value (e.g. those containing Ag) others a negative value; the overall value would be negative according to experts).

As for lithium-ion batteries, the development of specific recycling processes is in progress because of the security required (fire and explosion risks at the battery production and recycling steps). Most of collected quantities today are stored waiting for recycling processes to be ready.

Restriction concerning the marketing of batteries other than button cells containing Hg.

¹⁸ In Germany, main collector GRS estimates that the average Hg content of the ZnC + AlMn mixture was ca. 60 ppm in 1998, 100 ppm in 2002 and will be 10 ppm in 2005.

Other rechargeable or non rechargeable batteries (NiMH, lithium) are not always recycled yet, due to portable quantities.

Collected batteries which are not recycled are disposed of in landfill, as hazardous waste or non hazardous waste according to their type.

- Sorting prior to recycling is necessary to separate main flows:
- ZnC & Alkaline batteries.
- NiCd batteries,
- Portable lead acid batteries,
- Button cells,
- NiMH batteries,
- Li batteries.
- Li-ion batteries.

Dedicated sorting plants exist in all countries where separate collection is developed (1 to 3 plants according to the size of the country and the current development of separate collection i.e. the current quantities of batteries to be sorted).

■ As for recycling, batteries are recycled in dedicated plants, smelting plants or electrical arc furnaces (EAF).

Three recycling processes exist:

- Hydrometallurgic process,
- Pyrometallurgic process,
- Thermal treatment.

Portable Batteries – Recycling Processes

Process technology	Hydrometallurgic	Pyrometallurgic	Thermal treatment
Primary batteries			
Button cells	X	X	X
Alkaline Manganese	X	X	X
Zinc Carbon	X	X	X
Lithium Manganese	X	X	
Zinc Air	X		
Secondary batteries			
Lead Acid		X	
Nickel Cadmium			X
Nickel Metal Hydride	X	X	
Lithium Ion	X	X	

About 32 dedicated recycling plants exist in the EU and are concentrated in certain countries (mainly France and Germany).

Several plants dedicated to batteries recycling are still under used (up to half of their capacity seems to be available) thus there is an overcapacity of recycling.

After collection, spent batteries are transported from countries where no recycling plant exist to over-capacity countries.

■ It is not the purpose of this study to analyse in detail the different types of recycling (dedicated plants, smelting plant, EAF).

It can just be mentioned that they are likely to have different profiles in terms of:

- Recovery rate (proportion of metals which can be recovered),
- Costs.
- Environmental impacts and benefits.

Some information will be given further in the report without pretending covering the whole issue.

Several stakeholders mentioned the usefulness to define a system to accredit battery recycling facilities.

A dedicated study would be necessary to cover that issue, in particular to analyse the advantages and disadvantages of systems based on best available technology (BAT) principles and systems based on best available technology not entailing excessive costs (BATNEEC) principles.

Portable Batteries - Recoverable Metals

Metals recoverable	
% weight per battery (1)	

Non rechargeable batteries

General purpos

Zn	20%
Mn	20%
Fe	20%
Cu	10%
Total	70%

Button cells

Zn	26%
Hg	34%
Fe	30%
Total	90%

Rechargeable batteries

Lead acid	Lead	58%
	Total	58%

NiCd	Cd	15%
	Ni	25%
	Stool	35%

•	
Total	75%
Steel	35%
Ni	25%

NiMH	Ni	40%
	Steel	18%

Total	58%
Steel	18%

 Acier
 22%

 Cobalt
 17%

 Total
 39%

Source: www.screlec.fr, June 2003

(1) without considering plastics which can also be recovered in certain conditions

2.4.7 Economics of Portable Batteries Collection and Recycling

Case studies were performed to gather updated cost data about existing collection and organisation schemes in countries where they are well or quite well developed.

From these data, we were able to define ranges for the different cost items and discuss with experts about expected economies of scale.

In this section, we successively consider:

- Methodological aspects, including cost items taken into account,
- Economics of collection and recycling of portable NiCd batteries,
- Economics of collection and recycling of all portable batteries.

2.4.7.1 Costs Taken Into Account

- The following cost items are distinguished:
- Variable costs
 - Collection points (equipment)
 - Collection (logistic)
 - Sorting
 - Transport
 - Recycling
- Fixed costs
 - Public relations & communication
 - Administration
- Total

We quantified costs per tonne collected and per battery sold.

Costs paid for by producers are indicated and quantified. Those paid for by retailers and / or public authorities are mentioned if any but no data were available to quantify them.

- For each collection and recycling scheme studied, a fact-sheet was elaborated based on a similar format summarising:
- results reached,
- stakeholders responsibility and organisation,
- costs,
- fees paid for by producers,
- evolution of costs, in the past and in future.

Detailed fact-sheets are presented in appendix 2. Comments and a summary are included in the following sections.

Fact-Sheet Format - Example of Belgium Fact-Sheet

Portable Batteries

Main Characteristics Bring back system to various collection points Financial responsibility: Consumer responsibility (3) General purpose batteries recycling Dedicated plants of all ZnC and Alk batteries A/ Quantities and Results Reached 3 955 tons Sales Spent batteries (assumption) 3 745 tons Spent batteries available for collection (assumption) 2 632 tons Collected quantities 2 368 tons Collection rate

60% of sales 63% of spent batteries 90% of spent batteries available for collection

228 g/inhabitant/yr Quantities entering a recycling plant 2 368 tons Recycling plant input 100% of collected

B/ Responsibility and organisation

- At the begining, high mandatory targets to be reached quickly (collection rate = 75% of batteries sold; threat of a high penalty: 80 cents / unit not collected). Because they were not reached (and considered not reacheable), they were revised. New targets: 60% in 2002 and 65% in 2004
- Starting date of separate collection and recycling: 1996 (7 years old)
- Collection points: a total of about 20 000 collection points (500 inhab / collection point); about 20% of collection points are located in super and hyper markets as well as schools and about 80% in municipal collection points; about 80% of quantities collected are collected with 20% of collection points available; 3 plastic bags per year are mailed by BEBAT to households they can use to store batteries and bring them back to collection points (they also allow to participate to a lotery).

Paid for by consumers (via producers)

Furne / t Cents /

- Collection: about 5000 collection points are collected automatically with an optimised time schedule and the others are collected when they call BEBAT
- Bulking up depot: 3 exist in Belgium
- Sorting: 1 sorting plant (one of the 3 bulking up depots); a partial sorting is also performed in another bulking up depot

3 1 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3 -11		3 - 1 1 1
- Sorted flows and destination	ZnC & Alk batteries (high or no Hg content)	Recycling in dedicated	1 000 Euros / t
	NiCd batteries	Recycling, F	400 Euros / t
	Small lead acid batteries	Recycling, B	50 - 100 Euros / t (2)
	Button cells	Recycling, B	4 000 Euros / t
	NiMH batteries	Recycling, F	nul
	Li & Li-ion batteries	Storage, B	-

Approximative sorting, transport and recycling costs (Euros / ton entering a recycling plant)

Belgium

BEBAT. 2002

Country

Scope

C/ Costs

C.1 2002 situation

	Budget	Euros / t		(1)
,	kEuros	collected	battery sold ((1)
Variable costs	5 221	2 205	5,3	
Collection points (equipment)	132	56	0,1	
Collection (logistic)	592	250	0,6	
Sorting Transport	582	246	0,6	
Recycling	1 279	540	1,3	
Provision	268	113	0,3	
Marking cost	2 368	1 000	2,4	
Fixed costs	5 988	2 529	6,1	
Distribution of plastic bags to households	1 206	509	1,2	
Other PR & communication	2 721	1 149	2,8	
Administration	2 061	870	2,1	
Total	11 209	4 733	11.3	

Paid for by local authorities or retailers
none

C.2 Financial fees paid for by consumers (via producers) to BEBAT

NB: BEBAT operates on a per unit basis

Cents / b	attery sold	Cents / kg so	old
InC & Alk batteries	12,39	428	
NiCd batteries	12,39	138	
5	Source: BEB	AT, July 2003	

C.3 Costs evolution in the past

NB: the table presents total costs except marking costs (which correspond to the refund to producers of their expenses to mark batteries put on the market) because it is specific to Belgium

1998 1 562 5 055 7 896 1999 1 834 5 092 9 339 2000 2 105 4 872 10 256		t collected	Euros / t collected	Budget kEuros
2000 2 105 4 872 10 256	1998	1 562	5 055	7 896
	1999	1 834	5 092	9 339
	2000	2 105	4 872	10 256
2001 2 325 3 806 8 849	2001	2 325	3 806	8 849
2002 2 368 3 733 8 841	2002	2 368	3 733	8 841

Source: BEBAT, July 2003

From 1998 to date:

- communication expenses increased then stabilised,
- collection expenses decreased due to the optimisation of collection circuits and time schedule,
- quantities collected regularly increased.

C.4 Expected costs evolution in the future

PR & communication expenses are planned to decrease because the maximum collection rate is considered to be reached; economies of scale are likely to happen for ZnC & alkaline batteries recycled in dedicated plants when more quantities arise in Europe (up to 600-700 Euros / t)

- (1) Hypothesis: average weight of small batteries = g
- (2) slightly negative if no sorting
- (3) Belgium is the only MS where consumers are legally in charge of the financial responsibility.

2.4.7.2 Economics of Portable NiCd Batteries Collection and Recycling

2.4.7.2.1 Recycling Costs of Portable NiCd batteries

- Portable NiCd recycling costs vary depending on the recycling technology.
- In dedicated plants, recyclers bill 0 Euros / t in case of individual cells and around 300 Euros / t in case of power packs because the latest require to be dismantled (in both cases, revenues amount at about 1 000 Euros / t). As a consequence, the recycling cost of a batch constituted of about 50% of individual cells and 50% of power packs amounts to about 150 Euros / t of NiCd batteries.

In the future, according to recyclers, economies of scale can be expected mostly for the packs preparation costs. Total recycling cost could be at 0 Euros / t for both individual cells and power packs.

■ In metal plants, recycling costs amounts to approximately 100 Euros / t of batteries. No major economies of scale can be expected in the future.

2.4.7.2.2 Collection and Recycling Costs of Portable NiCd batteries for Existing Schemes

- We collected and compiled cost data to illustrate 2 cases:
- Countries which focus on NiCd (or rechargeable) batteries collection and recycling (Dk, Nw),
- Collection circuits dedicated to power tools containing NiCd batteries in countries where separate collection of all portable batteries exist (D, F for instance).
- In Denmark, producers have to pay 81 cents / NiCd unit sold to cover collection and recycling costs. Total collection and recycling costs can then be estimated at about 2 830 Euros / t of NiCd collected. 43% of portable spent NiCd are assessed being collected and recycled.

Factsheet About Danish NiCd Collection and Recycling Scheme

Portable Batteries Main Characteristics Country Denmark Collection: Bring back system to sale points Financial responsibility: Producer responsibility Scope Dk, 2002 A/ Quantities and Results Reached Sales 110 tons NiCd Spent batteries (assumption) NiCd sales in 1997 250 tons Collected quantities 108 tons NiCd Collection rate 98% of sales 43% of spent batteries Quantities entering a recycling plant 108 tons Recycling plant input 100% of collected B/ Responsibility and Organisation - No mandatory targets but high financial incentive for collectors since 1996: a remuneration of 150 DKK / kg collected (20 Euros / kg) is granted by the government for spent closed NiCd batteries delivered to an approved recycling plant (1 DKK = 0.135 Euros). This incentive is financed by the eco-tax paid for by producers. According to industry, the fact that a large proportion of this financial tax is not paid back to producers results in the decreasing market of portable NiCd in Dk since 1996 (from 278 t in 1996 to 110 tons in 2002). - Sorted flows and destination NiCd batteries Recycling 0 - 300 Euros / t for transport and recycling Battery mix Disposal 90 Euros / t for transport and disposal Paid for by producers C/ Costs Paid for by Euros / t Cents / local C.1 2002 situation collected battery sold authorities (1) Variable costs Collection points (equipment) Collection (logistic) Sorting 2025 (2) Transport Recycling Fixed costs PR & communication Administration 805 (2) Miscellaneous Total 2830 (4) **81** (3) none C.2 Financial fees paid for by producers to the Danish EPA (3) Cents Cents / kg / battery sold sold (1) NiCd batteries 81 295 (1) Hypothesis: average weight of small batteries = g 275 (2) Hypotheses (3) An eco-taxe of 6 DKK / unit and 36 DKK / pack is levied on producers and importers; I;E. about 81 cents / battery sold (4) Deduced from 81 cents / battery sold (5) Deduced by difference between 2830 and 2025

■ For NiCd power tools collection circuits, data were compiled for Bosh system in Germany and Ecovolt system in France.

Collection and recycling costs vary between 1 300 and 1 750 Euros / t collected with about 50% collection rates for batteries sold by producers involved.

Factsheet About Danish NiCd Power Tools Collection Circuits

Portable Batteries

Main Characteristics

Collection: Bring back to sale points
Financial responsibility: Shared responsibility

	Bosc	h, D	Ecovolt, F
Collected (t / year)	100) t	20-30 t
Sales of producers concerned (t)	n.a	а.	about 60 t
Collection rate (% of sales)	n.a.		about 40%
	Containers + reverse logistics	Parcels sent back	

Costs		Paid for by producers					
	Euros / t collected	Euros / t collected	Euros / t collected	Cents / battery sold (1)	Paid for by retailers		
Variable costs	1 200	1 190					
Collection points (equipment)					✓		
Collection (logistic)	350	400					
Sorting	600	540	1677	46,1			
Transport	150	150					
Recycling (2)	100	100	100	2,8			
Fixed costs	130	130					
PR & communication	-	-	-	-			
Administration	130	130	-	-			
Total	1 330	1 320	1 777	20,0	no data available		

Source: EBRA, June 2003 BIO estimation from Ecovolt, June 2003

⁽¹⁾ Hypothesis: average weight of small NiCd batteries = g

⁽²⁾ Hypothesis: 2/3 of NiCd on which 50% of individual cells at 0 Euro / t of batteries, and 50% of power packs at 300 Euros / t of batteries

2.4.7.3 Economics of All Portable Batteries Collection and Recycling

2.4.7.3.1 Recycling Costs of All Portable Batteries

■ Considering the 5 schemes studied, the recycling costs of total portable batteries vary in a quite large range: 400 to 900 Euros / t entering a recycling plants (for transport and recycling).

As in the case of NiCd batteries, lower costs correspond to recycling in metal plants and higher costs in dedicated plants.

■ These costs aggregate different levels of cost according to the type of batteries. Some batteries have a zero even negative cost (portable lead acid in B, NiMH). Other have a positive cost, in particular general purpose batteries, which represent more than 80% of total portable batteries collected.

The following table summarises the information we were provided with (they cover only 2 or 3 countries).

Portable Batteries - Recycling Costs Inventoried

Euros / t entering a recycling plant

	Larce t entering a recycling plant
	about 900-1000 Euros / t in dedicated plants whatever Hg content (B, F) 180 to 700 Euros / t in metal plants for limited Hg content (D)
Small lead acid batteries	1000 Euros / t (F) 0 even negative costs (B)
	2600 Euros / t (F) 4000 Euros / t (B)
NiMH batteries	0 Euros / t (B, F)
Li batteries	2000 Euros / t (F)
Li-ion batteries	1000 Euros / t (F)

Further investigation would be required to explain differences between different countries for portable lead acid and button cells batteries.

2.4.7.3.2 Collection and Recycling Costs of All Portable batteries for Existing Schemes

The compilation of the different costs obtained in our analysis, together with ranges provided by EPBA, results in the following ranges.

Portable Batteries - Costs Ranges For Existing Schemes

Euros / t of portable batteries collected

Variable costs	
Collection points (equipment)	50 - 150
Collection (logistic)	250 - 550
Sorting	150 - 250
Transport & Recycling (excl. disposal)	400 - 900
Fixed costs	
Public relations & communication	50 - 1 700
Administration	125 - 900
Total	1 115 – 3 765

Portable Batteries - Collection and Recycling Costs in MSs Collecting All Portable Batteries

Detailed data presented in fact-sheets - See appendix 2

		AUSTRIA	BELGIUM	FRANCE	GERMANY	NETHERLANDS
Scope		UBF	BEBAT	SCRELEC	GRS	STIBAT
Main characteristics						
Financial responsibility		Shared	Consumers (via producers)	Partial shared	Producers	Partial shared
Mandatory collection targets		Only quite recently	Yes	Only from 2003	No	Yes
Starting date		1991	1996	2001	1998	1995
Collection system			Bring back to different types of collection points	Bring back to sale and municipal collection points	Bring back system mainly to sale points	Bring back system with small chemical waste
Nb of inhab/ collection point		1100	500	2000 - 2500	410	1500
Main general purpose batteries	recycling		Dedicated plants of all ZnC and Alk batteries	Dedicated plants	Mostly metal plants (except higher Hg- content batteries which are disposed of)	Metal plants + dedicated plants
Results						
Quantities collected	kt / yr	1 440 t	2 368 t	4 139 t	11 256 t	1 876 t
Collection rate	% of sales	44%	60%	16%	38%	32%
	% of spent batteries	45%	63%	17%	39%	33%
% of spent batteries a		80%	90%	45%	64%	82%
	g / inhab / yr	179	228	69	137	116
Recycling plant input	% of collected	100%	100%	96%	67%	100%
Costs paid for by producers						
Variable costs	Euros / t collected		1 205	1 610	<i>5</i> 98	(1 550
Collection points (equipment)	Euros / t collected		56		150	√ 450
Collection (logistic)	Euros / t collected		250	457	BIO	
Sorting	Euros / t collected		{246	√ 152	assum	assum 200
Transport	Euros / t collected	n.a.	7240	ر اعد	ption { for splift { 298	I / 1 2001
Treatment	Euros / t collected		653	1 000	for split 1 298	for split 900
Fixed costs	Euros / t collected		2 529	790	517	1 968
PR & communication	Euros / t collected		1 658	290	267	1 568
Administration	Euros / t collected		870	500	250	400
Total	Euros / t collected	1 113	3 733 (3)	2 400	1 115	3 518
-	Conto /it =l	2.2	1440	4.0	4 -	4.5
Total	Cents / unit sold	, -	11,3	1,6	1,7	4,5
	Cents / kg sold (2)	49	283	39	42	112
Fees paid for by producers				,		
Total portable batteries	Cents / kg sold (1)	90	428	46 - 175	24 - 78	65
Portable NiCd batteries	Cents / kg sold (2)	90	138	175	51	65

⁽¹⁾ According to battery type

2.4.7.4 Other Cost Data

Collection of batteries with WEEE

The cost of collection and disassembly would stand in a range of 100 to 1000 Euros / t of small appliances according to the volume¹⁹. Disassembly of batteries, separate recovery and delivery to battery collection organisations would account for a fraction of these costs as batteries represent less than 1/1000 by weight of total WEEE collected.

■ Collection of batteries with MSW and magnetic separation at the entrance of incineration plant A cost of 30 to 50 Euros / t of ferro magnetic products was found in the literature, without being able to confirm this figure.

⁽²⁾ Hypothesis: 40 g / unit

⁽³⁾ Marking costs not included

¹⁹ Source: FEE (Belgium) & CollectNiCad, June 2003

2.5 SUMMARY OF THE CURRENT SITUATION IN EUROPE

- Among countries where portable NiCd batteries collection is well developed, three types of scheme can be distinguished, which are further analysed in the next section about options:
- Scheme 1 Collection and recycling of portable NiCd only,
- Scheme 2 Collection and recycling of all portable batteries (not only NiCd),
- Scheme 3 Collection of all portable batteries in view of recycling primarily NiCd (and also batteries whose recycling cost is zero or negative).

(Portable and Industrial) NiCd Batteries Market, Collection, Recycling

Tonnes/year	Sold			Collected				Recycled										
	tota	al	sm	nall	indus	strial	tota	al	sm	all	indus	strial	tot	al	sm	all	indus	strial
Year				2001		1999				2001		2001				2001		2001
Total Europe	100%	13899	73%	10193	27%	3706	100%	5035	43%	2141	57%	2894	100%	5035	43%	2141	57%	2894
Austria	100%	391	63%	247	37%	144	100%	218	39%	84	61%	134	100%	218	39%	84	61%	134
Belgium	100%	358	73%	261	27%	97	100%	174	40%	70	60%	104	100%	174	40%	70	60%	104
Denmark	100%	130	85%	110	15%	20	100%	142	76%	108	24%	34	100%	142	76%	108	24%	34
Finland	100%	175	61%	107	39%	68	100%	2	50%	1	50%	1	100%	2	50%	1	50%	1
France	100%	2865	62%	1768	38%	1097	100%	962	19%	182	81%	780	100%	962	19%	182	81%	780
Germany	100%	2059	88%	1808	12%	251	100%	1747	53%	921	47%	826	100%	1747	53%	921	47%	826
Greece	100%	553	58%	323	42%	230	100%	2	50%	1	50%	1	100%	2	50%	1	50%	1
Ireland		-		186		-	100%	13	38%	5	62%	8	100%	13	38%	5	62%	8
Italy	100%	1496	84%	1253	16%	243	100%	226	16%	36	84%	190	100%	226	16%	36	84%	190
Luxemburg	100%	21	95%	20	5%	1	100%	10	50%	5	50%	5	100%	10	50%	5	50%	5
Netherlands	100%	601	87%	521	13%	80	100%	284	56%	160	44%	124	100%	284	56%	160	44%	124
Norway	100%	157	64%	100	36%	57	100%	127	34%	43	66%	84	100%	127	34%	43	66%	84
Portugal	100%	206	94%	193	6%	13				1		-				1		-
Spain	100%	1692	55%	934	45%	758	100%	220	30%	66	70%	154	100%	220	30%	66	70%	154
Sweden	100%	349	57%	199	43%	150	100%	462	36%	167	64%	295	100%	462	36%	167	64%	295
Switzerland				-		93	100%	240	83%	198	18%	42	100%	240	83%	198	18%	42
United Kingdom	100%	2567	84%	2163	16%	404	100%	205	45%	93	55%	112	100%	205	45%	93	55%	112

Source: TRAR, Risk Assessment Targeted Report - Cadmium (oxide) as used in batteries - Draft version of February 2003
Page 37 39 42 44

- The following table summarises the current situation. Bold circles highlight collection rates and recycling plant inputs for different segments:
- · NiCd batteries (total industrial and small).
- starter batteries,
- total industrial batteries.
- total portable batteries,
- total batteries.

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Summary of the Current Situation in Europe – All Segments

Spent batteries	Current s	Current situation 2002 - Collection rates					
kt of spent batteries and collection rates as % of spent batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment				
Starter Batteries	611 kt						
	80-95% (1) (4)	ı	-				
NiCd Batteries		3,1 kt	10,5 kt				
	-	80-90%	15-20%				
		14 kt					
		30-	35%				
Other batteries		184 kt	142 kt				
	-	80-90% (2)	15-20%				
Total batteries	611 kt	187 kt	153 kt				
	80-95%	80-90%	15-20%				
		950 kt					
		70-85%					

Spent batteries available for collection	Current situation 2002 - Collection rates					
kt of spent batteries available for collection	Starter batteries	Starter batteries Industrial batteries P				
rates as % of spent batteries	segment	segment	segment			
available for collection						
Starter Batteries	611 kt					
	80-95% (1) (4)	-	-			
NiCd Batteries		3 kt	4 kt (3)			
	-	80-90%	45-55%			
		7	kt			
			70%			
Other batteries		184 kt	92 kt (3)			
	-	80-90% (2)	25-30%			
Total batteries	611 kt	187 kt	97 kt			
	80-95%	80-90%	25-30%			
		894 kt				
		75-90%				

Recycling plant inputs	Current situation 2002 - Recycling plant inputs				
kt of collected batteries and recycling plant input as % of collected batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment		
Starter Batteries	490-590 kt				
	95-100%	-	-		
NiCd Batteries		2,8 kt	2,1 kt		
	-	98%	100%		
		4,9	9 kt		
			0%		
Other batteries		145-165 kt	25 kt		
	-	95-100%	90%		
Total batteries	490-590 kt	148-168 kt	27 kt		
	95-100	95-100%	90%		
		665-800 kt			
		95-100%			

⁽¹⁾ Hypothesis because no statistics available at the EU level; countries where data are available, 90% to 97% of spent batteries are collected and recycled

⁽²⁾ No statistics available at the EU level; in France, more than 90% of sales are collected; as an hypothesis, the same collection rate range as for industrial NiCd batteries is considered

⁽³⁾ Hypothesis about hoarding: 30% of spent non rechargeable batteries and 60% of rechargeable ones are considered being hoarded by households and professional users

⁽⁴⁾ It is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared. In that case, this difference in scope of stakeholders would result in an overestimation of collection rate.
BIO Intelligence Service

Summary of the Current Situation in Europe – Portable Batteries²⁰ 21 22

		Curr	ent Situation - Tot	tal Portable Batte	eries	
		Collect	Larr Ortabio Batte		plant input	
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of sales	% of collected
Countries where	e all small batteries	s are separately c	ollected - 2001	_		
Austria	44%	45%	80%	179 g	44%	100%
Belgium	60%	62%	85%	230 g	60%	100%
France	16%	17%	45%	69 g	16%	96%
Germany	39%	40%	56%	157 g	17%	44%
Netherlands	32%	33%	82%	116 g	32%	100%
Sweden	55%	56%	81%	193 g		
Average	33%	34%	59%	132 g		60%
	e small NiCd (or re					
Denmark	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Norway	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Countries where	e separate collection	on is not develope	ed - 2002			
Average	0 to 15%	0 to 15%	n.a.	0 to 60 g		10 to 100%
T-4-1 F11 45 + C	h . N. 2002		-			
<u>Total EU-15 + C</u> Total portable						
batteries	17%	18%	28%	70 g	15%	90%
			ent Situation - Po ion rates	rtable NiCd Batte		plant input
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of sales	% of collected
Countries where	e all small batteries	s are separately c	ollected - 2001	_		
Austria	34%	35%	70%	10 g	34%	100%
Belgium	92%	96%		34 g	92%	100%
France	17%	17%	64%	4 g	17%	100%
Germany	45%	46%	67%	16 g	45%	100%
Netherlands	31%	32%	69%	10 g	31%	100%
Sweden	84%	87%		19 g	84%	100%
Average	40%	42%		12 g		100%
	e small NiCd (or re					
Denmark	98%	43%	n.a.	20 g	98%	100%
Norway	47%	49%	n.a.	27 g	47%	100%
Average	62%	46%	n.a.	24 g		100%
Countries where Average	e separate collection 0 to 7%	n.a.	ed - 2001 & 2002 n.a.	0 to 2 g		100%
Total EU-15 + C	h + N - 2002					
Total portable NiCd batteries	19%	20%	51%	5 g	19%	100%

Collection rate as % of spent batteries available for collection is assessed with the current level of hoarding estimated at about 37% of all small spent batteries (average between 30% for non rechargeable batteries and 60% for rechargeable batteries)

The proportion of collected batteries sent to a recycling plant increases in Germany: 44% in 2001 as mentioned here and 67% in 2002.

Recycling plant input is commented in the next section hereafter.

3 IMPACT ASSESSMENT OF POLICY OPTIONS

3.1 BASELINE SCENARIO

■ The baseline scenario aims at describing 2007 situation without any revision of the Batteries directives. The policy options to be analysed are compared to this baseline scenario.

We make the assumption that existing separate collection systems dedicated to batteries will still exist and maybe develop.

In addition, because spent batteries can be separately collected not only 'alone' through separate collection systems dedicated to batteries but also through scrapped ELVs and WEEE, the implementation of both WEEE directive and ELV directive may have an impact.

■ Expected impacts of the WEEE directive implementation

It potentially concerns both industrial and portable batteries.

No data are available concerning the proportion of industrial batteries contained in EEE covered by the WEEE directive. But a large proportion of industrial batteries being already collected and recycled because of their positive market value, it seemed reasonable to consider no major impact of the WEEE directive on industrial batteries collection rate.

As for portable batteries, no statistics were available concerning the proportion of spent portable batteries contained in WEEE. An hypothesis of 90% for rechargeable batteries and 10% of non rechargeable batteries was made.

An hypothesis of 30% was made for the impact of the directive implementation on collection rate, i.e. 30% of batteries contained in WEEE would be collected with WEEE in addition to quantities already collected today.

The robustness of this hypothesis is difficult to assess because:

- Collection objectives set up in the WEEE directive are expressed in g of WEEE per inhabitant and not in %.
- This % would even not apply directly to batteries because the weight of batteries contained in EEE varies significantly according to the type of EEE.

Portable Batteries Hypotheses About the Impact of the WEEE Directive Implementation On Collection Rate

Type of apont bottories	Hypotheses 2007				
Type of spent batteries contained in WEEE	Spent batteries contained in WEEE	Spent batteries collected in 2007			
Rechargeable batteries sold in EEE	90% of rechargeable spent batteries	30% of rechargeable spent batteries contained in WEEE			
Non rechargeable batteries sold in EEE	10%	30%			
Non rechargeable batteries sold alone and used in EEE as safe batteries	of non rechargeable spent batteries	of non rechargeable spent batteries contained in WEEE			

Implementation of the WEEE directive

These two hypotheses seemed acceptable to some industrial experts, others were neither able to refute nor to confirm.

As shown on the table next page, additional quantities collected through the WEEE directive would represent about 6% of spent portable NiCd batteries and 7% of other spent portable batteries (respectively 4 and 5% of spent batteries available for collection).

Regarding the impact on the recycling plant inputs, we have to consider that EEE producers are only responsible for WEEE collection and not for recycling of spare parts including batteries. Most likely this would impact countries differently depending on whether collection and recycling practice exists:

- Countries where collection and recycling are not developed: it is assumed that only about 30% of batteries collected through WEEE would be recycled.
- Countries where collection and recycling already exist: the current proportion of batteries collected which are sent to recycling is likely to be the same for additional batteries coming from WEEE.
- Expected impacts of the ELV directive implementation

It potentially concerns lead acid starter batteries, NiCd batteries for electrical cars and NiMH batteries for hybrid vehicles.

No major impact can be expected for lead acid starter batteries. Most of starter batteries are already collected and recycled because of their positive market value. In addition, ELV directive sets up no collection target; targets concern the % of each scrapped car which has to be recycled and batteries are one of spare parts already well recycled.

About 20% of industrial NiCd batteries are used in electrical vehicles in 2002. Considering their high weight, they are expected to be collected and recycled independently from the ELV directive.

NiMH industrial batteries for hybrid vehicles represent portable quantities. Only marginal quantities if any are expected to come from end-of-life hybrid vehicles in 2007.

Remark: the ELV directive targets only part of the starter batteries market: batteries from M1 and N1 vehicles (passengers vehicles up to 8 seats and freight transport vehicles up to 3.5 tones). Are not covered: motorised bikes, buses above 9 seats, trucks above 3.5 tonnes, agricultural equipments, military vehicles... (20% in weight of total starter batteries?).

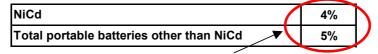
■ The tables hereafter give a summary of the baseline scenario.

Portable Batteries - Impact of the WEEE Directive on Collection Rates

Spent batteries	Composition	Contained in WEEE	Collected w	ith WEEE
Non rechargeable batteries	78%	10%	Hyp: 30%	2%
Rechargeable batteries	22%	90%	of batteries	6%
Spent NiCd batteries Others	1%		contained in WEEE	
Total portable batteries	100%	28%		8%
NiCd	6%			
Total small ba	7%			

Additional collection rates

Spent batteries available for collection	Composition	Contained in WEEE	Collected w	ith WEEE
Non rechargeable batteries	86%	10%	Нур: 30%	3%
Rechargeable batteries Spent NiCd	4%	90% 90%	of batteries	4%
batteries Others		90%	in WEEE	
Total portable batteries	100%	21%		6%



Additional collection rates

Summary of the Baseline Scenario 2007 - All Segments

Spent batteries	Baseline s	Baseline scenario 2007 - Collection rates				
kt of spent batteries and collection rates as % of spent batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment			
Starter Batteries	642 kt					
	80-95% (8)	-	-			
NiCd Batteries		3,3 kt	11,0 kt (1)			
	-	80-90%	20-25% (6)			
		14 kt				
		35-	40%			
Other batteries		193 kt	150 kt (1)			
	-	80-90%	20-25% (6)			
Total batteries	642 kt	196 kt	161 kt (1)			
	80-95%	80-90%	20-25%			
		1 000 kt				
		70-85%				

Spent batteries available for collection	Baseline s	scenario 2007 - Collec	ction rates
kt of spent batteries available for collection and collection rates as % of spent batteries available for collection	Starter batteries segment	Industrial batteries segment	Portable batteries segment
Starter Batteries	642 kt		
	80-95% (8)	-	-
NiCd Batteries		3,3 kt	4,4 kt (1)
	-	80-90%	50-60% (6)
			kt 70%
Other batteries		193 kt	97 kt (1)
	-	80-90%	30-35% (6)
Total batteries	642 kt	196 kt	102 kt
	80-97%	80-90%	30-35%
		940 kt 75-90%	

Recycling plant inputs (7)	Baseline sce	nario 2007 - Recycling plant inputs		
kt of collected batteries and recycling plant input as % of collected batteries	Starter batteries segment	Industrial batteries segment	Portable batteries segment	
Starter Batteries	510-610 kt			
	95-100%	-	-	
NiCd Batteries		2,5-3 kt	2,2-2,8 kt	
	-	98%	100%	
		4,7-	5,8 kt	
		10	0%	
Other batteries		155-175 kt	30-37 kt	
	-	95-100%	90%	
Total batteries	510-610 kt	157,5-178 kt	32-40 kt	
	95-100%	95-100%	90%	
		700-850 kt		
		95-98%		

See footnotes next page

Summary of the Baseline Scenario 2007 – All Segments Footnotes

- (1) Hypothesis: 1% growth rate per year
- (2) ELV directive implementation: no major impact can be expected. Most of starter batteries are already collected and recycled because of their positive market value. In addition, ELV directive sets up no collection target; targets concern the % of each scrapped car which has to be recycled; batteries being one of spare parts already well recycled, no significant effect can be expected
- (3) WEEE directive implementation: no data was available concerning the proportion of industrial batteries contained in EEE covered by the WEEE directive. In addition, targets in the WEEE are expressed as g / inhab / year, which make impossible to easily deduce a % of collection rate for batteries. But a large proportion of industrial batteries being already collected and recycled because of their positive market value, it was decided to consider no major impact of the WEEE directive
- (5) ELV directive implementation: about 20% of industrial NiCd batteries are used in electrical vehicles in 2002; considering their high weight, they are expected to be collected and recycled independently from the ELV directive
- (5) ELV directive implementation: only NiMH industrial batteries for hybrid vehicles are concerned and marginal quantities if any are expected to come from end-of-life hybrid vehicles in 2007
- (6) WEEE directive implementation:
- Proportion of spent portable batteries contained in WEEE: no statistics were available; an hypothesis of 90% for rechargeable batteries and 10% of non rechargeable batteries is made; this hypothesis seemed acceptable to some industrial experts, others were able neither to refute nor to confirm
- Spent portable batteries contained in WEEE collected following the WEEE implementation: an hypothesis of 30% is made (i.e. 30% of batteries contained in WEEE would be collected with WEEE in addition to quantities already collected today); this hypothesis seemed acceptable to some industrial experts, others were able neither to refute nor to confirm
- Spent portable batteries other than NiCd are composed of about 83% of non rechargeable batteries and 17% of rechargeable batteries
- Spent portable batteries available for collection other than NiCd are composed of about 88% of non rechargeable batteries and 12% of rechargeable batteries
- (7) No major impact on quantities sent to recycling can be expected from WEEE & ELV directives
- (8) It is likely that the high value of the range (95%) is overestimated since it is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared.

Summary of the Baseline Scenario 2007 – Portable Batteries²³

		Baseline Scena	ario 2007 - Total	Portable Batteri	ies			
		Collecti	on rates		Recycling plant input			
	% of sales	% of spent batteries	% of spent batteries available for collection	g / capita / yr	% of collected			
Countries where all	portable batteries	s are separately co	ollected in 2002					
A, B, F, D, NL, Sw	30-65%	30-65%	60-85%	120-230 g	70-100%			
Countries where po	ortable NiCd (or re	chargeable) batter	ies are separately	collected in 2002	ı _r			
DK, NW	IOW ?	IOW ?	IOW ?	IOW ?				
Countries where se	parate collection i	is not developed i	n 2002					
Other countries	5-20%	5-20%	n.a.	20-80 g	10-100%			
				ole NiCd Batteri				
	% of sales		ario 2007 - Portal on rates % of spent batteries available for collection	g / capita / yr				
Countries where all	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Collecti % of spent batteries	on rates % of spent batteries available for collection		Recycling plant input			
Countries where all	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Collecti % of spent batteries	on rates % of spent batteries available for collection		Recycling plant input			
A, B, F, D, NL, Sw	portable batteries 35-95%	% of spent batteries s are separately co	% of spent batteries available for collection bllected in 2002 about 70%	g / capita / yr 10-35 g	Recycling plant input % of collected			
1	portable batteries 35-95%	% of spent batteries s are separately co	% of spent batteries available for collection bllected in 2002 about 70%	g / capita / yr 10-35 g	Recycling plant input % of collected			
A, B, F, D, NL, Sw Countries where po	portable batteries 35-95% ortable NiCd (or re	% of spent batteries s are separately co	on rates % of spent batteries available for collection bllected in 2002 about 70%	g / capita / yr 10-35 g collected in 2002	Recycling plant input % of collected 100%			
A, B, F, D, NL, Sw	portable batteries 35-95% ortable NiCd (or recently services of the services	% of spent batteries s are separately constrained as 35-95% chargeable) batter 43% (1) 49%	on rates % of spent batteries available for collection ollected in 2002 about 70% ries are separately n.a. n.a.	g / capita / yr 10-35 g collected in 2002 20 g	Recycling plant input % of collected 100%			

⁽¹⁾ Sales are radically decreasing since 1996

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Compare to the current situation, 3 elements are taken into account: (i) a 5 point increase in taken into account for collection rates following the WEEE directive implementation, (ii) the development of separate collection in France (which just begun 2 years ago), (iii) increase of recycling input plant in Germany (to about 70%; this is 67% in 2003 and was 44% in 2001)

3.2 OPTIONS STUDIED

■ The different options contained in the terms of reference concern collection and recycling rates and, for NiCd, the ban option as well.

Policy Options to Be Studied

Scope	Collection rate	Recycling plant input		Other options
	% of spent batteries	% of spent batteries	% of collected	
	50-60%	45-55%		
All batteries	60-70%	55-65%	90%	
	70-80%	65-75%		
	70-80%	50-60%		-
All starter	80-90%	60-70%	75%	
batteries	90-100%	70-80%		
	60-70%	50-60%		Ban NiCd
All NiCd batteries	70-80%	60-70%	80%	
	80-90%	70-80%		

- For NiCd batteries, given that:
- the highest target (80-90% of collection rate) is already reached for industrial NiCd batteries in the baseline scenario,
- 1/5th of total spent NiCd batteries are industrial batteries,

high collection rates will have to be reached by portable NiCd batteries.

For that reason, the impacts of the following options are also studied in the next sections.

Policy Options Studied for Portable NiCd

Scope	Collection rate	Recycling	plant Input
	% of spent batteries	% of spent batteries	% of collected
D () N''O	50-60%	50-60%	
Portable NiCd batteries	60-70%	60-70%	80%
Datteries	70-80%	70-80%	

The collection rates for portable NiCd can be set up 10 points lower than for total NiCd batteries. Added to industrial NiCd already collected, the overall NiCd targets included in the terms of reference would be reached.

- Stakeholders also proposed targets for total portable batteries. Data provided in this report can also help to assess related impacts.
- In the tables next pages, quantities concerned by each option are estimated.

Options to Be Studied - Estimation of Quantities Concerned²⁴

	Baseline scenario 2007					
	Spent batteries		1 000 kt			
	Spent batteries available for collection	940 kt				
	Collected		700-850 kt			
	Collection rate					
	% of spent batteries		70-85%			
Total	% of spent batteries available for collection		75-90%			
batteries	Recycling plant input (% of collected)		> 95%			
	Options to b	e analysed				
	Collection rate - % of spent batteries	50-60%	60-70%	70-80%		
	Collected	500-600 kt	600-700 kt	700-800 kt		
	% of spent batteries available for collection	55-65%	65-75%	75-85%		
	Recycling plant input: 90% of collected	400-540 kt	540-630 kt	630-720 kt		
	recojeming plant input co/v or concetta			(000.120.11)		
	Baseline sce	nario 2007				
	Spent batteries		642 kt			
	Spent batteries available for collection		642 kt			
	Collected		510-610 kt			
	Collection rate % of spent batteries		80-95%	1		
	% of spent batteries % of spent batteries available for collection		80-95%			
Starter	Recycling plant input (% of collected)		> 95%			
batteries	receycling plant input (70 or conceted)		7 3070			
	Options to b	e analysed				
	Collection rate - % of spent batteries	70-80%	80-90%	90-100%		
	Collected	450-510 kt	510-560 kt	560-640 kt		
	% of spent batteries available for collection	70-80%	80-90%	90-100%		
	Recycling plant input: 75% of collected	340-380 kt	380-420 kt	420-480 kt		
	5					
	Baseline sce	nario 2007				
	Spent batteries		14 kt			
	Spent batteries available for collection		8 kt			
	Collected Collection rate		4,7-5,8 kt			
	% of spent batteries		35-40%			
	% of spent batteries available for collection	60-70%				
NiCd	Recycling plant input (% of collected)	100%				
Batteries						
	Ontions to h	e analysed				
	-	CO 700/	70 00/			
	Collection rate - % of spent batteries	60-70%	70-80%	80-90%		
	Collection rate - % of spent batteries Collected	8,5-10 kt	10-11 kt	11-12,5 kt		
	Collection rate - % of spent batteries					
	Collection rate - % of spent batteries Collected	8,5-10 kt	10-11 kt	11-12,5 kt		

The fact that for NiCd batteries options, the collection rates expressed as % of spent batteries available for collection are higher than 100% for the 3 options to be analysed implies that current domestic hoarding behaviours will have to be reduced significantly.

Options to Be Studied - Possible Options for Portable NiCd Batteries Considering That High Collection Rates Are Already Reached for Industrial NiCd Batteries²⁵

	Baseline sce	nario 2007		
	Spent batteries		11 kt	
	Spent batteries available for collection		4 kt	
	Collected		2,2-2,8 kt	
	Collection rate	•		
	% of spent batteries		20-25%	
Portable	% of spent batteries available for collection		50-60%	
	Recycling plant input (% of collected)		100%	
Batteries				
	Options to b	e analysed		
	Collection rate - % of spent batteries	50-60%	60-70%	70-80%
	Collected	5,5-6,5 kt	6,5-7,5 kt	7,5-9 kt
	% of spent batteries available for collection	135-165%	165-190%	190-220%
	Recycling plant input: 90% of collected	5-6 kt	6-7 kt	7-8 kt

The fact that for small NiCd batteries options, the collection rates expressed as % of spent batteries available for collection are higher than 100% for the 3 options to be analysed implies that current domestic hoarding behaviours will have to be reduced significantly.

3.3 QUANTITATIVE OPTIONS ABOUT STARTER BATTERIES

3.3.1 Feasibility

Folicy Options to be studied for starter batterie	Policy	/ Options	to Be Studied for	or Starter Batteries
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Scope	Collection rate	Recycling	plant input	
	% of spent batteries	% of spent batteries	% of collected	
A.I	70-80%	50-60%	750/	
All starter	80-90%	60-70%	75%	
batteries	90-100%	70-80%		

■ In the baseline scenario for 2007, 80-95% of spent starter batteries are collected and more than 95% of them are sent to a recycling plant.

We are between the 80-90% and 90-100% policy options to be studied for collection rate and above the highest policy options for recycling.

Remark: as stated above, it is likely that the high value of the range (95%) is overestimated since it is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared.

3.3.2 Economic Impacts

- As described in section 2.2.7 page 38, the revenues from recycling (mostly sale of recovered lead and also of plastics) are generally sufficient to cover all of the collection and re-processing costs involved in the sector. However, the economics is sensitive to the lead market price which can fluctuate significantly over years. But the industry has shown in the past that they can deal with that lead market fluctuation, using intermediate temporary storage as a hedging effect. This may explain that 5-10% of spent starter batteries available for collection are actually not collected and recycled.
- The setting up of mandatory targets would require the implementation of a monitoring system which does not exist today in most countries. Costs will be involved, without being certain of the reliability of measurements at such high levels of collection and recycling targets.

Regarding the quantification of the economic impact of mandatory targets, only two sources of data were found.

Denmark has introduced fees for starter batteries. Producers have to pay fees to a collective scheme which amount to 875 000 Euros / year, i.e. about 80 Euros / t of spent batteries sold.

In their report²⁶, ERM estimated a cost of 133 to 171 Euros / t according to the level of mandatory collection rates (respectively 95% and 80%).

- Other additional costs are likely to be not significant, even for countries where starter batteries recycling is less developed (because lead recycling is financially self sufficient).
- On the contrary, market efficiency could be hurt by the setting up of 90-100% mandatory collection target with very high recycling plant input targets. As a matter of fact, this could oblige the industry to reduce the temporary storages they use as a hedging effect, which could affect their capacity to adjust when facing low lead prices.

The risk is that lead recycling could become no more financially self sufficient, which would oblige producers to create a collective system to finance recycling (for instance with a compensation fund fed when lead market price is high as it is done in some countries for packaging paper recycling).

However, this risk is likely to not exist in the case of 90-100% mandatory collection target with 75% recycling plant input target as considered here.

3.3.3 Environmental Impacts

3.3.3.1 Objective of This Section

The purpose of this section is to give an overview of the environmental impacts related to the various policy options under study for starter batteries.

Generally speaking, the establishment of separate collection and recycling targets are expected to cause both positive and negative environmental consequences. The positive consequences are associated with the control of hazardous substances in batteries currently disposed of with mixed wastes, but also in connection with the use of recovered, rather than virgin, materials (which can therefore avoid the environmental impacts due to the production of virgin materials). However, these environmental benefits are expected to be at least partially compensated by environmental impacts due to additional activities required to separate, collect and recycle batteries, including, *inter alia*, the provision of containers, transport associated with collection and delivery to reprocessing facilities and the recycling processes themselves.

Thus, the control of hazardous substances, the principal objective which drives the policy options under study, will induce a change in the balance of environmental impacts due to additional recycling and collection activities.

Therefore, analysis and assessment have to be done through a life cycle approach. The life cycle assessment (LCA) methodology is fairly well developed and can reasonably well support comparisons of environmental benefits of various batteries disposal options. LCA is regarded by many as the most rigorous scientific approach available to quantify environmental impacts of a given 'system' (i.e. the activities to which the technique is applied).

ISO 14040 defines: "LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradle-to-grave) from raw material acquisition through production use and disposal. The general categories or environmental impacts needing consideration include resource use, human health and ecological consequences".

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Analysis of the Environmental Impact and Financial Costs of a Possible New European Directive on Batteries – November 2000

The methodology of LCA is still under development, but a great part of standardisation has been achieved. Standards in the ISO 14040 series describe principles and framework and the four stages of an LCA:

- Goal and scope definition (ISO 14040 and 14041),
- Life cycle inventory analysis (ISO 14041),
- Impact assessment (ISO 14042)
- LC interpretation / improvement assessment (ISO 14043).

3.3.3.2 Previous Work and Derived Results

■ The ERM study

In the ERM study ('Analysis of the environmental impact and financial costs of a possible new European directive on batteries', 2000), the environmental impacts of the lead-acid automotive battery collection and recycling scenarios in UK were predicted using a life cycle assessment (LCA) approach.

Nine scenarios were examined separately, each defined by collection and recycling targets (the overall recycling rate is the quantity of batteries entering reprocessing facilities divided by total spent batteries):

Collection	Recycling target (defined	Overall
target (a)	as a percentage of	recycling
target (a)	collected batteries) (b)	target (a x b)
	85%	68%
80%	90%	72%
	95%	76%
	85%	76.5%
90%	90%	81%
	95%	85.5%
	85%	80.8%
95%	90%	85.5%
	95%	90.3%

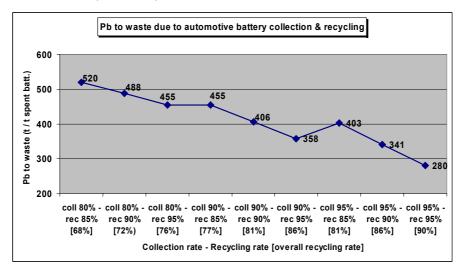
With respect to collection of automotive batteries, it was assumed that lead acid batteries are collected by waste management companies and transported by trucks to the lead smelters, principally in UK, over a total distance of 275 km (75 km from a collecting point to a depot for storage/sorting, then 200 km to the recycling facility).

BIO was not able to obtain and manipulate background LCA data used by ERM, since the report is not transparent enough. Thus, it was not possible to review the reliability of the results.

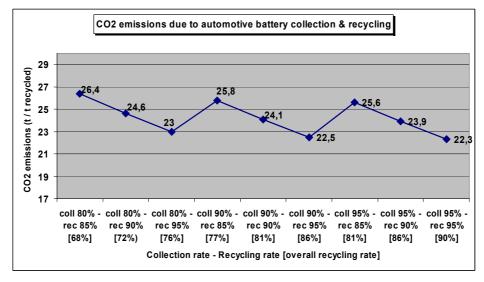
Results are summarised in the following table (adapted from table 7.10 of the study, simply by dividing original results by the quantities of collected and recycled batteries as given in table 5.2).

Collection	Recycling	Overall recycling	t of batteries	Ld to to	otal waste	CO2 en	nissions	NOx en	nissions
target (a)	target (b)	target (a x b)	recycled (a x b)	kg / t recycled	kg / t spent batt.	t / t recycled	t / t spent batt.	kg / t recycled	kg / t spent batt.
	85%	68%	73 834	765	520	26.4	18.0	242	164
80%	90%	72%	78 177	637	488	24.6	17.7	228	164
	95%	76%	82 520	599	455	23.0	17.5	215	164
	85%	76.5%	83 063	595	455	25.8	19.8	241	184
90%	90%	81%	87 949	502	406	24.1	19.5	227	184
	95%	85.5%	92 835	418	358	22.5	19.3	215	184
	85%	80.8%	87 678	499	403	25.6	20.7	240	194
95%	90%	85.5%	92 835	399	341	23.9	20.4	227	194
	95%	90.3%	97 993	310	280	22.3	20.1	214	194

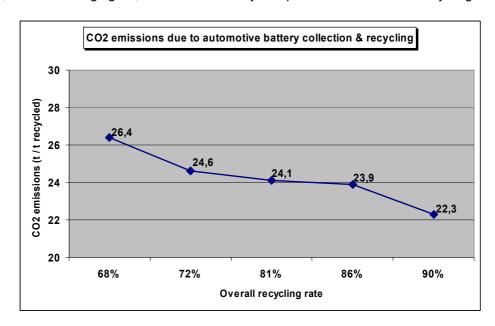
According to the authors, results indicate a complicated environmental trade-off in the scenarios. As collection and recycling rates increase, the heavy metals (lead) in batteries are progressively diverted from waste. Clearly this is most effective when the recycling rate is maximised and when batteries are not simply collected for separate disposal.



However, as collection rates increase, other environmental impacts examined, such as global warming, NOx and SOx emissions, etc., also increase. These impacts are claimed to be associated with the demands and activities of battery collection (eg transport), and are offset only to a limited extent by the avoided impacts associated with the recovery of materials through recycling.



At a first glance, the above figures seem consistent with the conclusions given by the authors. But each value is very difficult to compare with others since two parameters have to be considered: the collection rate and the recycling rate (expressed as a percentage of collected batteries). Consequently, in the following figure, we considered only one parameter: the overall recycling rate.

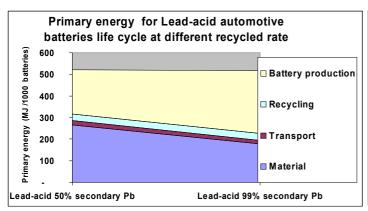


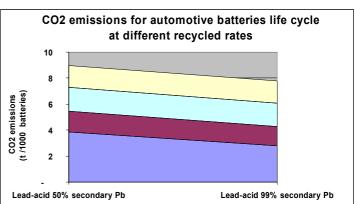
Interestingly, the above figure gives a quite different trend than the one claimed by the authors: results indicate a clear environmental benefit in the scenarios with higher overall recycling rates. With respect to the other environmental indicators, a similar presentation would have shown a similar trend.

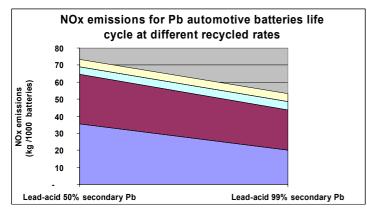
LCA of Lead-acid batteries

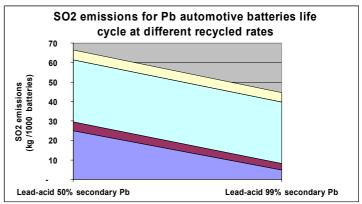
During the present work, and due to the very short duration of the study, we were not able to find any other LCA study covering the scope of the present work. However, one useful study was considered²⁷.

In this paper, a life cycle assessment approach was used to compare vanadium redox and lead-acid batteries for stationary energy storage. Two types of lead-acid batteries were considered: a lead-acid battery with 50% secondary (recycled) lead and one with 99% secondary lead. It is thus possible to derive from this paper some relevant conclusions with respect to the recycling of lead into batteries. Furthermore, the material composition of a lead-acid automotive battery is very similar to the one of a lead-acid batteries for stationary energy storage: in both types, lead represents around 60% in mass of the battery, and the other components are also the same. With the objective to derive from this paper results related to the comparison of the life cycle of a lead-acid automotive battery with 50% of secondary lead versus the life cycle of a lead-acid automotive battery with 99%, we modified the functional unit of the study and considered the life cycle of 1000 automotive batteries²⁸. Results are given in the following figures.









The results of this environmental assessment indicate that the rate of re-use of secondary lead in new batteries is of major importance for the environmental impact.

As a conclusion, the larger quantity of recycled lead in a lead-acid battery, the less environmental damages of its life cycle.

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Environmental assessment of vanadium redox and lead-acid batteries for stationary energy storage, C.J. Rydh, Journal of Power Sources 80 (1999) 21-29

The original functional unit (FU) was defined as 'an electricity storage system with a power rating of 50 kW, a storage capacity of 450 kW and an average delivery of 150 kWh electricity energy per day for 20 years'. This FU corresponds to a mass of lead-acid batteries of 47 974 kg. Considering 14.7 kg for an average automotive battery, we recalculated results on this basis.

3.3.4 Social Impacts

No major additional social impacts are expected compared to the baseline scenario given that high collection and recycling rates are already reached.

3.3.5 Summary of Starter Batteries Policy Options Impact Assessment

Baseline scenario 2007	Collection rate Recycling plant input Economics Economics Environmental profile	% of spent % of batteries collected	5-90% > 95% Recycling revenues cover collection and rental damages linked to collection, transport and re-processing costs benefits brought by virgin material savings
	Recyclir	% of spent batteries	%06-92
	Collection rate	% of spent batteries	80-95%

	Social impacts		Mandatory targets will	require the creation of monitoring	systems with new jobs.
Impact Assessment	Environmental impacts		The higher the collection and recycling targets,	For a given collection target, the higher recycling target, the lower environmental	damages due to transport (recycling benefits increase more than transport negative impacts).
Impac	Economic impacts		ivolve costs to tain of	to be where	starter batteries recycling is less developed (because lead recycling is financially self sufficient). (1)
	Technical feasibility		Yes (already	between the 2 highest	collection targets)
	plant input	% of collected		%92	
Policy options	Recycling	% of spent batteries	%09-09	%02-09	%08-02
Pc	Collection rate Recycling plant input	% of spent batteries	%08-02	%06-08	90-100%

oblige the industry to reduce the temporary storages they use as a hedging effect, which could affect their capacity to adjust when facing low lead prices. The risk is that lead recycling (1) If recycling targets higher than 90-95% of collection (i.e. higher than those considered here) would be considered, market efficiency could be hurt. As a matter of fact, this could could become no more financially self sufficient, which would oblige producers to create a collective system to finance recycling.

3.4 QUANTITATIVE OPTIONS ABOUT ALL BATTERIES

Policy Options to Be Studied for All Batteries

Scope	Collection rate	Recycling	plant input
	% of spent batteries	% of spent batteries	% of collected
	50-60%	45-55%	
All batteries	60-70%	55-65%	90%
	70-80%	65-75%	

- When considering the baseline scenario for 2007, the highest policy options to be studied for all spent batteries, a collection rate of 70-80%, is already reached due to the fact that:
- 80 to 95% of spent starter batteries, which represent about 65% of all spent batteries, are believed to be collected,
- 80 to 90% of spent industrial batteries, which represent about 20% of all spent batteries, are collected.

As far as policy options about recycling plant inputs is concerned, 95-98% of all spent batteries collected in 2007 will be sent to a recycling plant, for the same reason.

No major environmental impacts are thus expected for policy options about all batteries.

Regarding economic impacts, the setting up of mandatory targets will require to implement monitoring systems for all types of batteries, in particular starter batteries and industrial batteries where statistics do not exist at all in most countries today. This will generate costs (see section 3.3.2 page 79 for starter batteries), without being certain of the reliability of the measurements considering the high levels already reached.

As for social impacts, job would be created with the implementation of monitoring systems.

3.5 QUANTITATIVE OPTIONS ABOUT NICD BATTERIES

3.5.1 Feasibility

■ As mentioned before, in the baseline scenario, industrial NiCd batteries are believed to already reach the highest collection target (80-90% of spent batteries).

But they only represent 1/5th of total spent NiCd batteries and collection rate of portable NiCd batteries is estimated at 20-25% in the baseline scenario.

To reach the total targets for NiCd batteries, targets no lower than 10 points would be necessary for portable NiCd batteries.

Policy Options About NiCd Batteries Policy options 80-90% of spent **Policy options Collection rate Industrial NiCd Collection rate** batteries are already % of all spent % of spent collected **NiCd batteries** portable NiCd batteries 60-70% 50-60% 70-80% 60-70% 80-90% 70-80% All NiCd **Portable batteries** NiCd % of all spent % of spent NiCd batteries **batteries** portable NiCd available for batteries collection²⁹ available for collection 100-120% 135-165% 120-140% 165-190% 140-155% 190-220%

This is technically possible, but will require both:

- current domestic hoarding behaviours to be reduced significantly,
- refractory persons to participate to separate collection.

Corresponding costs are assessed in the next section.

3.5.2 Economic Impacts

Among countries where portable NiCd batteries collection is well developed, three types of scheme can be distinguished:

- Scheme 1 Collection and recycling of NiCd only,
- Scheme 2 Collection and recycling all portable batteries,

²⁹ Estimated with current hoarding behaviours of end users.

 Scheme 3 - Collection of all portable batteries in view of recycling primarily NiCd (and also batteries whose recycling cost is 0 or negative).

Because economic impacts are a priori different according to the type of scheme, we consider them separately hereafter.

3.5.2.1 Economic Impacts for Scheme 1 - Collection and Recycling of NiCd Only

■ The only costs available concern the Danish situation, where total collection and recycling costs amount at about 2 830 Euros / tonne collected, i.e. about 80 cents / battery sold. And 40-45% of spent portable NiCd batteries are collected and recycled.

As mentioned in section 2.4.7.2 page 62, economies of scale can be expected for NiCd power packs recycling cost. Recycling cost is then expected to decrease from an average of 150 Euros / tonne (for a mix of individual cells and power packs) today to zero Euros / t.

A total collection and recycling costs could then reach 2600-2700 Euros / tonne in a system as in Denmark, i.e. about 75 cents / battery sold.

Remark: these cots are likely to be influenced by the size of Denmark. It is not sure these costs are representative of what would cost this system in larger countries.

■ The question should be asked if such scheme focusing on NiCd could reach policy targets under consideration. As a matter of fact, despite very high financial incentives for collectors to collect since 1996, only 43% are collected.

3.5.2.2 Economic Impacts for Scheme 2 - Collection and Recycling of All Portable Batteries

3.5.2.2.1 Economic Model Built

■ An economic model was built to assess economic impacts. Hypotheses are based on the case studies analysed (see section 2.4.7.3 page 65).

Important remark about the purpose of the model: the main purpose of the economic model built is to try to estimate the level of costs to reach different levels of collection rate, with a specificity: the existence of hoarding behaviors. When considering countries advanced in batteries collection, it appears that hurdles exist which are difficult to overcome. The model does not aim at describing how costs would evolve in a given country with years (in that case, there could be collection cost optimisation for instance after a while... - we did not integrate these elements in the modelisation).

- The following costs are estimated:
- Variable costs:
 - Collection points (equipment)
 - Collection (logistic)
 - Transport
 - Sorting
 - Recycling or disposal
 - Miscellaneous

- Fixed costs:
 - Public relation and communication
 - Administration.

Remark about the terminology: We kept the common definition of 'variable' and 'fixed' costs terms which are meant to reflect how total expenses (yearly budget) evolve when collected quantities increase in a given system. Given that the purpose of the model differs, some cost qualified as 'fixed cost' are not necessarily considered fixed in the model.

- To take into account the ranges in which actual costs vary, we considered two scenarii:
- Scenario L 'Low costs' scenario, corresponding to relatively low collection and recycling costs,
- Scenario H 'High costs' scenario, corresponding to relatively high collection and recycling costs.

For each scenario, we studied 3 ranges of recycling plant inputs:

- 50-60%,
- 60-70%.
- 90-100%.

The costs for any other ranges of recycling plant input can easily be calculated from the detailed data provided in the report.

Portable Batteries - Scenarii Analysed

		Level o	of costs
		"Low costs" Relatively low collection and recycling costs	"High costs" Relatively high collection and recycling costs
Recycling	50-60%	Scenario L _{50 - 60%}	Scenario H _{50 - 60%}
plant input (% of	60-70%	Scenario L _{60 - 70%}	Scenario H _{60 - 70%}
collected)	90-100%	Scenario L _{90 - 100%}	Scenario H _{90 - 100%}

■ A set of hypotheses was defined for one point of the curves: collection rate of 20-30% of sales (i.e. 21-31% of spent batteries), based on existing collection scheme costs.

Then hypotheses about evolution of costs with the collection rate targeted and economies of scale were introduced, as described in the following table.

Portable Batteries - Main Hypotheses for the Economic Model

NB: collection rate as % of sales in this table		71	for a 20 - 30% ion rate	Variation wit	h collection rate
		Scenario L	Scenario H	Scenario L	Scenario H
		"Low costs"	"High costs"	"Low costs"	"High costs"
Variable costs	•				
Collection points (equipment)	€ / t collected	60	60	Constant (60)	Constant (60)
Collection (logistic)	€ / t collected	250	550	Constant (250)	Constant (550)
Sorting and transport	€ / t collected	130	250	Constant (130)	Constant (250)
Recycling	€ / t entering a recycling plant	300	800	Constant (300)	Economies of scale from 900 € / t when 25 kt are recycled in the EU as in 2002 to 400 € / t if 140 kt are recycled
Disposal	€ / t disposed of	90	90	Constant (90)	Constant (90)
Others	€ / t collected	10% of ot	hers costs	10% of 0	others costs
Fixed costs					
PR & communication	€ / t collected	150	150	€ / t collected to reach to 4000 € / t collect	n collection rates, from 50 n 10 - 20% collection rate ed to reach 90 - 100% ction rate
				· ·	economies of scale in ween:
Administration	€ / t collected	85	240	200 € / t at 10 - 20% collection rate	400 € / t at 10 - 20% collection rate
				400 € / t at 50 - 60% collection rate	800 € / t at 50 - 60% collection rate

As it will be shown hereafter, a threshold appears to be near a collection rate of 40-50% of spent batteries, which correspond to about 60-75% of spent batteries available for collection when considering the current hoarding behaviors.

In the model, this threshold is mostly linked to the hypotheses about communication costs, then to hypotheses about administration cost (the lattest represent about 30% of the cost increase and communication about 65% of cost increase).

The reason of this threshold is that we introduced, in the model, important communication costs increase with collection rate above 40-50% because such level of collection rate is reached today in Belgium and Netherlands with no significant collection rate increase over the last years although already relatively high costs, high communication expenses and high targets set up by the law with, in Belgium, the threat of penalties for producers if not reached. So we concluded from this situation on the ground (and from discussion with BEBAT in particular) that to obtain higher collection rates, even more communication expenses will be required (without being sure that it will be enough to have people changing their behavior!).

Belgium communication cost reach 1660 Euros / t collected and a collection rate of 63% of spent batteries. But because the quantities collected in Belgium have not increased significantly for several years, BEBAT planned to decrease them. That is why we considered 'only' 1000 Euros / t for 50-60%.

As for administration costs, the hypothesis we made are rough assumption. It corresponds to a first size of organisation with no additional administration budget till 50-60% collection rate (so with economies of scale from 10-20% to 40-50%) then a doubled budget (with again economies of scale from 50-60% till 90-100%). This is what we called a step function.

Remark: for a given collection rate, the scenarii for different recycling plant inputs differ on the proportions of spent batteries collected which are recycled (at a recycling cost assessed as described in the above-mentioned table) or disposed of (at a cost of 90 Euros / t disposed of). In order to not complicate to much the model, a simplification had thus been made; it concerns the fact that economies of scale for recycling are accounted for function of collection rate (and thus quantities collected) and not function of quantities actually sent to a recycling plant. Considering the prospective dimension of the approach, and the uncertainties associated independently from that simplification, it is likely not to introduce too big a biais.

- For each scenario, 2 levels of costs paid for by producers are represented depending on their responsibility:
- costs paid for by producers when a producer responsibility is introduced.
 - They give a good estimate of the total collection and recycling costs of the scheme.
- costs paid for by producers when a shared responsibility is introduced.
 - The difference between the two costs give an order of magnitude of the costs taken in charge by public authorities and retailers.

Remark: the costs paid for by local authorities may even be lower because optimisation with other waste management scheme is possible.

3.5.2.2.2 Detailed Results

- The detailed results are successively presented first for scenario L then for scenario H.
- The following 8 pages present the curves and detailed data for each 'low costs' scenario L:
- Scenario L_{50 60%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate,
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Scenario L_{60 70%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Scenario L_{90 100%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Two tables contain all detailed data used to build the curves, one in € / tonne collected and the
 other in cents / unit sold.

Low cost with no economies of scale Low cost **20 - 60%** Recycling: Collection system: Small Batteries - Scenario L_{50 - 60}% Collected batteries sent to recycling

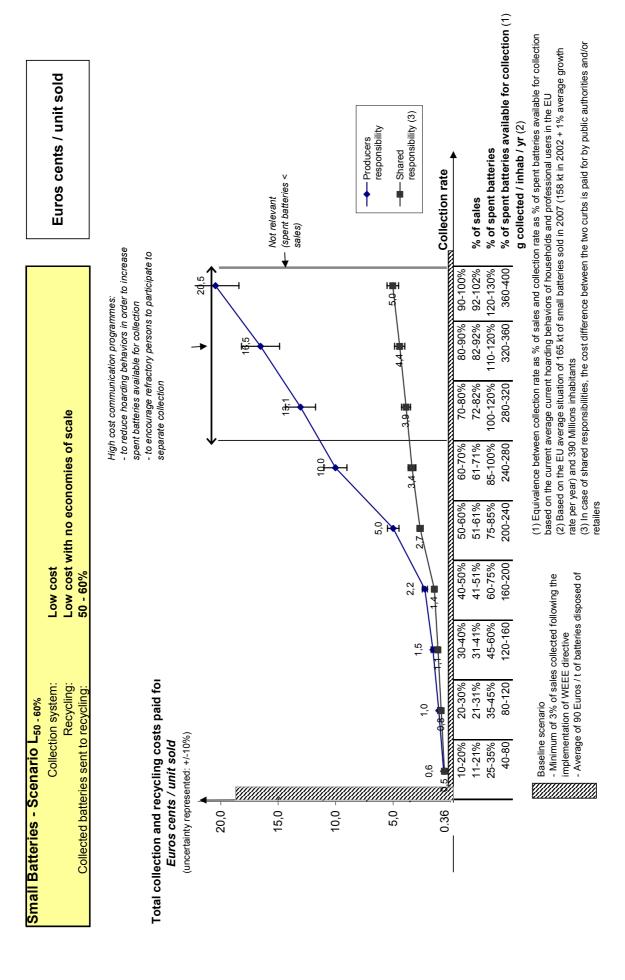
(1) Equivalence between collection rate as % of sales and collection rate as % of spent batteries available for collection (2) Based on the EU average situation of 165 kt of small batteries sold in 2007 (158 kt in 2002 + 1% average growth % of spent batteries available for collection (1) Euros / tonne collected based on the current average current hoarding behaviors of households and professional users in the EU g collected / inhab / yr (2) responsibility (3) % of spent batteries Collection rate responsibility --- Producers (spent batteries < ---Shared % of sales Not relevant sales) - to reduce hoarding behaviors in order to increase - to encourage refractory persons to participate to 120-130% 90-100% 92-102% 360-400 5 383 1 323 High cost communication programmes: spent batteries available for collection 110-120% 320-360 80-90% 82-92% administration budget 1 303 Increase of 100-120% 280-320 70-80% 72-82% separate collection 4 351 ₩² 85-100% 240-280 %02-09 61-71% 3851 1 291 75-85% 200-240 51-61% 20-60% 2 269 1 209 compensates economies of scale for recycling 160-200 41-51% 60-75% 40-50% - Minimum of 3% of sales collected following the 1 242 782 Increase of communication costs Total collection and recycling costs paid for by producers 31-41% 120-160 30-40% 45-60% 1 098 788 21-31% 35-45% 80-120 20-30% separately collected in view of recycling 1 026 Baseline scenario 816 Euros / t of small batteries (uncertainty represented: +/-10%) 25-35% 1-21% 40-80 30°0 1 004 894 000 9 5 000 4 000 3 000 2 000 1 000 8 Economies of scale of administration costs

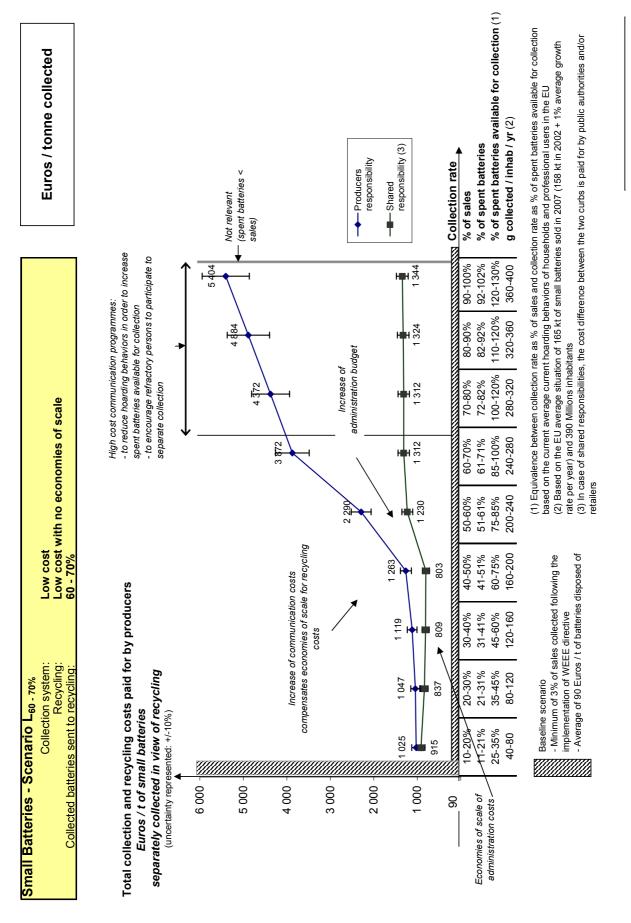
implementation of WEEE directive - Average of 90 Euros / t of batteries disposed of

(3) In case of shared responsibilities, the cost difference between the two curbs is paid for by public authorities and/or

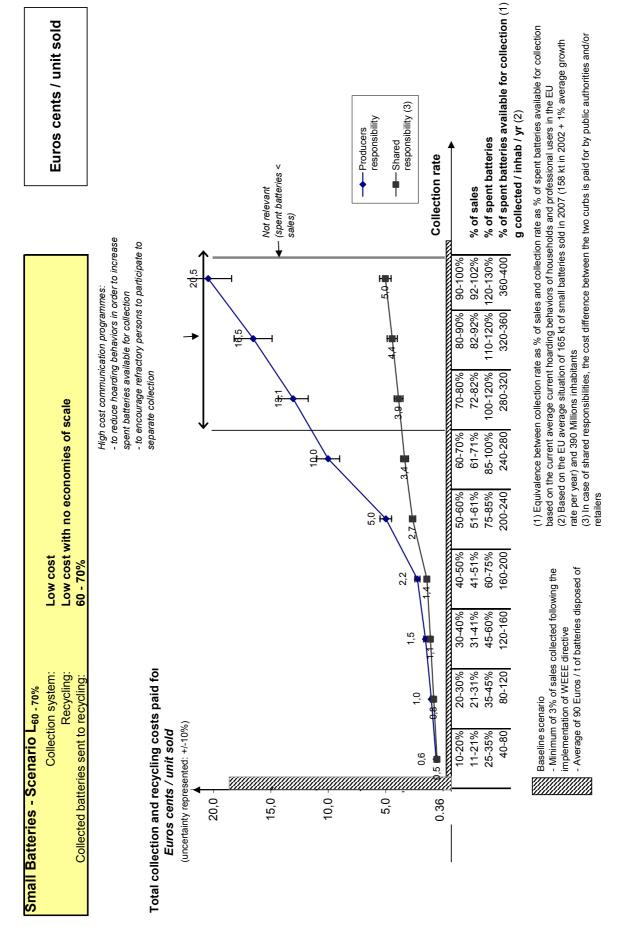
rate per year) and 390 Millions inhabitants

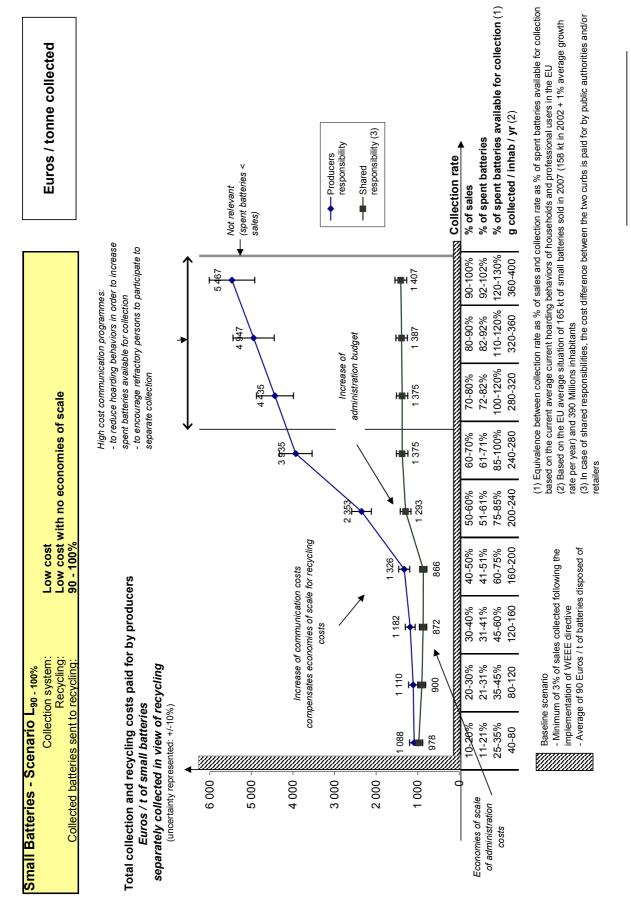
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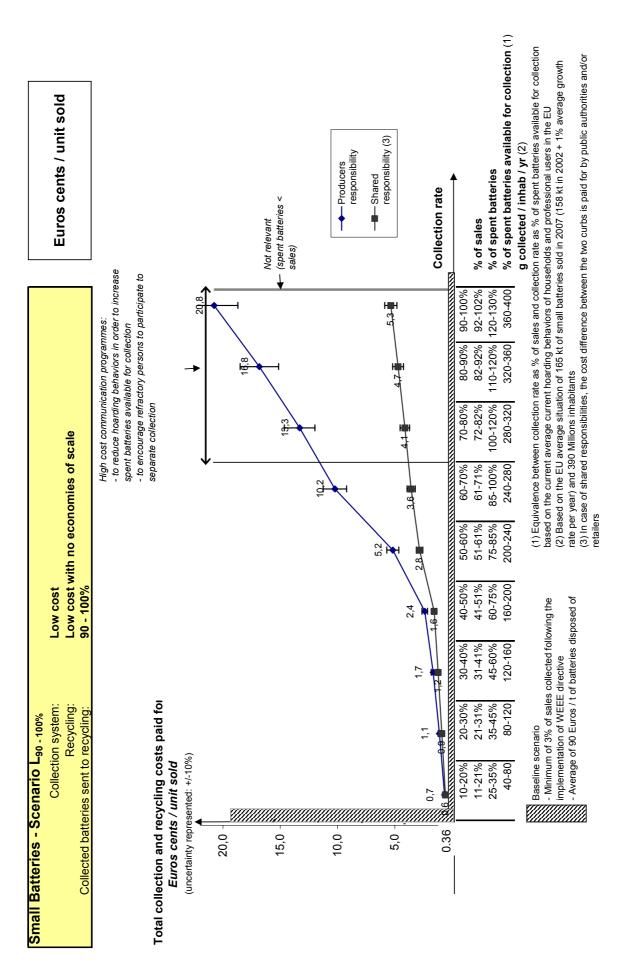




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		b 3% % of sales d' = d x l	
Small batteries - Baseline scenario 2007	Sales	Quantities collected following the implementation of WEEE directive	

			υ	2%	% of spent b	oatteries ava	% of spent batteries available for collection	lection			
Small batteries - Scenario L	Colle	Collection system: Low cost Recycling: Low cost with no economies of scale	ow cost	th no econ	omies of se	cale					Euros / tonne collected Detailed data
Collection rate	Θ	10-20%	20-30%	30-40%	20-30% 30-40% 40-50%		20-60% 60-70%	%08-02		80-90% 90-100% % of sales	% of sales
	-	15%	25%	35%	45%	22%	%59	75%	85%	%26	average % of sales
		11-21%	21-31%	31-41%	41-51%	51-61%	61-71%	72-82%	82-92*%	92-102%	92-102% % of spent batteries
		25-35%	35-45%	45-60%	60-75%	75-85%	85-100%	100-120%	110-120%	120-130%	120-130% % of spent batteries available for collection (1)
		40-80	80-120	120-160	120-160 160-200	200-240	240-280	280-320	320-360	360-400	200-240 240-280 280-320 320-360 360-400 g collected / inhab / yr (2)
Quantities collected	g=axf	25	41	28	74	91	74 91 107 124 140 157 kt/year	124	140	157	kt / year

Variable costs for 100% recycled V=v1->v4 +v6 Collection points (equipment) v1 Collection (logistic) v2 Sorting and transport v3 Recycling v4 Disposal v5 Others v6	4+76											
)	848	820	857	870	963	1 107	1 152	1 199	1 246	€ / t collected	
		09	09	09	09	09	09	09	09	09	€ / t collected	
		250	250	250	250	250	250	250	250	250	€ / t collected	
		130	130	130	130	130	130	130	130	130	€ / t collected	
		300	300	300	300	300	300	300	300	300	€ / t entering a recycling plant	cling plant
		06	06	06	06	06	06	06	06	06	€ / t disposed of	
		108	110	117	130	223	367	412	459	206	€ / t collected	
Fixed costs F=f1+f2	.	250	270	336	467	1 400	2 838	3 293	3 7 59	4 232	€ / t collected	
PR & communication f1		20	150	250	400	1 000	2 500	3 000	3 500	4 000	€ / t collected	
Administration f2		200	120	86	29	400	338	293	259	232	€ / t collected	k (3):
Total costs for recycling plant input $T(3)$ = 100% of collected	(1 098	1 120	1 192	1 336	2 363	3 945	4 446	4 958	5 478	€ / t collected	_
a plant input											Potogloo + / 9	
Lotal costs for recycling plant input $T(3)$ = 50 - 60% of collected	(1 004	1 026	1 098	1 242	2 269	3 851	4 351	4 863	5 383	e / r collected	0,55
Total costs for recycling plant input $T(3)$ = 60 - 70% of collected		1 025	1 047	1 119	1 263	2 290	3 872	4 372	4 884	5 404	€ / t collected	0,65
Total costs for recycling plant input $T(3)$ = 90 - 100% of collected	(1 088	1 110	1 182	1 326	2 353	3 935	4 435	4 947	5 467	€ / t collected	0,95
2. Costs paid for by producers												Recycling plant input
		1 098	1 120	1 192	1 336	2 363	3 945	4 446	4 958	5 478	€ / t collected	400%
Shared responsibility (1) T - v1 - f1	- f1	988	910	882	876	1 303	1 385	1 386	1 398	1 418	€ / t collected	8/ 001
Producer responsibility T		1 004	1 026	1 098	1 242	2 269	3 851	4 351	4 863	5 383	€ / t collected	%U9 ⁻ U5
Shared responsibility (1) T - v1 - f1	- f1	894	816	788	782	1 209	1 291	1 291	1 303	1 323	€ / t collected	8/00 - 00 - 00
_		1 025	1 047	1119	1 263	2 290	3 872	4 372	4 884	5 404	€ / t collected	%UZ - U9
Shared responsibility (1) T - v1 - f1	- f1	915	837	809	803	1 230	1 312	1312	1 324	1 344	€ / t collected	0/01 - 00
		1 088	1 110	1 182	1 326	2 353	3 935	4 435	4 947	5 467	€ / t collected	90 - 100%
Shared responsibility (1) T - v1 - f1	- f1	978	006	872	866	1 293	1 375	1 375	1 387	1 407	€ / t collected	200

(3) If k=recycling input plant rate, T=v1+v2+v3+k*v4+(1-k)*v5+v6+F	
	g / unit
etailers	40
ublic authorities or I	ᆫ
(1) Remaining costs are paid for by pu	(2) Hypothesis:

Small batteries - Baseline scenario 2007 Sales Quantities collected following the implementation of WEEE directive	cenario 200 ementation of W	Sales Sales EEE directive	വവത	165 3% 5%	kt / year % of sales % of spent batteries available for collection	atteries ava	lable for coll	ection	Dispos	sal cost of b	Disposal cost of batteries not recycled	d 90 € / tof batteries d'=d×h 0,36 €/ unit sold
Small batteries - Scenario L	Colle	Collection system: Low cost	ow cost								Euros	Euros cents / unit sold Detailed data
		Recycling:	Low cost w	ith no ecor	Recycling: Low cost with no economies of scale	ale						
Collection rate	٥	40.20%	7006.06	30 400/	40 E00/	EO 600/	700%	70 000	7000 00	70007	seles to %	
	υ 4	15%	25%	35%	40-50%	55%	%5% 65%	75%	%06-80% 85%	90-100%	average % of sales	
		11-21%	21-31%	31-41%	41-51%	51-61%			82-92*%	92-102%	% of spent batteries	
		25-35% 40-80	35-45% 80-120	45-60% 120-160	60-75%	75-85%	85-100% 7	100-120%	110-120% 320-360	120-130% 360-400	% of spent batteries	% of spent batteries available for collection (1) o collected / inhab / vr (2)
Quantities collected	g=axf	25	41	58	74	91	107	124	140	157	kt / year	
											_	
1. Cost structure	, c	u c	ć	,	4		ć		•	1	6 000 tian / tago 3	
Variable costs for 100% recycled	באש/מאב	o, c	5 6	, c	ر . م	, c	אי כ מי	ກໍດ ດີຕ	4 , c	4 , 0	6 cent / unit sold	
Collection Pollits (equipment)		0,0	- e	-, 0	- v	- 6	, O V, C	7,0	ν, o	, t	€ cent / unit sold	
Sorting and transport		0.1	0,0	0.0	0,2	o, c,	, c 0.3	0,0	0,0	0,5	€ cent / unit sold	
Recycling		0,2	0,3	4,0	0,5	0,7	8,0	6,0	1,0	1,1	€ cent/ unit entering a recycling plant	a recycling plant
Disposal		0,1	0,1	0,1	0,2	0,2	0,2	0,3	0,3	0,3	€ cent/ unit disposed of	of .
Others		0,1	1,0	0,2	0,2	0,5	1,0	1,2	1,6	1,9	€ cent / unit sold	
Fixed costs		0,2	0,3	0,5	8,0	3,1	4,7	6,6	12,8	16,1	€ cent / unit sold	
PR & communication		0,0	0,0	4, 6	0,7	2,2	o,5	0,0	11,9	15,2	€ cent / unit sold € cent / unit sold	k (3).
		-,'-	-,	-,0	-,-	0,9	9,0	6,0	0,9	9,0	ב הפווני חווור פסום	.(6)
Total costs for recycling plant input = 100% of collected	T (3)	7,0	1,	1,7	2,4	5,2	10,3	13,3	16,9	20,8	€ cent / unit sold -	_
treating the section of the section of the T											6100 tig., / tage 2	
lotal costs for recycling plant input = 50 - 60% of collected	T (3)	9'0	1,0	1,5	2,2	5,0	10,0	13,1	16,5	20,5		0,55
Total costs for recycling plant input = 60 - 70% of collected	T (3)	9'0	1,0	1,6	2,3	5,0	10,1	13,1	16,6	20,5	€ cent / unit sold	0,65
Total costs for recycling plant input	T (3)	0,7	1,1	1,7	2,4	5,2	10,2	13,3	16,8	20,8	€ cent / unit sold	0,95
											_	
2. Costs paid for by producers												Recycling plant input
Producer responsibility		2,0	1,1	1,7	2,4	5,2	10,3	13,3	16,9	20,8	€ cent / unit sold	100%
Shared responsibility (1)	T - V1 - I	9,0	6,0	1,2	1,6	2,9	3,6	4,2	4,8	5,4	€ cent / unit sold	
Producer responsibility (1)	T - V1 - f1	0,0 5.0	0,0	, τ,	2, L 2, 4	5,0	10,0 3.4	13,1 3.9	16,5 4 4	20,5	€ cent / unit sold € cent / unit sold	%09 - 09
Producer responsibility	⊩	9.0	1.0	1,6	2,3	5.0	10,1	13.1	16.6	20.5	€ cent / unit sold	
Shared responsibility (1)	T - v1 - f1	0,6	6,0	1,2	1,6	2,8	3,6	4,1	4,7	5,3	€ cent / unit sold	%0 <i>-</i> 20%
Producer responsibility	- 5 - 1 - 1	0,7	1,1	1,7	2,4	5,2	10,2	13,3	16,8	20,8	€ cent / unit sold	90 - 100%
Shared responsibility (1)	I - V1 - †1	9,0	6,0	1,2	1,6	2,8	3,6	4,1	4,7	5,3	€ cent / unit sold	

(3) If k=recycling input plant rate, T=v1+v2+v3+k*v4+(1-k)*v5+v6+F

g / unit

(1) Remaining costs are paid for by public authorities or retailers (2) Hypothesis:

■ Short comments on the previous curves to facilitate the reading

The shapes and ranges of the different graphs are sensibly the same for the three recycling plant inputs examined here. This is because in this model, recycling and disposal costs remain constant whatever the collection rate is (there is no economies of scale for the low recycling cost). The only cost differences come from the ratio waste batteries entering a recycling plant / waste batteries disposed of. Indeed, the recycling cost is $300 \in /$ tonne collected, whereas the disposal cost is only $90 \in /$ tonne collected.

Up to a certain level of collection rate estimated near 40-50%, the costs remain quite constant, due to compensation of communication costs increase and economies of scale of administration costs.

After this threshold, a step of increase of administration costs is assumed, so the still increasing communication costs would not be compensated any more: the costs would increase faster with collection rate.

For each scenario, the same differences of shapes for the 'Producers responsibility' and 'Shared responsibility' curves are observed. In case of shared responsibility, collection equipment and communication costs are considered being paid for by public authorities and / or retailers. So the 'Shared responsibility' curve only follows the variations of administration costs, that is to say economies of scale until 40-50% of collection rate, then a step of increase, and economies of scale again.

Remark: the threshold appears to be near a collection rate of 40-50% of spent batteries, which correspond to about 60-75% of spent batteries available for collection when considering the current hoarding behaviours. Such level of collection rate is reach today in Belgium and Netherlands with no significant collection rate increase over the last years although already relatively high costs. Considering a high cost increase above that level is then coherent with the situation on the ground.

- The following 8 pages present the curves and detailed data for each 'high costs' scenario H:
- Scenario H_{50 60%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate,
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Scenario H_{60 70%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Scenario H_{90 100%}:
 - Graph: Total collection and recycling costs in € / tonne collected, function of the collection rate
 - Graph: Total collection and recycling costs in € cent / unit sold, function of the collection rate.
- Two tables contain all detailed data used to build the curves, one in € / tonne collected and the other in cents / unit sold.

Small Batteries - Scenario H_{50 - 60}%

Recycling: Collection system:

High cost High cost with economies of scale 20 - 60% Collected batteries sent to recycling

Euros / tonne collected

High cost communication programmes:

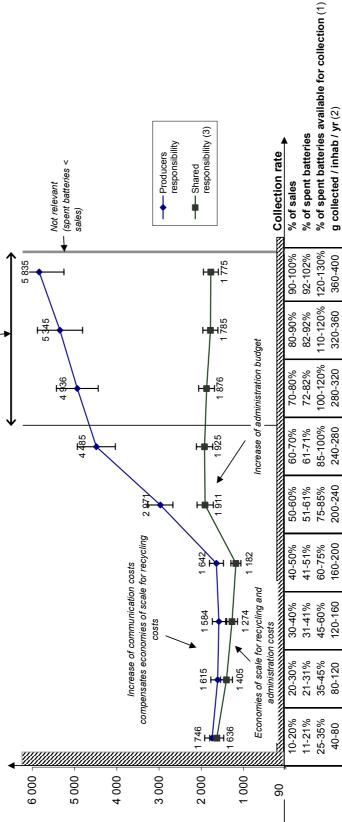
- to reduce hoarding behaviors in order to increase spent batteries available for collection

Total collection and recycling costs paid for by producers

separately collected in view of recycling

Euros / t of small batteries

 to encourage refractory persons to participate to separate collection (uncertainty represented: +/-10%)



implementation of WEEE directive - Average of 90 Euros / t of batteries disposed of - Minimum of 3% of sales collected following the

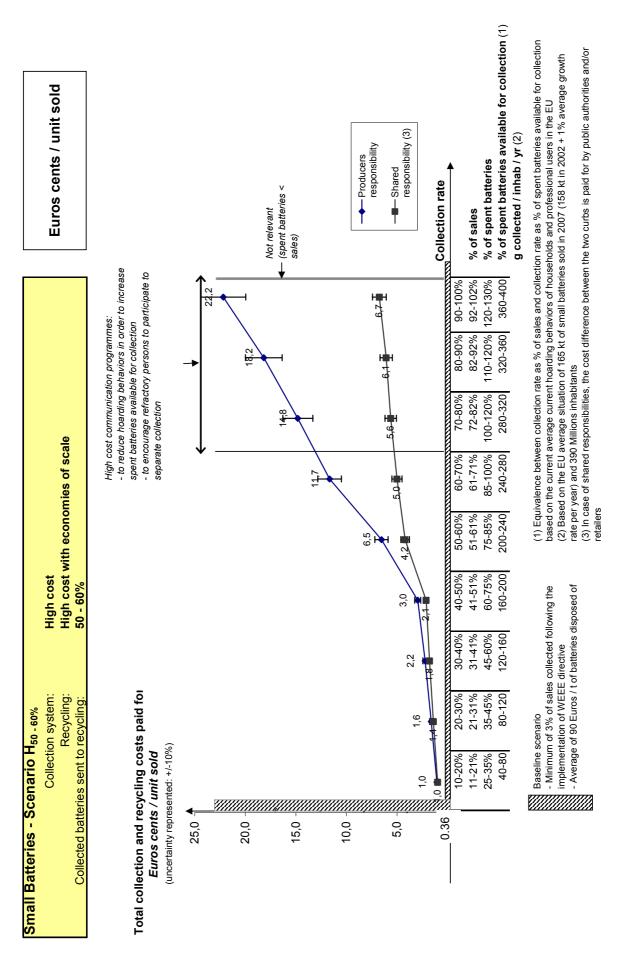
Baseline scenario

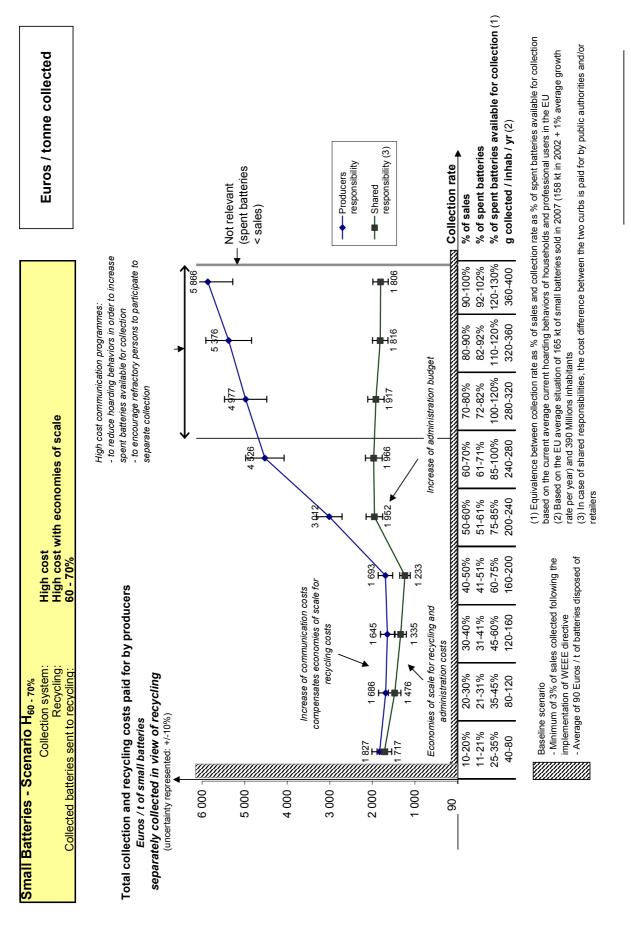
(1) Equivalence between collection rate as % of sales and collection rate as % of spent batteries available for collection (2) Based on the EU average situation of 165 kt of small batteries sold in 2007 (158 kt in 2002 + 1% average growth based on the current average current hoarding behaviors of households and professional users in the EU

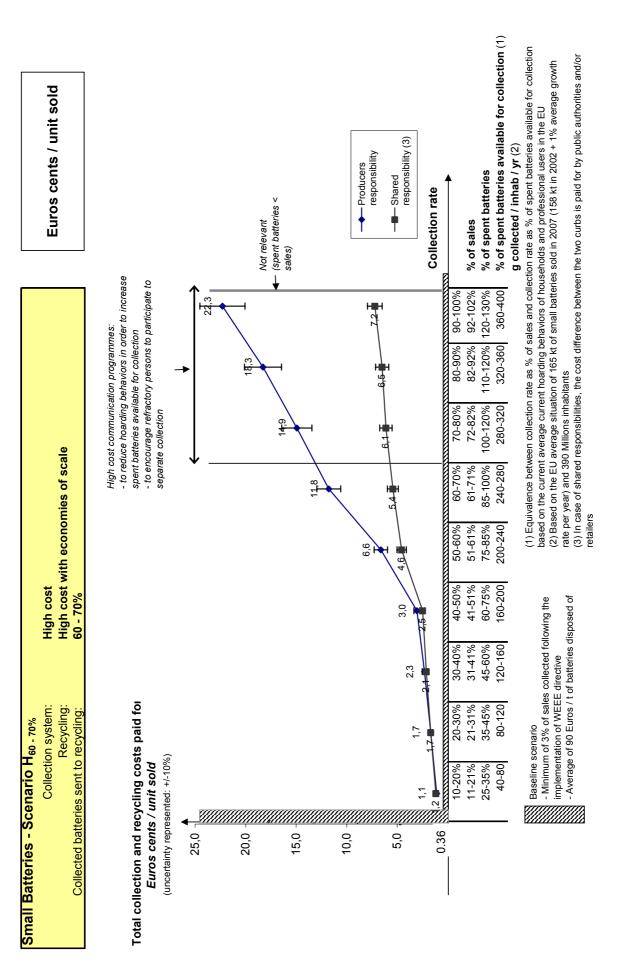
rate per year) and 390 Millions inhabitants

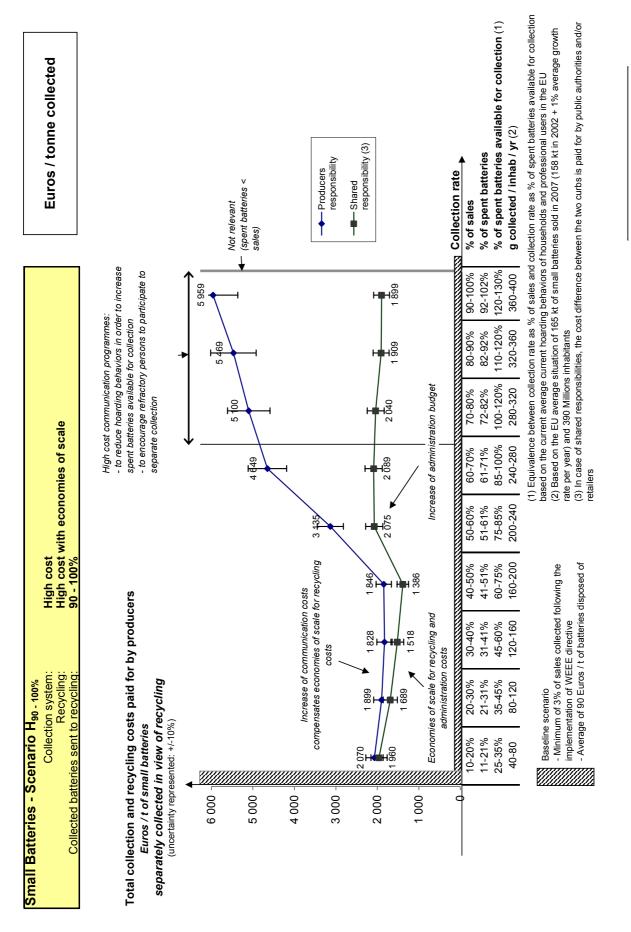
(3) In case of shared responsibilities, the cost difference between the two curbs is paid for by public authorities and/or retailers

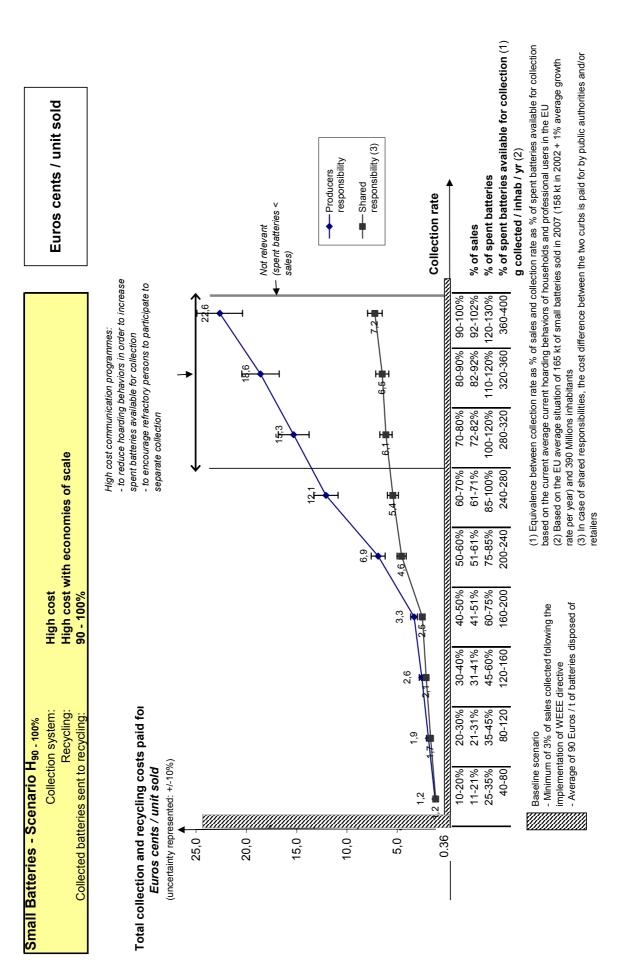
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Small batteries - Baseline scenario 2007						
Sales	_	65	kt / year	Disposal cost of batteries not recycled	ъ	90 € / t of batteries
Quantities collected following the implementation of WEEE directive	р 3	3%	% of sales	= ,p	$d' = d \times h$	0,36 €/ unit sold
	C 2	2%	% of spent batteries available for collection			

Quantities collected following the implementation of WEFF directive	mentation of WFF	- directive	2.2	8 %	% of sales				2		
			υ		% of spent batteries available for collection	atteries ava	ilable for co	llection			
Small batteries - Scenario H											Euros / tonno collected
	Collectic	Collection system: High cost Recycling: High cost	igh cost igh cost w	ith econon	on system: High cost Recycling: High cost with economies of scale	•					Detailed data
Collection rate	Ф	10-20%	20-30%	30-40%	40-20%	20-60%	%02-09	%08-02	%06-08	90-100% % of sales	% of sales
	-	15%	25%	35%	45%	22%	%59	75%	85%	%56	average % of sales
		11-21%	21-31%	31-41%	41-51%	51-61%	61-71%	72-82%	82-92*%	92-102%	% of spent batteries
		25-35%	35-45%	45-60%	9-12%	75-85%	85-100%	100-120%	110-120%	120-130%	100-120% 110-120% 120-130% % of spent batteries available for collection (1)
		40-80		120-160	160-200	200-240	240-280	280-320	320-360	360-400	280-320 320-360 360-400 g collected / inhab / yr (2)
Quantities collected	g=axf	25	41	28	74	91	107	124	140	157 kt / year	kt / year

0,65 0,95 0,95 Recycling plant in	<pre>€ / t collected € / t collected</pre>	5 8 35 5 959 5 974 1 914 5 835	5 345 5 376 5 469 5 489 1 924 5 345	5 100 5 100 5 120 5 2 060 7 936	4 4 4 8 5 4 4 4 8 5 4 4 6 4 9 4 6 4 9 4 6 7 0 4 4 4 8 5 6 4 9 4 4 8 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	3 012 3 135 3 135 3 155 2 095 2 971	1 693 1 846 1 872 1 412 1 642	1 645 1 828 1 859 1 549 1 584	1686 1899 1934 1724 1615	1 746 1 827 2 070 2 110 2 100 2 000 1 746	T (3) T (3) T (3) T (3) T - v1 - f1 T	Total costs for recycling plant input = 50 - 60% of collected Total costs for recycling plant input = 60 - 70% of collected Total costs for recycling plant input = 90 - 100% of collected 2. Costs paid for by producers Producer responsibility Shared responsibility (1) Producer responsibility (1)
0,95	€ / t collected	5 959	5 469	5 100	4 649	3 135	1 846	1 828	1 899	2 070		T (3)
0,65	€ / t collected	2 866	5 376	4 977	4 526	3 012	1 693	1 645	1 686	1 827		T (3)
0,55	€ / t collected	5 835	5 345	4 936	4 485	2 971	1 642	1 584	1 615	1 746		T (3)
_	€ / t collected	5 974	5 484	5 120	4 670	3 155	1 872	1 859	1 934	2 110		T (3)
k (3):	€ / t collected	463	518	587	677	800	133	171	240	400		t 2
	€ / t collected	4 000	3 500	3 000	2 500	1 000	400	250	150	20		Ξ
	€ / t collected	4 463	4 0 1 8	3 587	3 177	1 800	533	421	390	450	Ŋ	F=f1+f2
	€ / t collected	551	202	474	433	295	178	177	184	200		9/
	€ / t disposed of	06	06	06	06	06	06	06	06	06		۸5
ycling plant	€ / t entering a recycling plant	400	400	200	200	200	009	200	800	006		۷4
	€ / t collected	250	250	250	250	250	250	250	250	250		۸3
	€ / t collected	250	250	250	250	250	250	250	250	250		۸2
	€ / t collected	09	09	09	09	09	09	09	09	09		۲>
	€ / t collected	1 511	1 467	1 534	1 493	1 355	1 338	1 437	1 544	1 660	4^6	Variable costs for 100% recycled V=v1->v4 +v6

	Ī											
%/001 - 06	€ / t collected	1 899	1 909	2 040	2 089	2 075	1 386	1 518	1 689	1 960	T - v1 - f1	Shared responsibility (1)
90 - 100%	€ / t collected	2 959	5 469	5 100	4 649	3 135	1 846	1 828	1 899	2 070	⊢	Producer responsibility
8/61-66	€ / t collected	1 806	1816	1 917	1 966	1 952	1 233	1 335	1 476	1 717	T - v1 - f1	Shared responsibility (1)
%UZ = U9	€ / t collected	2 866	5 376	4 977	4 526	3 012	1 693	1 645	1 686	1 827	⊢	Producer responsibility
%/00 - 0C	€ / t collected		1 785	1 876	1 925	1 911	1 182	1 274	1 405	1 636	T - v1 - f1	Shared responsibility (1)
%U9 U9	€ / t collected		5 345	4 936	4 485	2 97 1	1 642	1 584	1615	1 746	⊢	Producer responsibility
% 200	€ / t collected	1 914	1 924	2 060	2 110	2 095	1 412	1 549	1 724	2 000	T - v1 - f1	Shared responsibility (1)
700%	€ / t collected	5 974	5 484	5 120	4 670	3 155	1 872	1 859	1 934	2 110	⊢	Producer responsibility
Recycling plant input												2. Costs paid for by producers

(3) If k=recycling input plant rate, T=v1+v2+v3+k*v4+(1-k)*v5+v6+F

g / unit

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(1) Remaining costs are paid for by public authorities or retailers(2) Hypothesis:

Sales Quantities collected following the implementation of WEEE directive	lementation of W	Sales /EEE directive	ပေသတ	165 3% 5%	kt / year % of sales % of spent b	oatteries ava	kt / year % of sales % of spent batteries available for collection	llection	Dispo	sal cost of b	Disposal cost of batteries not recycled d 90 \in / t of batteries d'= $d \times h$ 0,36 \in / unit sold
Small batteries - Scenario H	Ļ										Plos timi / staco somi
	CO	Collection system: High cost	High cost								Detailed data
		Recycling:	Recycling: High cost w i		th economies of scale	ө					
Collection rate	Ф	10-20%	20-30%	30-40%	40-20%	20-60%	%02-09	%08-02	%06-08	90-100%	% of sales
	-	15%	72%	35%	45%	22%	%59	75%	85%	%26	average % of sales
		11-21%	21-31%	31-41%	41-51%	51-61%	61-71%	72-82%	82-92*%	92-102%	% of spent batteries
		25-35% 40-80	35-45% 80-120	45-60% 120-160	60-75% 160-200	75-85% 200-240	85-100% 240-280	100-120% 280-320	110-120% 320-360	120-130% 360-400	% of spent batteries available for collection (1) g collected / inhab / vr (2)
Quantities collected	g=axf	25	41	58	74	91	107	124	140	157	kt / year
1. Cost structure											
Variable costs for 100% recycled	Fxg/axh	1,0	1,5	2,0	2,4	3,0	3,9	4,6	5,0	5,7	€ cent / unit sold
Collection points (equipment)		0,0	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,2	€ cent / unit sold
Collection (logistic)		0,2	0,3	4,0	0,5	9,0	0,7	0,8	6,0	1,0	€ cent / unit sold
Sorting and transport		0,2	0,3	0,4	0,5	9,0	0,7	0,8	6,0	1,0	€ cent / unit sold
Recycling		0,5	8,0	1,0	L, L,	1,1	1,3	1,5	1 ,	1,5	€ cent/ unit entering a recycling plant
Disposal		0,1	0,1	0,1	0,2	0,2	0,2	0,3	0,3	0,3	€ cent/ unit disposed of
Others		0,1	0,2	0,2	0,3	9,0	1,1	4,1	1,7	2,1	€ cent / unit sold
Fixed costs		0,3	0,4	9,0	1,0	4,0	8,3	10,8	13,7	17,0	€ cent / unit sold
PR & communication		0,0	0,2	4,0	2'0	2,2	6,5	0'6	11,9	15,2	
Administration		0,2	0,2	0,2	0,2	1,8	1,8	1,8	1,8	1,8	€ cent / unit sold k (3):
Total costs for recycling plant input = 100% of collected	T (3)	1,3	1,9	2,6	3,4	6'9	12,1	15,4	18,6	22,7	€ cent / unit sold 1
Total costs for recycling plant input = 50 - 60% of collected	T (3)	1,0	1,6	2,2	3,0	6,5	11,7	14,8	18,2	22,2	€ cent / unit sold 0,55
Total costs for recycling plant input = 60 - 70% of collected	Т (3)	1,1	1,7	2,3	3,0	9'9	11,8	14,9	18,3	22,3	€ cent / unit sold 0,65
Total costs for recycling plant input = 90 - 100% of collected	T (3)	1,2	1,9	2,6	3,3	6,9	12,1	15,3	18,6	22,6	€ cent / unit sold 0,95
Control for by by and for of the control of the con											and the second of the second o
2. Costs paid for by producers	F	0	4	ď		9	40,	45.4	40 6	700	Recycling plant input

Small batteries - Baseline scenario 2007

Recycling plant i	4000/	0.0070	70US US	0/ 00 - 00	7002 03	00 - 1070	90 100%	0/ 001 - 06
	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold	€ cent / unit sold
	22,7	7,3	22,2	6,7	22,3	7,2	22,6	7,2
	18,6	6,5	18,2	6,1	18,3	6,5	18,6	6,5
	15,4	6,2	14,8	5,6	14,9	6,1	15,3	6,1
	12,1	5,5	11,7	2,0	11,8	5,4	12,1	5,4
	6,9	4,6	6,5	4,2	9,9	4,6	6,9	4,6
	3,4	2,5	3,0	2,1	3,0	2,5	3,3	2,5
	2,6	2,2	2,2	1,8	2,3	2,1	2,6	2,1
	1,9	1,7	1,6	4,1	1,7	1,7	1,9	1,7
	1,3	1,2	1,0	1,0	1,1	1,2	1,2	1,2
	⊥	T - v1 - f1	⊥	T - v1 - f1	Τ	T - v1 - f1	⊥	T - v1 - f1
2. Costs paid for by producers	Producer responsibility	Shared responsibility (1) T - v1 - f1	Producer responsibility	Shared responsibility (1) T - v1 - f1	Producer responsibility	Shared responsibility (1) T - v1 - f1	Producer responsibility	Shared responsibility (1) T - v1 - f1

(1) Remaining costs are paid for by public authorities or retailers (2) Hypothesis:

(3) If k=recycling input plant rate, T=v1+v2+v3+k*v4+(1-k)*v5+v6+F g / unit

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Short comments on the previous curves to facilitate the reading

With this scenario again, the shapes and ranges of the graphs according to the different recycling plant inputs do not vary a lot.

Administration and communication costs are much higher than in the 'Low costs' scenarii, so do the total costs.

Contrary to scenario L, economies of scale of recycling costs are accounted for scenario H, which explains the slight decrease of total costs up to a certain of collection rate near 50%.

An increase in the slope of the graphs is then observed from that level of collection rate due to an increase of administration costs.

The same remarks as for the difference of shapes between the 'Producers responsibility' and 'Shared responsibility' in scenario L curves are worth for this scenario H too.

3.5.2.2.3 Summary of the Results

■ The following graphs summarise the main results, for 90-100% recycling plant input.

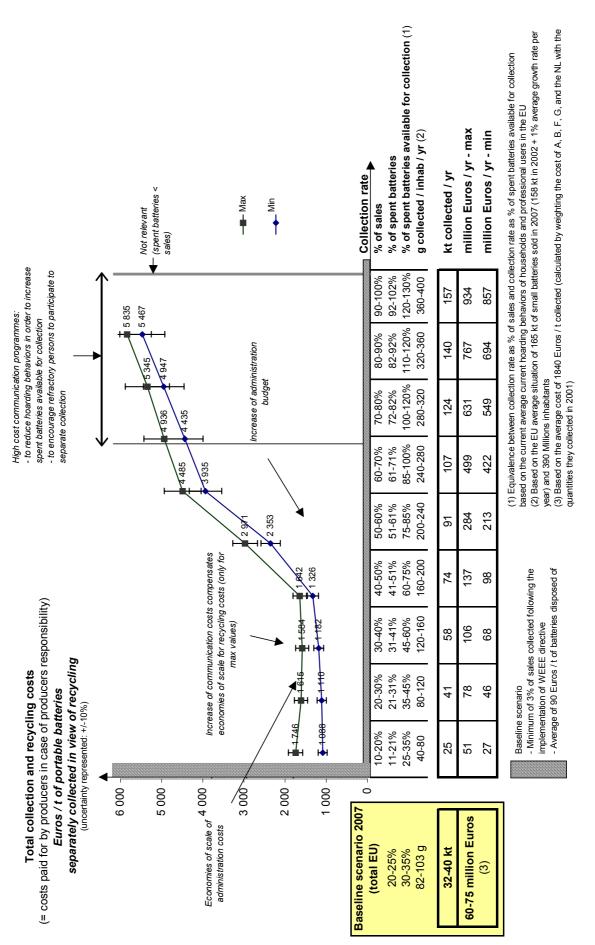
Total collection and recycling costs are represented. They correspond to costs that producers would have to pay for in case of producer responsibility.

Yearly budget for separate collection and recycling of concerned spent batteries is also presented on the bottom of the page.

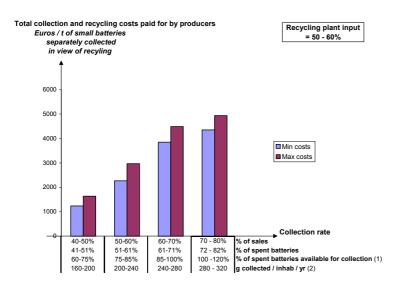
Portable Batteries - Total Collection and Recycling Costs Function of Collection Rate (orders of magnitudes)

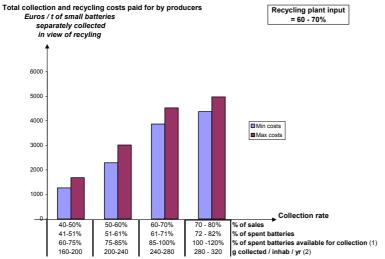
Euros / tonne collected

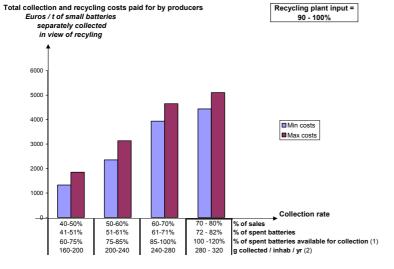
Collected batteries sent to recycling: 90 - 100%



Scheme 2 - Collection and Recycling of All Portable Batteries Estimation of Total Collection and Recycling Costs With Collection Rate and Recycling Plant Input Euros / Tonne Collected



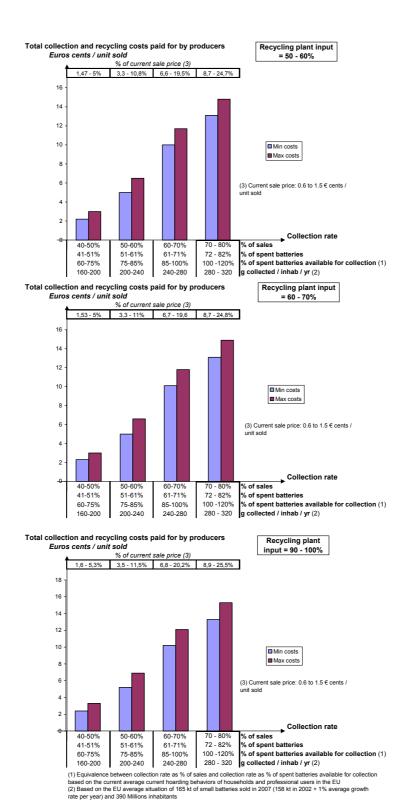




(1) Equivalence between collection rate as % of sales and collection rate as % of spent batteries available for collection based on the current average current hoarding behaviors of households and professional users in the EU (2) Based on the EU average situation of 165 kt of small batteries sold in 2007 (158 kt in 2002 + 1% average growth rate per year) and 390 Millions inhabitants

The following graphs show the same data in € cents / unit sold.

Scheme 2 - Collection and Recycling of All Portable Batteries Estimation of Total Collection and Recycling Costs With Collection Rate and Recycling Plant Input Euros Cents / Unit Sold



■ The following tables summarise total collection and recycling costs (min-max ranges) for the different policy options about collection rates (50-60%, 60-70%, 70-80% of spent portable batteries) and recycling plant input (40-50%, 50-60%, 60-70%, 70-80% of collected), with a reminder of the baseline scenarion. A collection rate of 40-50% is also included to better show cost evolution.

The 2 tables differ in the scope they cover:

- The first table focuses on batteries separately collected, i.e. costs concern separate collection and recycling as well as the disposal of separately collected quantities which are not recycled depending in the recycling plant input considered.
 - These costs are those that producers would have to pay for in case of producer responsibility.
- The second table covers all spent batteries, those separately collected with costs from the 1st table and the remaining fraction collected and disposed of with MSW (at a cost of 120 Euros / t).
 - They correspond to the total end-of-life cost of spent batteries.
 - The comparison with the baseline scenario is particularly appropriate.

NB: The figures presented are to be regarded as orders of magnitude and trends rather than absolute figures. Ranges correspond to the low and high costs assessed with scenario L and scenario H.

Scheme 2 - Collection and Recycling of All Portable Batteries Economic Impacts of Policy Options

Scope: Small batte	ries separately o	collected		ts paid	for by p	d recyc roducei sponsil	rs in ca		pro cas	s paid for oducers i e of shar ponsibili	in ed
			ı	Policy o	ptions	- Recycl	ing plan	input (%	of coll	lection)	
Policy options - Collection rate (% of all spent NiCd batteries)	Separate collection target for small batteries (% of small spent batteries)		50%	- 60%	60%	- 70%	90% -	- 100%	909	% - 100% ·	(2)
		•	Min	Max	Min	Max	Min	Max	Mir	n Ma	ax
Baseline scenario	20% - 25%	€ / t collected					1105	1942			
(2007)	20% - 25%	€ cent / unit sold					1,1	1,9			
option 50 - 60% (1) for	40% - 50%	€ / t collected	1240	1640	1265	1685	1325	1845	866	1386	
all batteries containing Cd	40% - 50%	€ cent / unit sold	2,2	3	2,3	3	2,4	3,3		1,6	2,5
option 60-70% for all	50% - 60%	€ / t collected	2270	2 970	2290	3 012	2352	3 135	1293	2075	
batteries containing Cd	30% - 60%	€ cent / unit sold	5	6,5	5	6,6	5,2	6,9		2,8	4,6
option 70-80% for all	60% - 70%	€ / t collected	3 850	4485	3 870	4526	3 935	4650	1 375	2089	
batteries containing Cd	00% - 70%	€ cent / unit sold	10	11,7	10,1	11,8	10,2	12,1		3,6	5,4
option 80-90% for all	70% - 80%	€ / t collected	4351	4 936	4372	4 977	4435	5 100	1375	2040	
batteries containing Cd	1070 - 8070	€ cent / unit sold	13,1	14,8	13,1	14,9	13,3	15,3		4,1	6,1

- (1) Option not contained in the terms of reference, but presented here because cost evolution is interesting to show
- (2) Data for other recycling input plant rates can be found part 3.5.2.2.2 of the report

Separate collection

target for small

Scope:	All small	spent	batteries (2)
--------	-----------	-------	---------------

Policy options -

Collection rate (% of

all spent NiCd batteries)	batteries (% of small spent batteries)	
		•
Baseline scenario (2007)	20% - 25%	€ / t of spent batteries
option 50 - 60% (1) for all batteries containing Cd	40% - 50%	€ / t of spent batteries
option 60-70% for all batteries containing Cd	50% - 60%	€ / t of spent batteries
option 70-80% for all batteries containing Cd	60% - 70%	€ / t of spent batteries
option 80-90% for all batteries containing Cd	70% - 80%	€ / t of spent batteries
_	•	-

		sm	all spen	t batter		
l	Policy	y option		ction)	an input	. (% 01
	50%	- 60%	60%	- 70%	90% -	100%
İ	Min	Max	Min	Max	Min	Max
					342	530
	624	804	635	824	662	896
	1303	1688	1314	1711	1348	1778
	2545	2957	2558	2984	2600	3065
	3293	3732	3309	3763	3356	3855

- (1) Option not contained in the terms of reference, but presented here because cost evolution is interesting to show
- (2) Small spent batteries which are not collected separately are collected and disposed of with MSW at a cost of 120 € / tonne

Main conclusions about the cost for separate collection and recycling of portable batteries

Euros / tonne collected:

- A 10 point increase of recycling plant input (e.g. from 50-60% to 60-70%) results in an increase of 10 to 55 € / t collected, due to the fact that additional tons recycled are recycled at an average cost of 300-700 € / t of portable batteries entering a recycling plant (depending on the type of recycling technology and the economies of scale) instead of 90 € / t of batteries disposed of.
- For a constant recycling input plant, a 10 point increase of collection rate results in an increase of about 100-150 € / t collected for relatively low collection rates (e.g. 30 to 50% of sales), and more than 1000 € / t collected for high collection rates (from 50 to 100%). This is because of both communication and administration costs:
 - communication costs regularly increase as collection rate targeted increases. For example, to double collection rate from 30 to 60% of sales (45% to 85% of spent batteries available for collection with current level of hoarding), PR and communication budgets are estimated to be multiplied by 10 to avoid domestic hoarding (i.e. from 250 to 2500 € / t collected).
 - As for administration costs, economies of scale are observed until about 50 60% of collection rate, then a step of increase is considered being needed to ensure collection of higher quantities.

Overall budget concerned:

- In the baseline scenario 2007, a budget of 60 to 75 million Euros is already dedicated to separate collection and recycling of about 32-40 kt of portable batteries (collection rate of 20-25% of spent batteries).
- A target of 50-60% of spent batteries in the directive would require a budget of 215-285 million Euros, i.e. additional costs of 140-225 million Euros (extra costs are assessed at 345-420 million Euros in case of a 60-70% target and 475-570 million Euros for 70-80%).

Euros cents / unit sold:

- The collection and recycling cost in € cent / unit sold does not vary much function of recycling plant input rate, for a given collection rate (maximum 0.8 € cent / unit sold).
- For a given recycling plant input, costs vary from about 2 € cents / unit sold (30-40% collection rate) to 11 € cents / unit sold (60-70% collection rate) and about 17 € cents / unit sold (80-90% collection rate).
- Sale prices vary a lot for a same type of battery: from 0.6 to 1.5 € / unit for an alkaline battery for instance. Collection and recycling costs thus represent 1.5 to 25% of the sale price depending on the level of collection objective.
- Main conclusions about the cost for portable spent batteries collection and treatment

Compared to the baseline scenario (340-530 Euros / t of spent batteries), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is 2 times the baseline cost for 40-50% collection rate to more than 7 times for 70-80% collection rate.

Scheme 2 - Collection and Recycling of All Portable Batteries Economic Impacts of Policy Options Compared to Baseline Scenario

Scope: All small spent batteries

Policy options -

Collection rate (% of all spent NiCd batteries)	target for small batteries (% of small spent batteries)	
Baseline scenario (2007)	20% - 25%	€ / t of spent batteries
option 50 - 60% (1) for all batteries containing Cd	40% - 50%	€ / t of spent batteries
option 60-70% for all batteries containing Cd	50% - 60%	€ / t of spent batteries
option 70-80% for all batteries containing Cd	60% - 70%	€ / t of spent batteries
option 80-90% for all batteries containing Cd	70% - 80%	€ / t of spent batteries

Separate collection

Total collect		l treatm nt batter		ts for
Policy option		ycling pl ction)	an input	: (% of
50% - 60%	60%	- 70%	90% -	100%
Min Max	Min	Max	Min	Max
			342	530
		ne cost 5 to 2		
		ne cost to 4		
		ne cost to 7,5		
		ne cost to 10		

3.5.2.3 Economic Impacts for Scheme 3 - Collection of All Portable Batteries in View of Recycling Primarily NiCd

■ The difference considered here compared to the previous chapter is that only NiCd and other batteries which can be recycled at a low cost (even a 0 cost) are recycled.

It is considered that 15% of collected portable batteries are sent to recycling, at an average cost of 100 Euros / t with economies of scale (recycling cost = 0 Euros / t for 50-60% collection rate and above).

- Scheme 3 presents costs which are lower than scheme 2 of about 100-250 Euros /t.
- Compared to the baseline scenario (290-350 Euros / t of spent batteries), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is 2 times the baseline cost for 40-50% collection rate to 10 times for 70-80% collection rate.

Scheme 3 - Collection of All Portable Batteries in View of Recycling Primarily NiCd Economic Impacts of Policy Options

Scope: Small batteries separately collected

Separate collection

Policy options -

option 70-80% for all

Total collection and recycling costs = Costs paid for by producers in case of producer responsibility

Policy options - Recycling plan input (% of collection)

Collection rate (% of all spent NiCd batteries)	target for small batteries (% of small spent batteries)			15% (2)	
			Min	Ma	ax
Baseline scenario	20% - 25%	€ / t collected	890	1150	
(2007)	2070 2070	€ cent / unit sold		0,9	1,2
option 50 - 60% (1) for all batteries containing	40% - 50%	€ / t collected	1110	1310	
Cd	1070 0070	€ cent / unit sold		2	2,4
option 60-70% for all	50% - 60%	€ / t collected	2110	2 680	
batteries containing Cd	1	C 1 1 1	1	4.0	- 0

batteries containing Cd

option 80-90% for all batteries containing Cd

70% - 80%

€ cent / unit sold

€ / t collected

€ cent / unit sold

60% - 70%

€ cent / unit sold
€ / t collected
€ cent / unit sold
€ / t collected

0,9 1,2

1110 1310
2 2,4

2110 2680
4,6 5,8

3 690 4200
9,5 10,8

4190 4 650
12,5 13,8

Total collection and

treatment costs for small spent batteries

Policy options - Recycling plan input (% of collection)

15% (2)

Max

352

656

1528

2772

3518

Policy options - Collection rate (% of	Separate collection target for small
all spent NiCd	batteries (% of small
batteries)	spent batteries)

Scope: All small spent batteries (2)

all spent NiCd batteries)	batteries (% of small spent batteries)		
		•	Min
Baseline scenario (2007) (3)	20% - 25%	€ / t of spent batteries	293
option 50 - 60% (1) for all batteries containing Cd	40% - 50%	€ / t of spent batteries	566
option 60-70% for all batteries containing Cd	50% - 60%	€ / t of spent batteries	1215
option 70-80% for all batteries containing Cd	60% - 70%	€ / t of spent batteries	2441
option 80-90% for all batteries containing Cd	70% - 80%	€ / t of spent batteries	3173

⁽¹⁾ Option not contained in the terms of reference, but presented here because cost evolution is

⁽¹⁾ Option not contained in the terms of reference, but presented here because cost evolution is (2) Hypothesis: 15% of collected small batteries are NiCd and other batteries which can be recycled at

⁽²⁾ Hypothesis: 15% of collected small batteries are NiCd and other batteries which can be recycled at an average cost of 100 Euros / t with economies of scale (recycling cost = 0 Euros / t for 50-60% collection rate and above)

⁽²⁾ Small spent batteries which are not collected separately are collected and disposed of with MSW at a cost of 120 € / tonne

Scheme 3 - Collection of All Portable Batteries in View of Recycling Primarily NiCd Economic Impacts of Policy Options - Comparison with Baseline Scenario

Scope: All small s	pent batteries		treatment co	ection and osts for small patteries			
			, , .	ns - Recycling of collection)			
Policy options - Collection rate (% of all spent NiCd batteries)	Separate collection target for small batteries (% of small spent batteries)		1:	5%			
		I	Min	Max			
Baseline scenario (2007)	20% - 25%	€ / t of spent batteries	293	352			
option 50 - 60% for all batteries containing Cd	40% - 50%	€ / t of spent batteries	Baseline costs x 2				
option 60-70% for all batteries containing Cd	50% - 60%	€ / t of spent batteries		ne costs 4			
option 70-80% for all batteries containing Cd	60% - 70%	€ / t of spent batteries		ne costs			
option 80-90% for all batteries containing Cd	70% - 80%	€ / t of spent batteries	Baseline costs x 10				

3.5.3 Environmental Impacts

3.5.3.1 Introduction

3.5.3.1.1 Objective of This Chapter

The purpose of this section is to give an overview of the environmental impacts related to the various policy options under study.

As already introduced in the chapter relative to lead-acid automotive batteries, the control of hazardous substances, the principal objective which drives the policy options under study, will induce a change in the balance of environmental impacts. This change is due to additional recycling and collection activities which generate burdens on the one hand, and avoided impacts due to the savings of extraction, transport and processing or raw materials which generate benefits on the other hand.

The environmental impact assessment related to various policy options must therefore be based on a life cycle approach, in order to assess the overall balance between additional burdens and savings.

3.5.3.1.2 Previous Work

LCA of Recycling Portable NiCd batteries

The aim of this study³⁰ was to assess the environmental effects of recycling portable NiCd batteries in Sweden and to identify life cycle activities with significant environmental impacts. The assessment was made by varying recycling rates, using a life cycle inventory (LCI), which includes compiling an inventory of environmentally relevant inputs and outputs related to the functionality of a product. The functional unit of the study was defined as "a battery with an energy storage of 1.0 Wh electrical energy". This corresponds to a cylindrical NiCd battery with a mass of 25 g (40 Wh/kg), containing 16.4 % (weight) of Cadmium and 20.5% of Nickel. Hereafter, some important results of this study are detailed, after BIO recalculation in order to present the values for 1 kg of portable NiCd battery.

Emissions and resources use in the user phase of the battery were excluded from the study since they do not influence the materials management of metals for the functional unit chosen. Various kinds of end-of-life treatment (recycling, landfill and incineration) were considered.

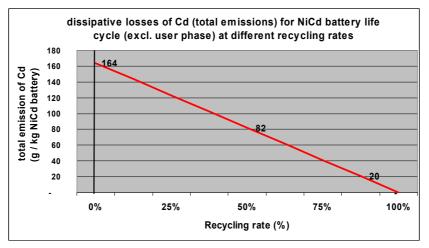
It was assumed that the NiCd batteries were manufactured in Germany and used in Sweden. Data on raw materials extraction and refining from cradle to gate are based on average data from manufacturers. Average transportation distances are estimated for materials production, collection and recycling of batteries in Sweden. Emissions from electricity generation (extraction, refining and combustion of duels) were calculated for base case based on country specific mix for electricity generation.

With respect to the collection stage, the transportation distances involved in collecting mixed household batteries from battery collection boxes and taking them to a central point within a municipality vary in the range 30 to 250 km (average 100 km) for the different municipalities in Sweden. After the sorting plant, the fraction of NiCd batteries is transported to cadmium recovery facility (AB SAFT) with an average distance of 600 km.

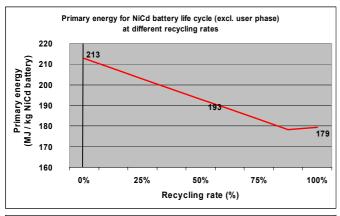
³⁰ Environmental assessment of battery systems in life cycle management, C.J. Rydh, Chalmers University of Technology, 2001 (thesis + paper submitted to Resources, conservation and Recycling)

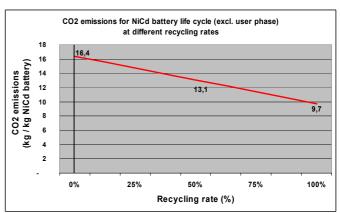
Recoverable materials (76wt.% of NiCd battery) are cadmium and nickel-iron scrap. The cadmium recovered is used in the production of new industrial NiCd batteries at SAFT, and nickel-iron scrap is sent to smelters for use as alloying metal in the steel industry. However, in this study, it was assumed that the cadmium recovered is used in the production of new portable batteries to avoid the use of different allocation procedures, which must be applied when recycling materials in cascade. As for the MSW fraction of NiCd batteries, it was assumed that 60% is incinerated and 40% is landfilled.

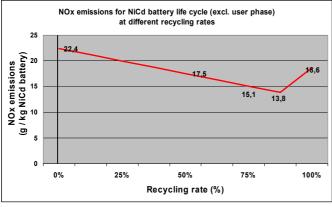
The following results represent selected inventory data for the NiCd batteries life cycle (excluding user phase), with different recycling rates (from 0 to 100%) in Sweden.

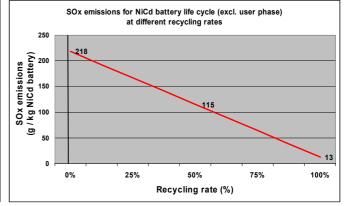


As recycling rates increase, the heavy metals in batteries are progressively diverted from waste. Clearly, this is most effective when the recycling rate is maximised.



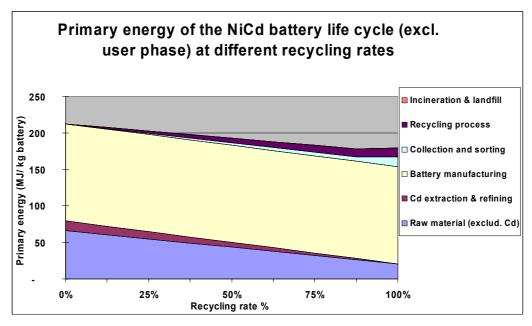






The figures show that increased recycling of NiCd batteries decreases the environmental impacts examined; thus, the predicted additional impacts due to separate collection (transports) are compensated by the avoided impacts due to the saving of extraction, transport and processing of raw materials. Consequently the overall environmental effects due to increased recycling rates are proved to be positive (environmental benefit). For instance, an increase in recycling rate from 0 to 90% decreases the total primary energy use by 17% (from 213 to 177 MJ/ kg NiCd battery³¹), the greenhouse warming potential by 36% (from 16.4 kg to 10.4 kg per kg NiCd battery), and the NOx emission by 39% (from 22.4 to 13.6 g / kg NiCd battery). With respect to NOx emission, the contribution of transportation and sorting increases from 7.5% to 53%. The minimum total NOx emission (and energy consumption) is found at a 90% recycling rate since it is modelled that increased local truck transportation for collection is needed to achieve very high collection rates. The minimum is due to the fact that recycled materials and longer transportation distances have less impact than extraction and refining of virgin materials³². At recycling rates greater than 90%, local transport for emptying collection boxes and delivery of batteries to sorting plants increase rapidly.

The following figure details the contribution of the different life cycle activities to the total primary energy use. Considering an increase in recycling rate from 0 to 90%, collection and sorting energy increases from 0.6% to 5% as a percentage of the total energy use, while energy use in raw materials production decreases from 36% to 15%. By using recycled metals, the energy for the processing of battery raw materials is reduced by 65% compared with virgin materials only. Energy use in the battery manufacturing activity remains constant irrespective of the recycling rate.



Quantification of the primary energy requirements for recycled metals relies on estimates and the values may vary depending on the system boundaries chosen. Lankey (1998) estimated the energy required for manufacture of batteries with recycled materials to be approximately half the energy

The author proved that compared to the country specific electricity mix used in the study, primary energy use is reduced by half or doubled depending on the energy conversion efficiencies of the different power sources (half if all electricity is generated by hydropower; doubled if all electricity is generated by coal). Therefore, the absolute values given by the study must be considered as country-specific, but the trends shown in the study may be considered valid at the EU level.

The average primary energy use for extraction and refining of cadmium (from zinc mining) and nickel was estimated at 70 MJ/ kg Cd and 159 MJ/ kg Ni respectively. The primary energy requirements for manufacturing processes of batteries produced in Germany were calculated to be 140 MJ/kg battery. For comparison, transportation requires around 1.6 MJ / txkm.

needed to manufacture batteries using only primary materials³³. In this study, the energy reduction was calculated to be 16%.

Extrapolation at the EU level: uncertainties in the results depend on the choice of methodology and data source. Choices in methodology that could affect the results are modelling of cadmium and nickel as closed-loop recycling, recycling of steel, choice of model for electricity production. Uncertain data values include assumptions about load factor for trucks and transport distances. Sensitivity analyses have, however, shown that these parameters are of minor importance in the final result. The absolute values may be distorted by methodological choices and data values but the identified trends will remain the same.

The ERM studies

A study published by the Department of Trade & Industry (DTI) in November 2000 ("Analysis of the environmental impact and financial costs of a possible new European directive on batteries"), using Life Cycle Assessment (LCA) methodology, concluded, that the collection of all batteries would cause additional environmental impacts instead of improving the environmental situation. The reason for this is simply because the emissions due to collection and transportation would more than cancel out the positive environmental benefit from the recycling of batteries.

From a strictly LCA point of view such a conclusion is very singular, since all the LCA studies published hitherto with respect to a wide variety of products and waste management systems, have generally concluded that the environmental impacts due to transport are of second order by comparison with the other life cycle stages.

In addition to this point, we were not able to include the results of the ERM study in the own calculations we performed in this study because:

- no life cycle inventory data (background data) were available in the report version we got,
- no hypotheses about save ratio (i.e. the quantity of virgin material saved per kg of material recovered) were found,
- not enough explanation about other main hypotheses were found...

Another ERM study was published by EPBA in August 2001: "Assessment of the environmental impacts associated with the transport of waste batteries in Europe". In this study, the LCA methodology was applied and background data and assumptions are transparent enough. Therefore, we have used hereafter the data presented in this study.

We were thus able to integrate some data from this study on our calculation.

Conclusion

The conclusions from the first ERM study are not suitable for the present work. It is thus necessary to perform new calculations, based on well sound data. Only two sources of data can be used:

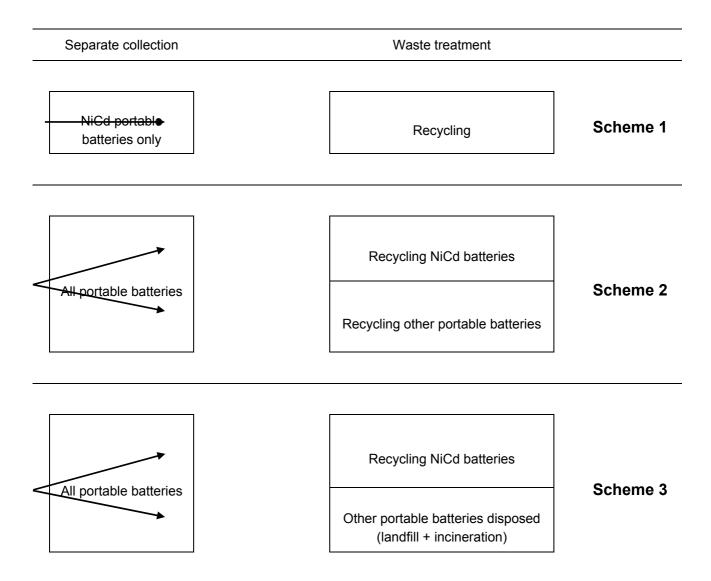
- Environmental assessment of battery systems in life cycle management, C.J. Rydh (2001)
- Assessment of the environmental impacts associated with the transport of waste batteries in Europe, ERM for EPBA (august 2001).

Lankey (in Lankey R., 1998. Materials management and recycling for nickel-cadmium batteries. Ph.D thesis, Carnegie Mellon University, Aug. Dept. Civil Envir. Engin.) claims that 190 MJ/kg is needed for virgin cadmium production and 22 MJ/kg for recycled cadmium. However, these data are uncertain since they are based on theoretical calculations and allocation principles, and the use of different energy carriers was not explained.

With respect to the recycling of general purpose batteries, no available LCA studies were identified. Due to this lack of data, it is not possible to describe the environmental consequences due to the separate collection and recycling of all the portable batteries (NiCd and other portable batteries). Nevertheless, a judicious combining of the only two available source of data will permit interesting computations, as described hereafter.

3.5.3.2 Methodology

Environmental profile of the separate collection and recycling of portable NiCd batteries was assessed by considering the three organisation schemes introduced above in the report.

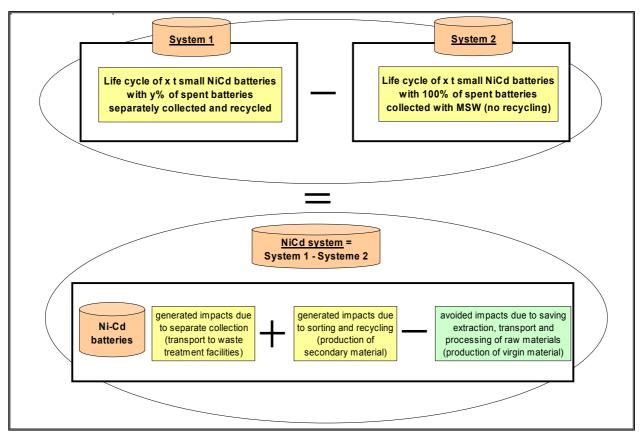


In assessing the environmental burdens and impacts associated with potential battery collection schemes, a number of individual systems were considered. For each of these, Life Cycle Assessment (LCA) was used to calculate the impacts associated with the collection schemes, as described hereafter.

Scheme 1 - Collection and recycling of NiCd Portable Batteries only

The Model system

In the objective of calculating the environmental impacts associated with the separate collection and recycling of portable NiCd batteries only (e.g. all other portable batteries are collected with MSW then disposed), the following system was considered in a life cycle assessment approach.



A 'differential' approach was adopted between a baseline (system 2) in which there is no separate collection of portable NiCd batteries (and no recovery of materials from batteries) and a range of collection rates with associated recovery of materials (system 1). This approach enables the evaluation of the environmental impacts of the various policy options under study (by taking the corresponding value of y% in system 1), by comparison with a common system (system 2). As system 2 is the same in every scenario, it is therefore possible to compare the environmental impacts of the various policy options considered.

■ Data used for impact assessment

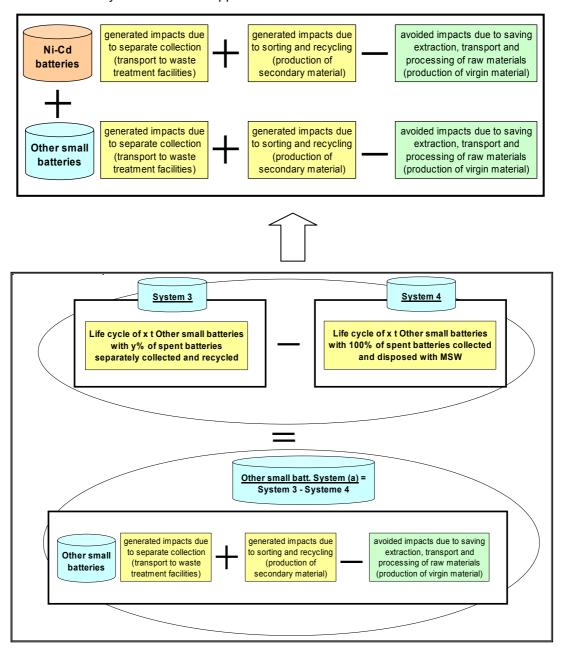
From the study: "Environmental assessment of battery systems in life cycle management", (C.J. Rydh, 2001), we were able to directly derive the life cycle inventory of both system 1 (with recycling in dedicated plants; no data available for recycling in metal plants) and system 2. We used the original data without any further modification.

We assumed that 100% of the batteries collected are recycled (i.e. recycling plant input is 100%).

Scheme 2 - COLLECTION OF ALL PORTABLE BATTERIES (INCLUDE. NI-CD) IN VIEW OF RECYCLING

■ The Model system

In the objective of calculating the environmental impacts associated with the separate collection and recycling of all portable batteries (e.g. NiCd and other portable batteries), the following system has to be considered in a life cycle assessment approach.



The model system is composed of two sub-systems. The first one (NiCd batteries) is the same than the one used above to describe scheme 1 (collection and recycling of NiCd only). The second one (other portable batteries) was also designed within a 'differential' approach between a baseline (system 4) in which there is no separate collection of other portable batteries (and no recovery of materials from batteries), and a range of collection rates with associated recovery of materials (system 3). This approach considers that the two sub-systems (NiCd on the one hand, all other portable batteries on the other hand) are independent, although actually both collection systems may operate together. Thus, this approach is likely to minimise the environmental savings due to synergy in collection and transport activities.

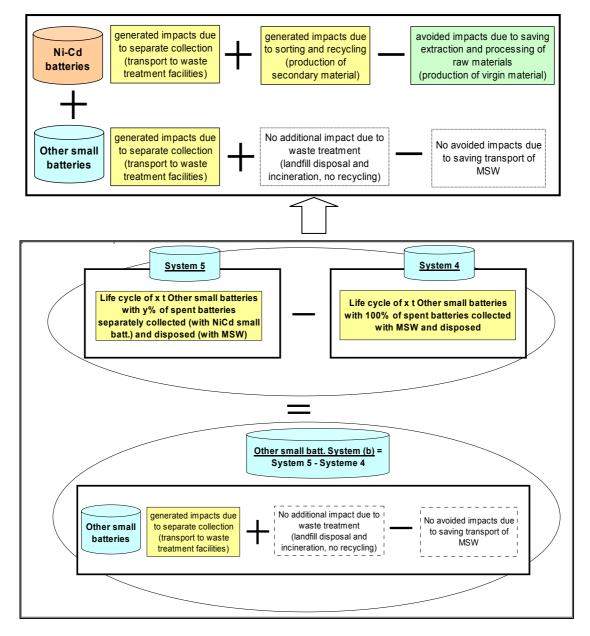
Available data for impact assessment

With respect to the recycling of portable batteries other than NiCd, no available LCA studies were identified. As stated above, due to this lack of data, it is not possible to describe the environmental consequences due to the separate collection and recycling of all the portable batteries (NiCd and other portable batteries). Therefore, no assessment was performed with respect to scheme 2 (separate collection and recycling of all portable batteries).

Scheme 3 - COLLECTION OF ALL PORTABLE BATTERIES IN VIEW OF RECYCLING NICD ONLY

The Model system

In the objective of calculating the environmental impacts associated with the separate collection of all portable batteries (e.g. NiCd and other portable batteries) and recycling of NiCd batteries only (e.g. all other portable batteries disposed with MSW), the following system was considered in a life cycle assessment approach:



The model system is composed of two sub-systems. The first one (NiCd batteries) is the same than the one used above to describe scheme 1 (collection and recycling of NiCd only). The second one (other portable batteries) was also designed within a 'differential' approach between a baseline (system 4) in which there is no separate collection of other portable batteries and no recovery of materials from batteries, and a range of separate collection rates (and no recovery of materials from batteries) (system 5). As shown in the figure, the difference between system 5 and system 4 may be reduced to the separate collection of other portable batteries (no change neither in the waste treatment nor in the MSW transport since batteries represent less than 0,07% of the total mass of MSW). Consequently, the sub-system was assessed by using transport data from the ERM study.

This approach considers that the two sub-systems (NiCd on the one hand, all other portable batteries on the other hand) are independent, although actually both collection systems may operate together. Thus, this approach is likely to at least minimise environmental savings due to synergy in collection and transport activities.

Data used for impact assessment

Results from scheme 1 were used to assess the NiCd sub-system. From the study "Assessment of the environmental impacts associated with the transport of waste batteries in Europe" (ERM for EPBA, august 2001), we directly derived the life cycle inventory of the other portable batteries sub-system (system 5 – system 4). Therefore, we used the original assumptions (transport distances with respect to the Europe Kerbside - 500 km scenario, emission factors related to 16 t truck) without any further modification.). However, ERM data used for emission factors about transport are 5 times lower than data currently used by most of LCA studies. To obtain more reliable figures, further LCA work would be necessary.

We assumed that 100% of the batteries collected are recycled (i.e. recycling plant input is 100%).

3.5.3.3 Results

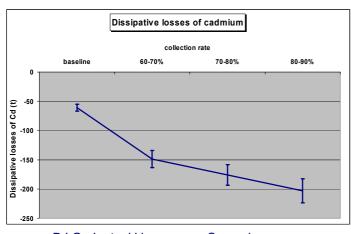
Scheme 1 - COLLECTION AND RECYCLING OF PORTABLE NICD BATTERIES ONLY

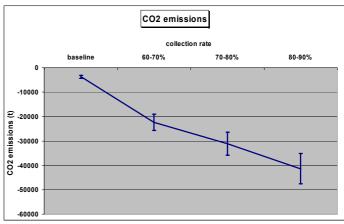
The following table gives results of the environment assessment of various policy options related to separate collection and recycling of portable NiCd batteries only (e.g. other portable batteries are collected with MSW then disposed), within a life cycle perspective. Negative values mean an avoided impact (i.e. environmental benefit) by comparison with the baseline system (system 2 above) with no recycling.

(Scheme 1)			separately es on the c				Tota	l e	nviror	onmental impacts of the waste management system (scheme 1) for spent Ni-Cd, at the UE level												
Policy option - Collection rate (% of spent batteries containing Cd)		t small teries	separate collection rate			batteries collected		•	ative of Cd	CO2 e	mis	ssions	SOx e	mis	ssions		NO iss	x ions	Primai cons	-		
Current situation	Ni-Cd	10 500 t	15% - 20% (a)	1 575 t	to	2 100 t	-39 t	to	-52 t	-1 575 t	to	-2 800 t	-49 t	to	-86 t	-2,3 t	to	-4,1 t	-9 334 GJ	to	-16 595 GJ	
Baseline scenario (2007)	Ni-Cd	11 000 t	20% - 25% (a)	2 200 t	to	2 750 t	-54 t	to	-68 t	-2 933 t	to	-4 583 t	-90 t	to	-141 t	-4 t	to	-7 t	-17 385 GJ	to	-27 164 GJ	
option 60-70% for all batteries containing Cd (=50- 60% for small NiCd batteries)	Ni-Cd	11 000 t	50% - 60% (b)	5 500 t	to	6 600 t	-135 t	to	-162 t	-18 333 t	to	-26 400 t	-565 t	to	-813 t	-27 t	to	-39 t	-108 656 GJ	to	-156 464 GJ	
option 70-80% for all batteries containing Cd (=60- 70% for small NiCd batteries)	Ni-Cd	11 000 t	60% - 70% (b)	6 600 t	to	7 700 t	-162 t	to	-189 t	-26 400 t	to	-35 933 t	-813 t	to	-1 107 t	-39 t	to	-53 t	-156 464 GJ	to	-212 965 GJ	
option 80-90% for all batteries containing Cd (=70- 80% for small NiCd batteries)		11 000 t	70% - 80% (b)	7 700 t		8 800 t	-189 t	to	-216 t	-35 933 t	to	-46 933 t	-1 107 t	to	-1 265 t	-53 t	to	-60 t	-212 965 GJ	to	-278 158 GJ	

(hypothesis: 100% of the separately collected batteries are recycled)

All the values are negative, indicating that the separate collection and recycling of portable NiCd batteries has positive environmental consequences for all the environmental indicators examined, irrespective of the collection and recycling rates. As indicated in the following figures, as collection and recycling rates increase, the predicted environmental benefits are maximised.





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In the two following tables, the former results are expressed for 1 ton of collected NiCd batteries, and for 1 ton of spent portable NiCd batteries. These values are thus independent from the assumption used to estimate the quantities of spent batteries in 2007.

Scheme 1 - COLLECTION AND RECYCLING OF PORTABLE NICD BATTERIES ONLY

(Scheme 1)				Environmen	tal im	pa	cts expressed	for	1	t of collected I	Ni-C	d	small batterie	s (N	i-C	Cd only)
Policy option - Collection rate (% of spent batteries containing Cd)	Small batteries	dis	ssip	pative losses of Cd		cc	02 emissions		s	Ox emissions		NO	Ox emissions			imary energy onsumption
Current situation	Ni-Cd	-25	to	-25 kg / t collected	-1 000	to	-1 333 kg / t collected	-31	to	o -41 kg / t collected	-1,5	to	-2,0 kg / t collected	-6	to	-8 GJ / t collected
Baseline scenario (2007)	Ni-Cd	-25	to	-25 kg / t collected	-1 333	to	-1 667 kg / t collected	-41	tc	51 kg / t collected	-2,0	to	-2,4 kg / t collected	-8	to	-10 GJ / t collected
option 60-70% for all batteries containing Cd (=50-60% for small NiCd batteries)	Ni-Cd	-25	to	-25 kg / t collected	-3 333	to	-4 000 kg / t collected	-103	tc	-123 kg / t collected	-5	to	-6 kg / t collected	-20	to	-24 GJ / t collected
option 70-80% for all batteries containing Cd (=60-70% for small NiCd batteries)	Ni-Cd	-25	to	-25 kg / t collected	-4 000	to	-4 667 kg / t collected	-123	tc	a -144 kg / t collected	-6	to	-7 kg / t collected	-24	to	-28 GJ / t collected
option 80-90% for all batteries containing Cd (=70-80% for small NiCd batteries)	Ni-Cd	-25	to	-25 kg / t collected	-4 667	to	-5 333 kg / t collected	-144	tc	o -144 kg / t collected	-7	to	-7 kg / t collected	-28	to	-32 GJ / t collected

(Scheme 1)				Envi	ro	nmental impacts e	xpre	SS	sed for 1 t of spen	t N	i-C	d small batteries		
Policy option - Collection rate (% of spent batteries containing Cd)	Small batteries	dis	sipative losses of Cd			CO2 emissions			SOx emissions			NOx emissions	Pri	imary energy consumption
Current situation	Ni-Cd	-4 to	-5 kg / t spent NiCd batt.	-150	to	-267 kg / t spent NiCd batt.	-5	to	-8 kg / t spent NiCd batt.	-0,2	2 to	o -0,4 kg / t spent NiCd batt.	-0,9	to -1,6 GJ / t spent NiCd batt.
Baseline scenario (2007)	Ni-Cd	-4,9 to	-6,2 kg / t spent NiCd batt.	-267	to	-417 kg / t spent NiCd batt.	-8	to	-13 kg / t spent NiCd batt.	-0,4	1 to	o -0,6 kg / t spent NiCd batt.	-1,6	to -2,5 GJ / t spent NiCd batt.
option 60-70% for all batteries containing Cd (=50-60% for small NiCd batteries)	Ni-Cd	-12,3 to	-14,8 kg / t spent NiCd batt.	-1 667	to	-2 400 kg / t spent NiCd batt.	-51	to	-74 kg / t spent NiCd batt.	-2,4	4 to	o -3,5 kg / t spent NiCd batt.	-10	to -14 GJ / t spent NiCd batt.
option 70-80% for all batteries containing Cd (=60-70% for small NiCd batteries)	Ni-Cd	-14,8 to	-17,2 kg / t spent NiCd batt.	-2 400	to	-3 267 kg / t spent NiCd batt.	-74	to	-101 kg / t spent NiCd batt.	-3,8	5 to	-4,8 kg / t spent NiCd batt.	-14	to -19 GJ / t spent NiCd batt.
option 80-90% for all batteries containing Cd (=70-80% for small NiCd batteries)	Ni-Cd	-17,2 to	-19,7 kg / t spent NiCd batt.	-3 267	to	-4 267 kg / t spent NiCd batt.	-101	to	-115 kg / t spent NiCd batt.	-4,8	3 to	-5,5 kg / t spent NiCd batt.	-19	to -25 GJ / t spent NiCd batt.

Scheme 3 - COLLECTION OF ALL PORTABLE BATTERIES IN VIEW OF RECYCLING NICD ONLY

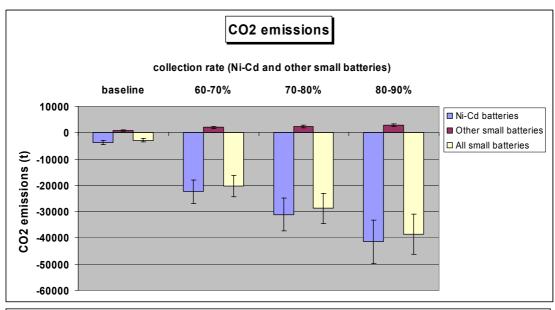
The following table gives results of the life cycle assessment of various policy options related to the separate collection of all portable batteries and recycling of portable NiCd batteries only (e.g. other portable batteries are disposed of with MSW). For each policy option, three datasets are given: the first line details results for the NiCd batteries fraction; the second line details results for the other portable batteries fraction (separate collection and transport to landfill or incineration plant); the last line details overall results for all portable batteries (line 1 + line 2).

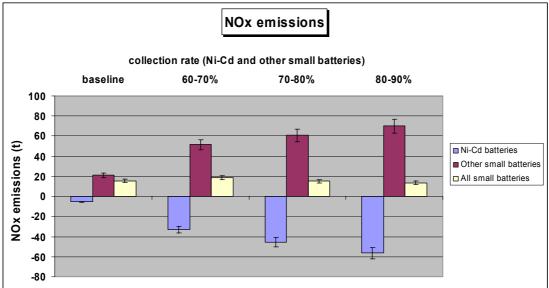
Reminder: negative values = avoided impacts = environmental benefit ; positive values = additional burdens = environmental damage

(scheme 3)			separately on the com				Total	er	nviron			pacts o				•			ystem for vel	sp	ent Ni-Cd
Policy option - Collection rate (% of spent batteries containing Cd)		nt small teries	separate collection rate	small separate		teries collected	diss	•		CO2 (emi	ssions	SOx	emis	sions		NO: issi	x ons	1	-	nergy ption
	Ni-Cd	10 500 t		1 575 t	to	2 100 t	-39 t	to	-52 t	-1 575 t	to	-2 800 t	-49 t	to	-86 t	-2,3 t	to	-4,1 t	-9 334 GJ	to	-16 595 GJ
Current situation	Others	142 000 t	15% - 20% (a)	21 300 t	to	28 400 t	0 t	to	0 t	535 t	to	713 t	1,2 t	to	2 t	13 t	to	18 t	12 137 GJ	to	16 182 GJ
	Total	152 500 t		22 875 t	to	30 500 t	-39 t	to	-52 t	-1 040 t	to	-2 087 t	-47 t	to	-85 t	11 t	to	14 t	2 802 GJ	to	-412 GJ
	Ni-Cd	11 000 t		2 200 t	to	2 750 t	-54 t	to	-68 t	-2 933 t	to	-4 583 t	-90 t	to	-141 t	-4 t	to	-7 t	-17 385 GJ	to	-27 164 GJ
Baseline scenario (2007)	Others	150 000 t	20% - 25% (a)	30 000 t	to	37 500 t	0 t	to	0 t	754 t	to	942 t	2 t	to	2 t	19 t	to	23 t	17 094 GJ	to	21 368 GJ
	Total	161 000 t		32 200 t	to	40 250 t	-54 t	to	-68 t	-2 180 t	to	-3 641 t	-89 t	to	-139 t	14 t	to	17 t	-291 GJ	to	-5 796 GJ
option 60-70% for all batteries	Ni-Cd	11 000 t		5 500 t	to	6 600 t	-135 t	to	-162 t	-18 333 t	to	-26 400 t	-565 t	to	-813 t	-27 t	to	-39 t	-108 656 GJ	to	-156 464 GJ
containing Cd (=50- 60% for small NiCd	Others	150 000 t	50% - 60% (b)	75 000 t	to	90 000 t	0 t	to	0 t	1 884 t	to	2 261 t	4 t	to	5 t	47 t	to	56 t	42 735 GJ	to	51 282 GJ
batteries)	Total	161 000 t		80 500 t	to	96 600 t	-135 t	to	-162 t	-16 449 t	to	-24 139 t	-560 t	to	-808 t	20 t	to	17 t	-65 921 GJ	to	-105 182 GJ
option 70-80% for	Ni-Cd	11 000 t		6 600 t	to	7 700 t	-162 t	to	-189 t	-26 400 t	to	-35 933 t	-813 t	to	-1 107 t	-39 t	to	-53 t	-156 464 GJ	to	-212 965 GJ
all batteries containing Cd (=60-	Others	150 000 t	60% - 70% (b)	90 000 t	to	105 000 t	0 t	to	0 t	2 261 t	to	2 638 t	5 t	to	6 t	56 t	to	65 t	51 282 GJ	to	59 829 GJ
70% for small NiCd batteries)	Total	161 000 t		96 600 t	to	112 700 t	-162 t	to	-189 t	-24 139 t	to	-33 295 t	-808 t	to	-1 101 t	17 t	to	13 t	-105 182 GJ	to	-153 136 GJ
option 80-90% for	Ni-Cd	11 000 t		7 700 t	to	8 800 t	-189 t	to	-216 t	-35 933 t	to	-46 933 t	-1 107	t to	-1 265 t	-53 t	to	-60 t	-212 965 GJ	to	-278 158 GJ
all batteries containing Cd (=70-	Others	150 000 t	70% - 80% (b)	105 000 t	to	120 000 t	0 t	to	0 t	2 638 t	to	3 015 t	6 t	to	7 t	65 t	to	75 t	59 829 GJ	to	68 376 GJ
80% for small NiCd batteries)	Total	161 000 t		112 700 t	to	128 800 t	-189 t	to	-216 t	-33 295 t	to	-43 919 t	-1 101	t to	-1 258 t	13 t	to	15 t	-153 136 GJ	to	-209 782 GJ

(hypothesis: 100% of the separately collected batteries are recycled)

With respect to all portable batteries, most values are negative, indicating that the separate collection of portable batteries in view of recycling portable NiCd batteries only (other portable batteries are disposed of) has positive environmental consequences for most of environmental indicators examined (CO2 emissions, SOx emissions, primary energy use), irrespective of the collection and recycling rates. However, positive values for NOx emission indicate an environmental damage due to the collection scheme; but as collection rate increases, the NOx emissions progressively decrease (because the avoided emissions due to the NiCd recycling compensate the generated emissions due to additional transport). As indicated in the following figures, as collection rate increases, the predicted environmental benefits are maximised.





Above figures show that conclusions about CO2 emissions are very robust: the absolute values for each sub-system (separate collection and recycling of NiCd batteries on the one hand, and separate collection and disposal of other portable batteries on the other hand) may be distorted by methodological choices and data values but the identified trends will remain the same (avoided impact due to NiCd recycling is more than ten fold higher than generated emissions caused by the transport of other portable batteries).

On the contrary, conclusions about NOx emission are less robust since avoided emissions due to recycling activities are of the same order of magnitude than additional emissions associated with battery collection.

Scheme 3 - COLLECTION OF ALL PORTABLE BATTERIES IN VIEW OF RECYCLING NICD ONLY

In the two following tables, the former results are expressed for 1 ton of portable batteries collected, and for 1 ton of spent portable batteries. These values are thus independent from the assumption used to estimate the quantities of spent batteries in 2007.

(scheme 3)		Enviro	nmental impacts expres	sed for 1 t of collected	d small batteries (Ni-C	d + other)
Policy option - Collection rate (% of spent batteries containing Cd)	Small batteries	dissipative losses of Cd	CO2 emissions	SOx emissions	NOx emissions	Primary energy consumption
	Ni-Cd	-25 to -25 kg / t collected (1)	-1 000 to -1 333 kg / t collected (1)	-31 to -41 kg / t collected (1)	-1,5 to -2 kg / t collected (1)	-6 to -8 GJ / t collected (1)
Current situation	Others	0 to 0 kg / t collected (2)	25 to 25 kg / t collected (2)	0,06 to 0,06 kg / t collected (2)	0,6 to 0,6 kg / t collected (2)	0,6 to 0,6 GJ / t collected (2)
	Total	-2 to -1,7 kg / t collected (3)	-45 to -68 kg / t collected (3)	-2,1 to -2,8 kg / t collected (3)	0,5 to 0,4 kg / t collected (3)	0,1 to -0,01 GJ / t collected (3)
	Ni-Cd	-25 to -25 kg / t collected (1)	-1 333 to -1 667 kg / t collected (1)	-41 to -51 kg / t collected (1)	-2,0 to -2,4 kg / t collected (1)	-8 to -10 GJ / t collected (1)
Baseline scenario (2007)	Others	0 to 0 kg / t collected (2)	25 to 25 kg / t collected (2)	0,06 to 0,06 kg / t collected (2)	0,6 to 0,6 kg / t collected (2)	0,6 to 0,6 GJ / t collected (2)
	Total	-2 to -1,7 kg / t collected (3)	-68 to -90 kg / t collected (3)	-2,8 to -3,5 kg / t collected (3)	0,45 to 0,41 kg / t collected (3)	-0,01 to -0,1 GJ / t collected (3)
option 60-70% for all batteries	Ni-Cd	-25 to -25 kg / t collected (1)	-3 333 to -4 000 kg / t collected (1)	-103 to -123 kg / t collected (1)	-5 to -6 kg / t collected (1)	-20 to -24 GJ / t collected (1)
containing Cd (=50- 60% for small NiCd	Others	0 to 0 kg / t collected (2)	25 to 25 kg / t collected (2)	0,06 to 0,06 kg / t collected (2)	0,6 to 0,6 kg / t collected (2)	0,6 to 0,6 GJ / t collected (2)
batteries)	Total	-2 to -1,7 kg / t collected (3)	-204 to -250 kg / t collected (3)	-7,0 to -8,4 kg / t collected (3)	0,25 to 0,18 kg / t collected (3)	-0,8 to -1,1 GJ / t collected (3)
option 70-80% for all batteries	Ni-Cd	-25 to -25 kg / t collected (1)	-4 000 to -4 667 kg / t collected (1)	-123 to -144 kg / t collected (1)	-6 to -7 kg / t collected (1)	-24 to -28 GJ / t collected (1)
containing Cd (=60-	Others	0 to 0 kg / t collected (2)	25 to 25 kg / t collected (2)	0,06 to 0,06 kg / t collected (2)	0,6 to 0,6 kg / t collected (2)	0,6 to 0,6 GJ / t collected (2)
70% for small NiCd batteries)	Total	-2 to -1,7 kg / t collected (3)	-250 to -295 kg / t collected (3)	-8,4 to -9,8 kg / t collected (3)	0,18 to 0,11 kg / t collected (3)	-1,1 to -1,4 GJ / t collected (3)
option 80-90% for	Ni-Cd	-25 to -25 kg / t collected (1)	-4 667 to -5 333 kg / t collected (1)	-144 to -144 kg / t collected (1)	-7 to -7 kg / t collected (1)	-28 to -32 GJ / t collected (1)
all batteries containing Cd (=70-	Others	0 to 0 kg / t collected (2)	25 to 25 kg / t collected (2)	0,06 to 0,06 kg / t collected (2)	0,6 to 0,6 kg / t collected (2)	0,6 to 0,6 GJ / t collected (2)
80% for small NiCd batteries)	Total	-2 to -1,7 kg / t collected (3)	-295 to -341 kg / t collected (3)	-9,8 to -9,8 kg / t collected (3)	0,11 to 0,11 kg / t collected (3)	-1,4 to -1,6 GJ / t collected (3)
(1) : per ton collected of	Ni-Cd batterie	s; (2): per ton collected of other sr	nall batteries; (3): per ton collected of sma	III batteries		

(scheme 3)		E	nvironmental impacts expi	ressed for 1 t of spent s	mall batteries (Ni-Cd + c	other)
Policy option - Collection rate (% of spent batteries containing Cd)	Small batteries	dissipative losses of Cd	CO2 emissions	SOx emissions	NOx emissions	Primary energy consumption
	Ni-Cd	-4 to -5 kg / t spent NiCd batt.	-150 to -267 kg / t spent NiCd batt.	-5 to -8 kg / t spent NiCd batt.	-0,2 to -0,4 kg / t spent NiCd batt.	-0,9 to -1,6 GJ / t spent NiCd batt.
Current situation	Others	0 to 0 kg / t spent other batt.	4 to 5 kg / t spent other batt.	0,01 to 0,01 kg / t spent other batt.	0,09 to 0,12 kg / t spent other batt.	0,09 to 0,11 GJ / t spent other batt.
	Total	-0,3 to -0,3 kg / t spent small batt.	-7 to -14 kg / t spent small batt.	-0,3 to -0,6 kg / t spent small batt.	0,07 to 0,09 kg / t spent small batt.	0,02 to -0,003 GJ / t spent small batt.
	Ni-Cd	-5 to -6 kg / t spent NiCd batt.	-267 to -417 kg / t spent NiCd batt.	-8 to -13 kg / t spent NiCd batt.	-0,4 to -0,6 kg / t spent NiCd batt.	-1,6 to -2,5 GJ / t spent NiCd batt.
Baseline scenario (2007)	Others	0 to 0 kg / t spent other batt.	5 to 6 kg / t spent other batt.	0,01 to 0,01 kg / t spent other batt.	0,12 to 0,16 kg / t spent other batt.	0,11 to 0,14 GJ / t spent other batt.
	Total	-0,3 to -0,4 kg / t spent small batt.	-14 to -23 kg / t spent small batt.	-0,6 to -0,9 kg / t spent small batt.	0,09 to 0,10 kg / t spent small batt.	-0,002 to -0,04 GJ / t spent small batt.
option 60-70% for all batteries	Ni-Cd	-12 to -15 kg / t spent NiCd batt.	-1 667 to -2 400 kg / t spent NiCd batt.	-51 to -74 kg / t spent NiCd batt.	-2,4 to -3,5 kg / t spent NiCd batt.	-10 to -14 GJ / t spent NiCd batt.
containing Cd (=50- 60% for small NiCd	Others	0 to 0 kg / t spent other batt.	13 to 15 kg / t spent other batt.	0,03 to 0,03 kg / t spent other batt.	0,3 to 0,4 kg / t spent other batt.	0,28 to 0,34 GJ / t spent other batt.
batteries)	Total	-0,8 to -1,0 kg / t spent small batt.	-102 to -150 kg / t spent small batt.	-3,5 to -5,0 kg / t spent small batt.	0,12 to 0,11 kg / t spent small batt.	-0,4 to -0,7 GJ / t spent small batt.
option 70-80% for	Ni-Cd	-15 to -17 kg / t spent NiCd batt.	-2 400 to -3 267 kg / t spent NiCd batt.	-74 to -101 kg / t spent NiCd batt.	-3,5 to -4,8 kg / t spent NiCd batt.	-14 to -19 GJ / t spent NiCd batt.
containing Cd (=60- 70% for small NiCd	Others	0 to 0 kg / t spent other batt.	15 to 18 kg / t spent other batt.	0,03 to 0,04 kg / t spent other batt.	0,37 to 0,44 kg / t spent other batt.	0,34 to 0,40 GJ / t spent other batt.
batteries)	Total	-1,0 to -1,2 kg / t spent small batt.	-150 to -207 kg / t spent small batt.	-5,0 to -6,8 kg / t spent small batt.	0,11 to 0,08 kg / t spent small batt.	-0,7 to -1,0 GJ / t spent small batt.
option 80-90% for all batteries	Ni-Cd	-17 to -20 kg / t spent NiCd batt.	-3 267 to -4 267 kg / t spent NiCd batt.	-101 to -115 kg / t spent NiCd batt.	-4,8 to -5,5 kg / t spent NiCd batt.	-19 to -25 GJ / t spent NiCd batt.
containing Cd (=70- 80% for small NiCd	Others	0 to 0 kg / t spent other batt.	18 to 20 kg / t spent other batt.	0,04 to 0,04 kg / t spent other batt.	0,44 to 0,50 kg / t spent other batt.	0,40 to 0,46 GJ / t spent other batt.
batteries)	Total	-1,2 to -1,3 kg / t spent small batt.	-207 to -273 kg / t spent small batt.	-6,8 to -7,8 kg / t spent small batt.	0,08 to 0,09 kg / t spent small batt.	-1,0 to -1,3 GJ / t spent small batt.

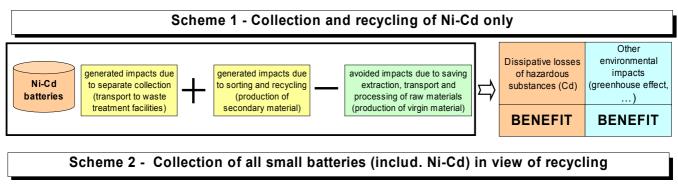
In the two following tables, the difference between the studied options and the baseline scenario is presented. In the first table, results are detailed for the total waste arisings in EU; in the second table, results are expressed for 1 ton of portable batteries collected, and for 1 ton of spent portable batteries.

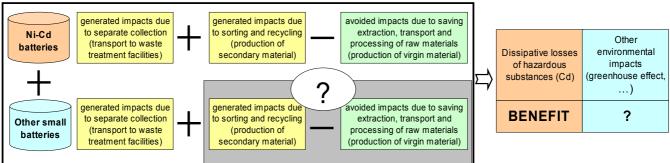
Scheme 3 - COLLECTION OF ALL PORTABLE BATTERIES IN VIEW OF RECYCLING NICD ONLY

(scheme 3)	Spent and s		-		Total additional environmental benefits and damage (by comparison with the baseline scenario) of the waste management system for spent Ni-Cd and other small batteries, at the UE level														
Policy option - Collection rate (% of spent batteries containing Cd)	spent small batteries (total)			teries collected		ative of C	e losses d	CO2 e	mi	ssions	SOx e	mi	ssions	NOx	emi	ssions	Primar cons	•	
option 60-70% for all batteries containing Cd (=50- 60% for small NiCd batteries)	161 000 t	80 500 t	to	96 600 t	-81 t	to	-95 t	-14 269 t	to	-20 498 t	-472 t	to	-669 t	5 t	to	1 t	-65 630 GJ	to	-99 386 GJ
option 70-80% for all batteries containing Cd (=60- 70% for small NiCd batteries)	161 000 t	96 600 t	to	112 700 t	-108 t	to	-122 t	-21 959 t	to	-29 654 t	-719 t	to	-962 t	3 t	to	-4 t	-104 891 GJ	to	-147 340 GJ
option 80-90% for all batteries containing Cd (=70- 80% for small NiCd batteries)	161 000 t	112 700 t	to	128 800 t	-135 t	to	-149 t	-31 116 t	to	-40 277 t	-1 012 t	to	-1 119 t	-2 t	to	-2 t	-152 845 GJ	to	-203 986 GJ

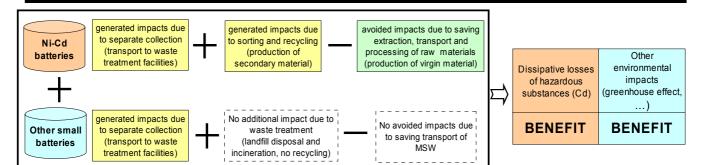
Policy option - Collection rate (% of spent batteries containing Cd)		diss	sipative losses of Cd			CO2 emissions			SOx emissions			NOx emissions	Pri	maı	y energy consumption
option 60-70% for all batteries containing	-1,0	to	-1,0 kg / t collected	-177	to	-212 kg / t collected	-5,9	to	-7 kg / t collected	0,07	to	0,01 kg / t collected	-0,8	to	-1,0 GJ / t collected
Cd (=50-60% for small NiCd batteries)	-0,5	to	-0,6 kg / t spent small batt.	-89	to	-127 kg / t spent small batt.	-2,9	to	-4,2 kg / t spent small batt.	0,03	to	0,004 kg / t spent small batt.	-0,4	to	-0,6 GJ / t spent small batt.
option 70-80% for all batteries containing	-1,1	to	-1,1 kg / t collected	-227	to	-263 kg / t collected	-7,4	to	-9 kg / t collected	0,03	to	-0,03 kg / t collected	-1,1	to	-1,3 GJ / t collected
Cd (=60-70% for small NiCd batteries)	-0,7	to	-0,8 kg / t spent small batt.	-136	to	-184 kg / t spent small batt.	-4,5	to	-6,0 kg / t spent small batt.	0,02	to	-0,02 kg / t spent small batt.	-0,7	to	-0,9 GJ / t spent small batt.
option 80-90% for all batteries containing	-1,2	to	-1,2 kg / t collected	-276	to	-313 kg / t collected	-9,0	to	-9 kg / t collected	-0,01	to	-0,02 kg / t collected	-1,4	to	-1,6 GJ / t collected
Cd (=70-80% for small NiCd batteries)		to	-0,9 kg / t spent small batt.	-193	to	-250 kg / t spent small batt.	-6,3	to	-7,0 kg / t spent small batt.	-0,01	to	-0,01 kg / t spent small batt.	-0,9	to	-1,3 GJ / t spent small batt.

3.5.3.4 Conclusion About Environmental Impacts





Scheme 3 - Collection of all small batteries in view of recycling Ni-Cd only



Conclusions for scheme 1

The separate collection and recycling of portable NiCd batteries in dedicated plants has positive environmental consequences for all the environmental indicators examined, irrespective of the collection and recycling rates. As collection and recycling rates increase, the predicted environmental benefits are maximised.

No LCA data were available about NiCd recycling in metal plants.

Conclusions for scheme 2

With respect to the recycling of portable batteries (neither for dedicated plants nor for metal plants) other than NiCd, no available LCA studies were identified. Due to this lack of data, it was not possible to describe the environmental consequences due to the separate collection and recycling of all the portable batteries (NiCd and other portable batteries).

Conclusions for scheme 3

The separate collection of portable batteries in view of recycling portable NiCd batteries only in (dedicated plants) (other portable batteries are disposed of) has positive environmental consequences for all the environmental indicators examined except NOx emissions, irrespective of the collection and recycling rates.

Regarding NOx emissions, the negative environmental consequence of the separate collection of all portable batteries may be compensated to a limited extent by the avoided impacts associated with the recovery of NiCd through recycling at rates above 80%. As collection and recycling rates increase, all other predicted environmental benefits are maximised.

No LCA data are available about NiCd recycling in metal plants.

The following tables summarise key results about first scheme 1 then scheme 3.

Environmental Impacts of Scheme1 - Collection and Recycling of Portable NiCd Batteries and Scheme 3 - Collection of All Portable Batteries and Recycling of NiCd Batteries Only

(Scheme 1)			-	the waste ma eries (scheme		stem for Ni-Cd level
Policy option - Collection rate (% of spent batteries containing Cd)	separate collection target for small NiCd batteries	dissipative losses of Cd	CO2 emissions	Sox emissions	NOx emissions	Primary energy consumption
Baseline scenario (2007)	20% - 25%	benefit ^(a) (baseline) - 54 to - 68 t	benefit (baseline) - 2 933 to - 4 583 t	benefit (baseline) - 90 to - 141 t	benefit (baseline) - 4 to - 7 t	benefit (baseline) -17 385 to -27 164 GJ
option 60-70% for all batteries containing Cd	50% - 60%	baseline benefit X 2.5	baseline benefit X 6	baseline benefit X 6	baseline benefit X 6 to 7	baseline benefit X 6
option 70-80% for all batteries containing Cd	60% - 70%	baseline benefit X 2.8 to 3	baseline benefit X 8 to 9	baseline benefit X 8 to 9	baseline benefit X 8 to 10	baseline benefit X 8 to 9
option 80-90% for all batteries containing Cd	70% - 80%	baseline benefit X 3 to 3<5	baseline benefit X 10 to 12	baseline benefit X 9 to 12	baseline benefit X 9 to 13	baseline benefit X 10 to 12

(a): as compared with a no recycling situation

(scheme 3)		Environmenta sma	al impacts of t II batteries (N		•	•
Policy option - Collection rate (% of spent batteries containing Cd)	separate collection target for all small batteries	dissipative losses of Cd	CO2 emissions	SOx emissions	NOx emissions	Primary energy consumption
Baseline scenario (2007)	20% - 25%	benefit ^(a) (baseline) : - 54 to - 68 t	benefit (baseline): - 2 180 to - 3 641 t	benefit (baseline): - 89 to - 139 t	damage (baseline) + 14 to +17 t	benefit (baseline): -291 to -5 796 GJ
option 60-70% for all batteries containing Cd	50% - 60%	baseline benefit x 2.5	baseline benefit x 6.6 to 7.5	baseline benefit x 5.8 to 6.3	baseline damage + 0 to 40%	baseline benefit x 18 to 226
option 70-80% for all batteries containing Cd	60% - 70%	baseline benefit x 2.8 to 3	baseline benefit x 9 to 11	baseline benefit x 8 to 9	baseline damage - 20 to +20%	baseline benefit x 26 to 360
option 80-90% for all batteries containing Cd	70% - 80%	baseline benefit x 3.1 to 3.5	baseline benefit x 12 to 15	baseline benefit x 9 to 12	baseline damage - 10%	baseline benefit x 36 to 526

(a): as compared with a no recycling situation

Uncertainties in the results presented here depend on the choice of methodology and data sources. Choices in methodology that could affect the results are system boundary as described earlier. Uncertain data values include assumptions about load factor for trucks, transport distances and emission factors. However, as shown in the tables, large order of magnitude differentiate the studied policy options from the baseline scenario. It is likely that the absolute values may be distorted by methodological choices and data values but the identified trends would remain the same.

3.5.4 Social Impacts

■ Estimation of jobs creation was made on the basis of a study carried out for BEBAT in 2000. Other sources of information could probably be used to cross-check information if more time were allocated to the study.

Portable Batteries - Employment For Collection and Recycling

For 2400 t collected	Dir	ect employme	ents
	Workers	Management	Total
Collection	9	1	10
Sorting	8	1	9
Recycling	14	2	16
Organisation			
On ground	12	2	14
Administration	5	3	8
Marketing	7	4	11
Total	55	13	68

Indirect employments

Approximately the same number of employments

Source: 'Coûts-bénéfice de la collecte BEBAT', 2000

From these data, we estimated jobs created for different collection rates.

Portable Batteries - Estimation of Jobs Creation with Collection Rate

At the EU level - Total Small Batteries Collection and recycling

Collection rate (% of spent batteries) Batteries collected (kt)

10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%
25	41	58	74	91	107	124	140	157

Direct employments (1) Indirect employments (2) **Total jobs created**

619	722	1031	1203	1444	1684	1856	2166	2269	2647	2681	3128	3094	3609	3506	4091	3919	4572
619	722	1031	1203	1444	1684	1856	2166	2269	2647	2681	3128	3094	3609	3506	4091	3919	4572
1238	1444	2063	2406	2888	3369	3713	4331	4538	5294	5363	6256	6188	7219	7013	8181	7838	9144

At the EU level - Small NiCd Batteries

Collection rate (% of spent batteries) Batteries collected (kt)

10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%
2	3	4	5	6	8	9	10	11

Direct employments (1) Indirect employments (2) **Total jobs created**

43	51	72	84	101	118	130	152	159	185	188	219	217	253	245	286	274	320
43	51	72	84	101	118	130	152	159	185	188	219	217	253	245	286	274	320
86,6	101	144	168	202	236	260	303	318	371	375	438	433	505	491	573	549	640

- (1) Hypothesis: 60 to 70 persons for 2400 tonnes collected (derived from BEBAT study)
- (2) Hypothesis: same as direct employments

- Other indicators are considered here for social impacts:
- Expected modification of end users behaviours (households and professional users),
- Perception of batteries by end users, in particular households,
- Perception of waste management by end users, in particular households,
- Gender employment.
- The same 3 schemes are distinguished as for economic and environmental impacts:
- Scheme 1 Collection and recycling of NiCd only,
- Scheme 2 Collection of all portable batteries in view of recycling (all portable batteries are recycled, not only NiCd),
- Scheme 3 Collection of all portable batteries in view of recycling primarily NiCd (and also batteries whose recycling cost is 0 or negative).

Social Impacts of Scheme 1 - Collection and Recycling of Portable NiCd Batteries

Policy options about collection rate	Separate collection target for portable NiCd batteries	Modification of end users behaviours	Perception of batteries by end users	Perception of waste management by end users	Jobs created at the EU level	Gender employment
Baseline scenario (2007)	20-25%	Hoarding = about 60% of portable NiCd batteries	Potential negative impact on the perception of batteries by consumers ('some would be dangerous others not')	Possible confusing message with other waste management policies (contrary to other waste, in the battery sector, recycling would be justified only by level of hazard)	About 140-160 (for NiCd only)	Sorting and recycling is not unfavourable to equal gender employment
Option 60-70% for all batteries containing Cd	50-60%	The higher the collection	Same potential	Same potential negative impact	About x 1.2 (+20%)	The higher the collection objective, the
Option 70-80% for all batteries containing Cd	60-70%	objective, the higher necessary	negative impact compared to	compared to baseline scenario	About x 1.6 (+60%)	higher the potential for equal gender employment
Option 80-90% for all batteries containing Cd	70-80%	hoarding decrease	baseline scenario		About x 2 (+100%)	opioymont

Social Impacts of Scheme 2 - Collection and Recycling of All Portable Batteries

Policy options about collection rate	Separate collection target for portable NiCd batteries	Modification of end users behaviours	Perception of batteries by end users	Perception of waste management by end users	Jobs created at the EU level	Gender employment
Baseline scenario (2007)	20-25%	Hoarding = about 60% of portable NiCd batteries	No difference between batteries in the perception by end users	Messages homogeneous with other waste management instructions to citizens (similarly to other waste, in the battery sector, separate collection is promoted independently of the hazardous content of waste)	About 2000- 2400 (for all portable batteries)	Sorting and recycling is not unfavourable to equal gender employment
Option 60-70% for all batteries containing Cd	50-60%	The higher the collection	-	-	About x 1.2 (+20%)	The higher the collection objective, the higher the
Option 70-80% for all batteries containing Cd	60-70%	objective, the higher necessary			About x 1.6 (+60%)	potential for equal gender employment
Option 80-90% for all batteries containing Cd	70-80%	hoarding decrease			About x 2 (+100%)	строутст

Social Impacts of Scheme 3 - Collection of All Portable Batteries in View of Recycling Primarily NiCd

Policy options about collection rate	Separate collection target for portable NiCd batteries	Modification of end users behaviours	Perception of batteries by end users	Perception of waste management by end users	Jobs created at the EU level	Gender employment	
Baseline scenario (2007)	20-25%	Hoarding = about 60% of portable NiCd batteries	No difference between batteries in the perception by end users	Messages homogeneous with other waste management instructions to citizens (similarly to other waste, in the battery sector, separate collection is promoted independently of the hazardous content of waste) But high risk to discourage endusers from participating to waste separation at home when they realise that most of separately collected waste are disposed of instead of being recycled	About 1600- 2000 (for all portable batteries collected and NiCd recycled – about 20% less jobs compared to scheme 2)	Sorting and recycling is not unfavourable to equal gender employment	
Option 60-70% for all batteries containing Cd	50-60%	The higher the	-	The higher the collection rate, the higher the risk	About x 1.2 (+20%)	The higher the collection objective, the	
Option 70-80% for all batteries containing Cd	60-70%	objective, the higher necessary		to discourage end users	About x 1.6 (+60%)	higher the potential for equal gender	
Option 80-90% for all batteries containing Cd	70-80%	necessary hoarding decrease			About x 2 (+100%)	- employment	

3.5.5 Summary of NiCd Quantitative Policy Options Impact Assessment

Policy options Waste management system	Waste management system	Waste management system	management system	nt system		-	_							Impact assessment					
Collection rate for NiCd Collection system Treatment Technical	Collection system Treatment	Treatment	Treatment	Treatment			Fechnical easability		5	Economic impacts	impacts	I				6,	Social impacts		
separate collection				`	`	`	`		3	compared to baseline scenario	ocilie ocelie	2							
% of spent available for batteries collection batteries batteries with MSW collection batteries with machine for batteries with m	other NiCd portable collection recycling batteries with MSW recycling	other collection recycling batteries with MSW	collection recyding with MSW	recycling	recycling disposal	Jisposal			N N		Porte	Portable batteries	ø	Environmental impacts compared to baseline scenario	Modification of end users	Per	Perception of waste management by	Job created at the EU	Gender employment
% of spent batteries Euros colled	Euros	Euros	Euros	Euros pe collecte	Euros pe collecte	Euros pe collecte	Euros pe collecte	Euros pe collecte		Euros per % of sale Euros per t Euros per % of sale unit sold price collected unit sold price	Euros per t collected	Euros per unit sold	% of sale price		Dellaviors	users	end users	level	
50-60% No?	50-60% No?	NO?						- For cc already (Dk, Nv	- For countries which have already adopted this scheme (Dk, Nw) and for countries which have developed to scheme till	- For countries which have already adopted this scheme (Dk, Nw) and for countries which have developed in scheme till	11	Ш	"	Baseline benefits: x 2 5 to 13	The higher the	Potential negative		+20%	The higher the
Scheme 1- other other now: no other collection and collection and recycling of Nicd portable Nicd only largets batteries - For collection and not now: no other now: no ot	60-70% 0% portable NiCd portable No? batteries	other other other 0% portable Nicd portable No? batteries	other other portable NiCd portable No?	other NiCd portable No? batteries	other portable No? batteries	No?		now: no targets - For co	now: not relevant (because targets possibly not reachable) For countries which have	reachable).	11	Ш	6 Z F 		collection objectives, the higher necessary hoarding	perception of batteries by consumers	Possible confusing message with other waste management policies (7)	%09+	objectives, the higher the potential for
100-120% 70-80% No? addition	NO?	NO?						F, NL,	aneauy auchteu schenne z (A, F, NL, Sw) or 3 (D): no major additional costs (if any)	Elle 2 (A, B, c no major any)	п	п	II		decrease	be dangerous others not')		+100%	employment
75-85% Scheme 2 - 50-60% 50-60% - yes	- %09-05 %09-05	- %09-09	+ Cin			yes	yes				x 1.5 to 2 x	< 3.5 to 4.5	3 to 7% b	The overall environmental balance can not be assessed 1 there is no data available to 1	The higher the	ž	Messages homogeneous with	+20%	The higher the collection
Collection and Nacor Nac	60-70% 60-70% - other portable -	60-70% - other - portable - hatteries	other portable -	1	1		yes				x 2.5 to 3.5	x 6 to 9	7 to 15% o	_	objectives, the higher necessary	ig p	other waste management instructions to	%09+	objectives, the higher the potential for
100-120% batteries (4) 70-80% 70-80% - gatteries yes	70-80% 70-80% -		- Datation	Datterlies		yes	yes				x 2.5 to 4	x 8 to 12 g	9 to 20% p	Cd are	decrease	by users	citizens (8)	+100%	equal gender employment
75-85% Scheme 3 - Scheme 3 - Salertion of all	50-60% 50-60% - (and other batteries	NiCd S0-60% - (and other batteries	NiCd (and other batteries			yes	yes				× 2.4	K K	3 to 6% in	Baseline behefits (b): x 2.5 to 7.5 according to envtal impact Baseline damage (NOx): + 0 10.40%.	The higher the	No difference	Messages homogeneous with other waste management	+20%	The higher the collection
85-100% batteries in view 60-70% 60-70% - recycling of recycling primarily NICd	60-70% 60-70% - recycling batteries	60-70% 60-70% - recycling batteries	with no / other low portable recycling batteries costs:	other portable batteries	other portable batteries		yes				× 4	x 9 to 10.5 (3 to 14% tc	o t	collection objectives, the higher necessary hoarding	between batteries in the perception by users	instructions to citizens (8). But high risk to discourage end users from	%09+	objectives, the higher the potential for equal gender
- 20-80% 70-80%	70-80% - NiNH)	70-80% - NINH)	and acid			yes	yes				x 4 to 4.5	: 11.5 to 14	8 to 19% B	Baseline benefits (6): x 3 to 15 x 4 to 4.5 x 11.5 to 14 8 to 19% Baseline damage (NOX): - 10%			participating to waste separation (9)	+100%	employment

(1) hypothesis: all batteries collected are sent to a recycling plant (2) from the control of spent batteries collected and disposed of with MSW) (2) for countries which do not separately collect and recycle batteries yet (baseline scenario = 0% collection rate of 20-25% of portable batteries and 1105-1940 Euros / t collected (4) baseline scenario = collection rate of 20-25% of portable batteries and 890-1150 Euros / t collected (5) baseline scenario = collection rate of 20-25% of portable batteries and 890-1150 Euros / t collected (6) dissipative losses of C4, CO2 emissions, SOx emissions and 890-1150 Euros / t collected (6) dissipative losses of C4, CO2 emissions, SOx emissions batteries and 890-1150 Euros / t collected (7) contrary to other waste, in the battery sector, respirate collection is promoted independently of the hazardous content of waste. (8) Similarly to other waste, in the battery sector, separate collection is promoted independently of the hazardous content of waste.

BIO Intelligence Service

3.6 NICD BATTERIES BAN OPTION

The key objective of the battery directive is to prevent the release of hazardous substances to the environment. This can be achieved by substituting dangerous substances as much as possible or by establishing effective collection schemes.

The purpose of this chapter is to consider the policy option consisting in the introduction of a ban on the use of cadmium in batteries and accumulators placed on the Community market, where commercially viable substitutes are available.

3.6.1 Background Data

3.6.1.1 EU Policy Background

In January 1988 a Council resolution invited the Commission to pursue without delay the development of specific measures for a Community action program to combat environmental pollution by cadmium. The Resolution stressed that the use of cadmium should be limited to cases where suitable alternatives do not exist. However most industrial cadmium used is to produce portable rechargeable batteries, mainly used for portable consumer products.

In line with the approach on hazardous substances set out in the 6th Environmental Action Programme and in the Johannesburg Plan of Implementation and in accordance with the principles of *substitution* and *precaution* as set out in the Commission white paper on chemicals, which is the basis for the new chemicals legislation under development in Europe, the guiding principles for revision of the battery directive could be to phase out hazardous substances where suitable alternatives exist. These concerns are restricted to mercury, lead and cadmium.

EU has decided to phase out the use of mercury, lead and cadmium in the directives concerning end-of life vehicles (2000/53/EC, and the commission decision³⁴ C(2002)2238 of 27 June 2002 amending annex II of Directive 2000/53/EC) and in the directive on the use of certain hazardous substances in electrical and electronic equipment (2002/95/EC). To be consistent with this policy the battery directive could have the same approach.

Mercury containing batteries are no longer a significant concern, following the implementation of Directive 98/101/EC. Due to the very high collection and recycling rates (close to 100%) of lead-acid automotive batteries in EU, a ban on lead containing batteries is not under discussion (lead emissions from landfill or MSW incinerators are not known to be a significant concern). As for cadmium, batteries are today the main use for cadmium, and cadmium from batteries accounts

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³⁴ According to this decision: "Cadmium in batteries for electrical vehicles should be exempted until 31 December 2005 since, in view of present scientific and technical evidence and the overall environmental assessment undertaken, by that date, substitutes will be available and the availability of electrical vehicles will be ensured. The progressive replacement of cadmium should, however, continue to be analysed, taking into account the availability of electrical vehicles. The Commission will publish its findings by 31 December 2004 at the latest and, if proven justified by the results of the analysis, may propose an extension of the expiry date for cadmium in batteries for electrical vehicles in accordance with Article 4(2)(b)of Directive 2000/53/EC".

for at least 50% of the cadmium content found in landfills within Europe; batteries are also the principal source of cadmium emissions from MSW incinerators within the EU.

Some stakeholders consider this situation is not acceptable since suitable alternatives for many kinds of NiCd batteries are claimed to exist. For other stakeholders, a ban on cadmium should be considered only in the context of a scientifically sound risk assessment. Therefore, in the next sections we question the environmental justification for a market restriction, then we investigate the availability of commercially viable substitutes, before assessing economic and social impacts. First, we summarise the industrial uses of cadmium in Europe.

3.6.1.2 Cadmium Market in Europe

Cadmium production and consumption

Based on the cadmium content in the zinc ore, between 18,000 and 21,000 tonnes of cadmium are produced per year in the world as a by-product of zinc refining³⁵ ³⁶. Roughly 60% of that amount is produced by the world largest producers: Japan, Canada, China, Belgium, Germany, Kazakhstan and USA. Among these 7 countries, Japan and Canada together produce about 45% of the total worldwide production (roughly 25% each).

Approximately 85% of the worldwide production of Cd are consumed by the 5 largest consumer countries listed by the World Bureau of Metal Statistics i.e. Japan, Belgium, France, USA and Germany (50-55% by Japan and Belgium, the two leading Cd consumer countries)³⁷. It should be noted that the "consumption" of cadmium in Belgium is, in fact, almost exclusively the conversion of cadmium metal to cadmium oxide which is then shipped to Japan for the NiCd battery industry usage. Thus, Japan is, by far, the world's largest consumer of cadmium in addition to being one of its largest producers³⁸.

The cadmium fraction which reaches the market (some of the cadmium is being stored) is transformed into products belonging mainly to five categories: **batteries**³⁹, **coatings**, **pigments**, **stabilizers** and **alloys**. Consumption and use patterns are currently changing, as indicated by reduced industrial use of cadmium for plating, stabilizers and pigments in several countries as a result of regulations. However, a significant increase in percentage of use in cadmium-containing batteries have occurred, resulting globally in increasing trends for the total consumption and production⁴⁰. In 1996, **Ni-Cd batteries contained approximately 75% of the 2,630 tonnes of refined cadmium used in the EU⁴¹**. It is also estimated that 80% of the cadmium consumed in NiCd batteries is for consumer batteries and 20% for industrial batteries.

³⁵ World Bureau of Metal Statistics, 2000

Gadmium has this unique characteristic that it is not produced from its own specific ore but it is an inevitable by-product of zinc primary production.

Japan, France, USA and Germany are the four largest producers of NiCd batteries

Japan, the country in the world with the largest production and consumption of cadmium in the last 15 years, is also the country which has had the world's worst disaster related to cadmium. In the 1950's, there was a spillage of cadmium wastes from a smelter on to rice fields which resulted in the so-called *Itai-Itai* disease affecting hundreds of people in the general population. While this disease is not related to cadmium exposure alone, it is obvious that, after this disaster, Japan has been able to cope with environmental issues and risks posed by cadmium.

Cadmium has been used in some primary batteries in the past. There is no application of cadmium in primary batteries anymore.

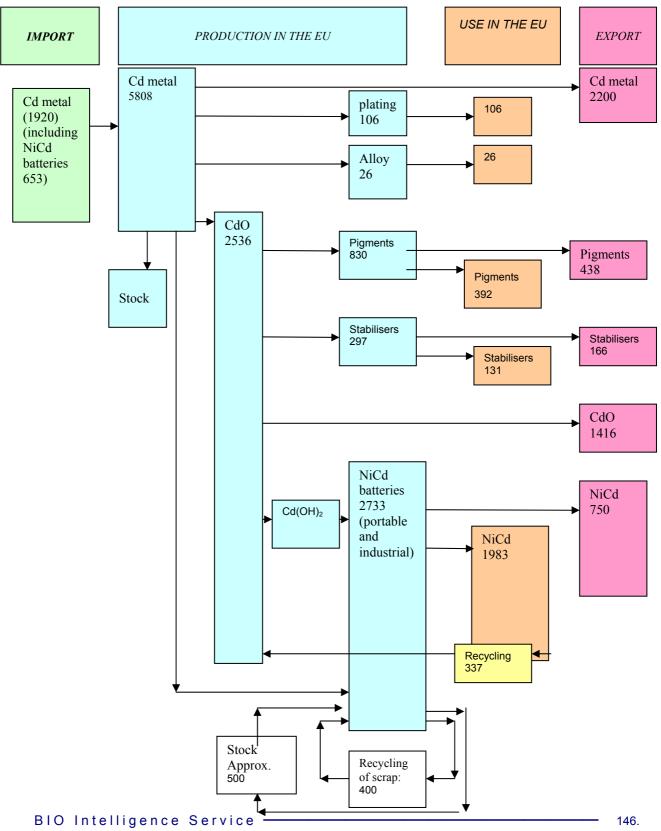
Draft Risk Assessment Report, February 2003 – from Jensen and Bro-Ramussen, 1992; Wiaux, 2000

The production volume of cadmium in Europe in 1996 is estimated at 5,808 tonnes. Corrected with import/export, 5,528 tonnes/year is available for different applications (draft RAR Cd/CdO, 1999). Approximately 2,733 tonnes/year is used for battery manufacturing which represent approximately 47% of cadmium produced in Europe. European regional consumption of cadmium reaches the value of 2,638 tonnes, among which 75.2% for Ni-Cd batteries, 14.9% for pigments, 5% for stabilisers and 5% for alloys and plating (draft TRAR, February 2003).

thus enabling a calculation of the total amounts of cadmium consumed in industrial and consumer batteries.

A complete overview of the mass balance for cadmium in Europe for the reference year 1996 is given hereafter.

Cadmium Mass Flowsheet (tonnes) - Reference Year: 1996



■ Ni-Cd chemistry and composition

A battery is made of cells assembled in series. Roughly Ni-Cd batteries can be divided into the following weight categories. Sealed cells: cell weight between 10 and 150 grams (maximum 500 g), usually assembled by 3 to 10 to make packs for portable applications. The most common are 3 and 4 cell packs. Larger batteries do exist for stationary industrial applications. Vented cells: cell weight between 1 and 70 kg (typically 3 to 10), usually assembled by at least 10 cells but up to several hundred.

Ni-Cd battery is a rechargeable battery system based on the reversible electrochemical reactions of nickel and cadmium in an alkaline potassium hydroxide electrolyte. The chemical compositions of Ni-Cd batteries can vary widely depending on the type and its specific application. For industrial batteries cadmium content may vary between 3 and 11%. For portable batteries, values between 11 and 15% have been reported⁴². In addition, most Ni-Cd batteries contain significant amounts of nickel, iron, plastics and electrolytes and portable amounts of metals such as cobalt and copper. A typical chemical composition for a Ni-Cd cell is given in the following table.

Average Chemical Composition of Ni-Cd Battery

Material	Weight %				
	Portable Ni-Cd battery ^a	Industrial Ni-Cd battery ^b			
Iron	35	48			
Nickel	22	8			
Cadmium ^c	<u>13.8°</u>	<u>8</u> °			
Plastic	10	10			
(OH) ₂	9	5			
Water	5	16			
Potassium hydroxide	2	5			
Others	3.2	0			
Total	100	100			

^a Portable Ni-Cd batteries are batteries weighing between 10 g and 3 kg. Since household applications represent to date less than 20% of the market by weightm it is deemed more appropriate to use the term portable (or small) batteries in order to indicate that the figures presented may include professional applications next to household applications.

Large, industrial-size batteries contain about an average of 8% of cadmium. Small, portable-type batteries contain approximately 13.8% of cadmium.

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^b Industrial Ni-Cd battery: large size batteries weighing over 3 kg in weight Source: EPBA and EUROBAT product information (1997) in ERM (1997)

c latest update of information from industry i.e. manufacturers/recyclers (CollectNiCad,2000)

Draft TRAR Cadmium (oxide) as used in batteries, February 2003

3.6.2 Environmental Impacts

3.6.2.1 Scientific Background on Hazard Associated with Cadmium

Cadmium, in its elemental form, occurs naturally in the earth's crust. Pure cadmium is a soft, silver-white metal; however cadmium is not usually found in the environment as a metal but as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). These solid compounds are soluble in water. Cadmium has no definite odor or taste. Most cadmium is extracted during the production of other metals such as zinc, lead or copper.

Cadmium is a flammable powder. Toxic fumes are produced in a fire. Cadmium is highly persistent in water, with a half-life of higher than 200 days.

The largest source of cadmium release to the general environment is the burning of fossil fuels (such as coal or oil) or the incineration of municipal waste materials. Cadmium may also escape into the air from zinc, lead or copper smelters. It can enter water from disposal of waste water from households or industries. Fertilizers often contain some cadmium.

Cadmium is a heavy metal with a high toxicity even at very low exposure levels and has acute and chronic effects on health and environment. Cadmium is not degradable in nature and will thus, once released to the environment, stay in circulation.

Human health

As a conservative approach, and based on the limited human data and the studies in rats, the United States Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer (IARC) has determined that cadmium is carcinogenic to humans. The USEPA has determined that cadmium is a probable human carcinogen by inhalation.

Cadmium enters the food chain through contamination of soil (by leaching from landfills and inappropriate disposal of the substance, burning in incinerators, etc.). It accumulates in the human body through ingestion of contaminated substance. Bio-accumulation causes a serious health hazard. Its targeted organs are kidneys, liver, bones and blood.

Food and cigarette smoke are the largest potential sources of cadmium exposure for the general population. An average person ingests about 30 micrograms (μ g) of cadmium from food each day. Smokers absorb an additional 1 to 3 μ g per day from cigarettes. Average cadmium levels in cigarettes range from 1,000 to 3,000 ppb. Average cadmium levels in food range from 2 to 40 parts of cadmium per billion parts of food (ppb). The level of cadmium in most drinking water supplies is less than 1 ppb. Air levels normally range from 5 to 40 ng/m³.

Cadmium can enter the blood by absorption from the stomach or intestines after ingestion of food or water, or by absorption from the lungs after inhalation. Very little cadmium enters the body through the skin. Usually only about 1 to 5% of what is taken in by mouth is absorbed into the blood, while about 30 to 50% of what is inhaled is taken up into the blood. However, once cadmium enters the body, it is very strongly retained; therefore, even low doses may build up significant cadmium levels in the body if exposure continues for a long time.

The amount of cadmium needed to cause an adverse effect in an exposed person depends on the chemical and physical form of the element. In general, cadmium compounds that dissolve easily in water (e.g. cadmium chloride), or those that can be dissolved in the body (e.g. cadmium oxide), tend to be more toxic than compounds that are very hard to dissolve (e.g. cadmium sulfide).

By the inhalation route, airborne concentrations of 1 mg/m³ are associated with acute irritation to lungs, and long-term exposure to levels of 0.1 mg/m³ may increase the risk of lung disease. These same levels are also associated with development of kidney injury similar to that observed following oral exposure. Long-term exposure to a level of 0.02 mg/m³ is thought to pose relatively little risk of injury to lung or kidney. It has been estimated that lifelong inhalation of air containing 1 ug/m³ (0.001 mg/m³) of cadmium is associated with a risk of lung cancer of about 2 in 1,000. For soluble cadmium compounds, an oral dose of about 0.05 mg/kg (3.5 mg in an adult) is considered to be the minimum which causes irritation to the stomach. Long-term intake of up to about 0.005 mg/kg/day (0.35 mg/day in an adult) is believed to have relatively little risk of causing injury to the kidney or other tissues.

Cadmium that enters the human body remains in the liver and kidneys. Most of the cadmium is stored in a form that is not harmful, but too much cadmium can overload the kidneys' storage system and lead to health problems. High exposures can cause severe lung damage with shortness of breath, chest pain, cough, and even a buildup of fluid in the lungs. In severe casesm death or permanent lung damage occurs. Illness can be delayed for 4 to 8 hours, allowing overexposure without warning.

Non-lethal exposure to high levels of cadmium may cause nausea, salivation, vomiting, cramps, and diarrhea. During heating or grinding operations, cadmium can cause a flu like illness with chills, headache, aching and/or fever. Emphysema and/or lung scarring can occur from a single high exposure or repeated lower exposures. Long term exposure can cause anemia, loss of sense of smell, fatigue and/or yellow staining of teeth.

Kidney damage has been observed in people who are exposed to excess cadmium either through air or through the diet. This kidney disease is usually not life-threatening, but it can lead to the formation of kidney stones and effects on the skeleton that are equally painful and debilitating. It may also promote hypertension and heart disease.

Exposure to cadmium (especially cadmium oxide) may increase the risk of lung, prostate, and kidney cancer in humans. There may be no safe level of exposure to a cancer-causing agent.

Cadmium also affects the bones; causing bone and joint aches and pains, a syndrome, first described in Japan (1995), where it was termed the itai-itai ("ouch-ouch") disease. Symptoms of this disease include weak bones that lead to deformities, especially of the spine, or to more easily broken bones. It is often fatal. Cadmium may damage the testes (male reproductive glands) and may affect the female reproductive cycle. Cadmium appears to depress some immune functions, mainly by reducing host resistance to bacteria and viruses.

Cadmium levels in humans tend to increase with age (probably because of chronic subtle exposure), usually peaking at around age 50 and then leveling off. No cadmium is present in newborns; cadmium does not cross the placenta-fetal barrier nor the blood-brain barrier as lead and mercury do. Exposure during pregnancy may not be toxic to fetuses, nor does it cause the mental and brain symptoms of lead and mercury.

Animal health

Animals given cadmium in food or water show iron-poor blood, liver disease, and nerve or brain damage. Inhaling cadmium causes liver damage and changes in the immune system in rats and mice. Reproductive and developmental effects have been observed in rats and mice treated with cadmium. Cadmium has been shown to cause lung and testes cancer in animals. In rat studies, higher levels of cadmium are associated with an increase in heart size, higher blood pressure, progressive atherosclerosis, and reduced kidney function. Acute toxic effects may include the death of animals, birds, or fish, and death or low growth rate in plants.

Cadmium has high acute toxicity to aquatic life. The concentration of cadmium found in fish tissues is expected to be much higher than the average concentration of cadmium in the water from which the fish was taken.

3.6.2.2 Risk Assessment on the Use of Cadmium in Batteries

3.6.2.2.1 Introduction and Warning

Facts above give an overview of intrinsic hazard of cadmium and cadmium compounds. They do not permit to justify a market restriction regarding NiCd batteries because they only consider one aspect of risk assessment: the hazard component. A ban on cadmium should be considered only in the context of a scientifically sound risk assessment (or risk characterisation) which integrates two components: the hazard and the exposure to that hazard.

A Targeted Risk Assessment on cadmium used in batteries is currently carrying out (in accordance with Council Regulation (EEC) 793/93⁴³ on the evaluation and control of the risks of "existing" substances). The methods for carrying out an in-depth Risk Assessment at Community level are laid down in Commission Regulation (EC) 1488/94⁴⁴ which is supported by a technical guidance document⁴⁵.

Remark: The last draft of the Targeted Risk Assessment Report (TRAR) on the use of cadmium in nickel-cadmium batteries available when carrying the study was dated on February 2003. The May 2003 version was provided to BIO IS at the end of the project. Only a rapid overview of this last version was possible, which lead us to conclude that no significant modification was introduced that thus that the analysis presented below remains unchanged.

Caveats: The draft TRAR is currently under discussion in a final written procedure by the Competent Group of Member States' experts with the aim of reaching consensus. In doing so, the scientific interpretation of the underlying information may change, more information may be included and even the results in this draft may change. Competent Group of Member State experts seek as wide a distribution of these drafts as possible, in order to assure as complete and accurate an information basis as possible. The information contained in this Draft Risk Assessment Report therefore does not necessarily provide a sound definitive basis for decision making regarding the hazards, exposures or the risks associated with the priority substance.

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O.J. No L 084, 05/04/199 p. 0001 – 0075 - Regulation 793/93 provides a systematic framework for the evaluation of the risks to human health and the environment of these substances if they are produced or imported into the Community in volumes above 10 tonnes per year.

⁴⁴ O.J. No. L 161, 29/06/1994 p. 0003 – 0011

⁴⁵ Technical Guidance Document, Part I-V, ISBN 92-827-801[1234]

3.6.2.2.2 Environmental Exposure and Risk Characterisation

Concepts introduced and used in the TRAR

The draft TRAR gives an analysis of the environmental impact of the production, use and end of life management of nickel-cadmium batteries. It examines various scenarios related to the marketing of nickel-cadmium batteries accompanied by various collection and recycling programs. The toxicological and ecotoxicological aspects related to the impact of cadmium emissions from nickel-cadmium batteries are analysed.

The draft TRAR develops scenarios for current and predicted future emissions to the environment of cadmium from the production and end of life management of nickel-cadmium batteries. The local exposure assessment addressed in this TRAR is based on emissions from Ni-Cd batteries producing plants, Cd recyclers, MSW incineration plants and MSW landfills, in order to estimate the contribution from the Ni-Cd batteries life cycle to the overall regional exposure (all anthropogenic Cd emissions). The "Predicted environmental concentration" (PEC) has been taken as a basis for estimating the environmental exposure to cadmium: for a particular environmental compartment (water, air, soil), a PEC is defined as the predicted cadmium concentration in that compartment due to actual Cd concentrations in the environment (ambient concentrations) and Cd that is added to the environment all over the NiCd batteries life cycle (pollution due to NiCd batteries).

The "Predicted No Effect Concentration" (PNEC) for Cadmium derived for different environmental compartments has been taken as a basis for the risk characterisation: for a particular environmental compartment (water, air, soil), a PNEC is defined as the maximum cadmium concentration which induces no environmental effects.

For every environmental compartment (water, air, soil), predicted total concentrations (PEC) are then compared to the specific PNEC for risk characterisation. If PEC / PNEC is higher than 1, a risk is predicted (as the predicted exposure is higher than the no effect concentration); if PEC / PNEC is lower than 1, no risk is predicted.

■ What we did in the present study, based on the TRAR

The risk linked to NiCd batteries life cycle can be assessed at two levels:

- · risk at a global level,
- risk at a local level.

For the global level analysis, we directly exploited TRAR data about environmental exposure (see section 3.6.2.2.3 hereafter).

For the local level:

- we first drew conclusions from environmental exposure.
- We then used the PEC/PNEC ratio for each different environmental compartments (water, air, soil) as a characterisation risk factor to assess local risk (either for human health or for ecosystems) arising from the different stages of nickel-cadmium batteries life cycle (production, use and end of life management).

We calculated a PEC/PNEC ratio for each life cycle stage and each environmental compartments by using TRAR values for PEC and PNEC obtained for the different scenarii analysed in the TRAR.

The results of our calculations and the conclusions drew are presented in section 3.6.2.2.4.

Remark: no conclusions about these local risk considerations were explicitly presented in the TRAR February version that is why we performed all the calculations presented hereafter and drew conclusions on our own.

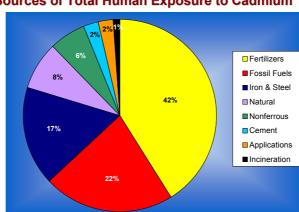
3.6.2.2.3 Conclusions Based on Environmental Exposure

Relevance to ban NiCd batteries from a global risk point of view

TRAR results

For all scenarios investigated in the TRAR, the added⁴⁶ regional/continental concentrations of Cd calculated from Cd emissions during NiCd batteries life cycle are very small. Furthermore, under the worse case scenario, NiCd batteries contribute to less than 1% of the anthropogenic emission sources.

These findings are compatible with previous studies from the U.S. EPA studies, which indicate that fertilizers and fossil fuel combustion are the major sources of human and environmental cadmium exposure, and cadmium products life cycle represent only a very portable fraction of the total. Studies on the relative contributions of various sources to total human cadmium exposure (Van Assche 1998, Van Assche and Ciarletta 1992) have also clearly demonstrated that cadmium products contribute only to about 2% of total human cadmium exposure. These results are shown in the figure below.



Sources of Total Human Exposure to Cadmium

Source: Van Assche 1998

BIO conclusions

From a global risk point of view, a ban of NiCd batteries would have almost no effect on total human cadmium exposure, given that most of it is due to other anthropogenic Cd emission sources. It will then not represent an appropriate solution to reduce total human cadmium exposure.

Nevertheless, Cd emission sources can have a major impact on the Cd concentration at a local level. This issue is now considered.

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Actual Cd concentrations in the environment (ambient concentrations) are determined by the natural background of Cd (from geological origin or from natural processes) and Cd that was added to the environment in the past by man (historical pollution). Natural Cd and Cd from historical pollution determine background Cd concentrations in the environment.

Relevance to ban industrial NiCd batteries from a local risk point of view

TRAR results

Cadmium emissions from the different stages of Ni-Cd batteries life cycle are summed up in the following table.

Remark: it should be noted that a large uncertainty surrounds the figures about the disposal stage.

Distribution of Cd Emissions of Ni-Cd Batteries Life Cycle Between Different Environmental Compartments (total kg in Europe)

Realistic scenario: 24.4% incineration and 75.6% landfilling. Scenario 10 mg/kg dry wt. Cadmium (current situation)

	Cd emission distribution in kg/year						
Life cycle stages	Air	Water	Urban/ind.	Ground-	Total		
			soil/agr. soil	water	release		
1 Manufacturing of Ni-Cd batteries and/or battery packs	51	65	0	0	116		
2 Incorporation into battery powered devices and applications	0	0	0	0	0		
3 Use, recharging and maintenance by end users	1	I	I	1	1		
4 Recycling (partial data only)	1.8	0.1	0	0	1.9		
5 Disposal (10-50% Ni-Cd batteries contribution) • Incineration (24.4%)	323-1,617	35-176	N/A	N/A	358-1,793		
Landfilling (75.6%)	N/A	55-275	63-314	13-66	131-655		
Total	376-1,670	155-516	63-314	13-66	607-2,566		

^{/ =} no direct emissions (indirect cadmium emissions associated to energy consumed to recharge batteries are deemed negligible).

The main Cd emission sources in NiCd batteries life cycle is thus household waste incineration and landfilling.

BIO conclusion

Because industrial NiCd batteries are believed to be already collected and recycled with a relatively high rate, most of them do not join incinerators or landfill and then do not represent a significant source of Cd emissions to the environment.

As a consequence, there is no strong argument to support a ban on industrial NiCd batteries.

N/A = Not applicable

3.6.2.2.4 Conclusions Based on Risk Characterisation

■ Relevance to ban portable NiCd batteries from a local risk point of view

BIO compilation of TRAR data

As explained above (see section 0 page 151), we used the PEC/PNEC ratios for the different environmental compartments (water, air, soil) as risk factors to assess the **local risk** (either for human health or for ecosystems) arising from production, use and end of life management of nickel-cadmium batteries.

The results of our compilation of all the scenarios analysed in the TRAR (current scenarios as well as future scenarios and/or sensitivity analysis) is summed up in the following table where "Yes" means that the risk factor is higher than 1 (e.g. a risk is predicted), and "No" means that the risk factor is lower than 1 (e.g. no risk is predicted).

		Risk characterization associated with the NiCd batteries life cycle				
		Life cycle stages of the NiCD batteries				
	onmental partment	NiCd producing & recycling plants	MSW incinerators	MSW landfills		
	fresh water ecosystems	No but risk factor close to 1 (0.94)	t risk factor close to 1			
	benthic organisms (sediment)	Yes (elevated risk factor from 2.4 to 10.8)	Yes	Yes		
Aquatic	micro- organisms in STP	No but risk factor close to 1 (0.95)	No	No		
	marine water ecosystems	? No risk assessment (no data on Cd toxicity in marine water)	No emissions	No emissions		
Atmospher	е	? No risk characterization (no data on Cd toxicity in the atmosphere compartment)				
Terrestrial	soil ecosystems	No after 10 years exposure Yes if Cd concentrations are predicted after 50 years exposure		No		

We can deduce that (conclusions coherent with the TRAR conclusions / results chapter contained in the May version):

- For all environmental compartments assessed in the TRAR:
 - If risk reduction measures and regulations which already exist are applied at all the life cycle stages and mainly incineration and landfill facilities, there is no local risk from Cd emissions except for local sediment compartment.
 - If existing regulations are not applied (in particular for incineration and landfill facilities), local risks exist for fresh water ecosystems.
 - For local sediment compartment, the background concentration is today already higher than the predicted no effect concentration (i.e. the existing Cd concentration in sediment has already eco-toxicological effect on benthic organisms).
- No risk assessment has been performed regarding air emissions due to a lack of toxicity data of cadmium in the atmospheric compartment.

BIO conclusion

When considering local risks, the TRAR does not permit to definitively exclude the relevance of a ban on portable NiCd batteries because:

- no risk assessment has been performed regarding air emissions,
- no conclusion can be drawn for additional risk in sediment compartment because existing cadmium concentration has already eco-toxicological effect,
- for the other compartments, the existence or absence of local risk depend on local characteristics: in particular, incineration and landfill facilities in conformity with EU regulations and applying existing risk reduction measures have no local risk whereas others have local risks for fresh water ecosystems.

On the other hand, a ban option will not necessarily result in a no risk situation because two flows of spent NiCd batteries will still have to be treated after the ban is into force: batteries which will become waste after the ban and batteries discarded after having been hoarded⁴⁷.

High rate collection and recycling of NiCd batteries and / or enforcement of existing regulations about incinerators and landfill facilities are likely to be good alternatives to a ban with a view to reduce local risks.

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^{47 60%} of rechargeable batteries are assumed being hoarded today by end users.

Uncertainties and current limitations of the TRAR

The risk assessment as currently performed in the TRAR suffers from several limitations.

Release to the environment and environmental exposure

- Some plants have not transmitted emission data, thus the distributions of Cd emissions (total kg in EU) to different environmental compartments during Ni-Cd batteries life cycle may be underestimated.
- Cd and CdO producing plants are not addressed in this TRAR but have been incorporated in the overall RAR on Cd metal and CdO (2001).
- Emissions from industrial NiCd batteries disposed of in industrial landfill are not addressed in this TRAR.
- The emissions associated with landfilling of incineration products (ashes) have not been assessed. Thus, delayed emissions associated with landfilling of output fractions of MSW incinerators (particularly ash) are not addressed (whereas 24 to 120 tonnes per year of Cd contained in ash are landfilled or are reused in road construction)⁴⁸.
- Long term (above 500 years) water emissions associated with Cd disposed of in landfill are not taken into account, although release of pollutants from a landfill can occur over an indefinite period. Cadmium emissions out of landfill (within leachate⁴⁹) are very uncertain (although Cd emission from landfill are reported to be the principal source of water release of Cd). Hence, the daily or annual release may result in a very portable PEC and does not reflect the long-term emissions of a landfill.
- The impact of an increasing cadmium content in the MSW on leachate composition cannot be predicted on the basis of current knowledge since there is no direct relationship between the total content of Cd and the leachability of Cd. A 10% increase of total Cd content in MSW landfilled will not necessarily lead to a 10% increase in the leachable amount of Cd. The leachability will depend on the chemical nature of the cadmium and the leaching conditions.
- In this TRAR, the cadmium concentration in the leachate originating from a fixed amount of cadmium being landfilled is assumed to be constant over time. The question arises whether or not it is reasonable to assume one constant leachate concentration since the conditions in landfills are changing during the different degradation phases in a landfill.
- The environmental impacts after a hypothetical infinite time period has not been addressed in this TRAR since scientific knowledge on this issue is insufficient.

Risk characterisation

No toxicity data of cadmium in the atmospheric compartment have been found. Therefore no risk assessment has been performed regarding air emissions.

At present 8,333 kt of bottom ash and 1,095 kt of fly ash have to be disposed of on a yearly basis. The cadmium concentrations in the bottom ash and fly ash are respectively 3.8 mg Cd/kg dry wt. and 192 mg Cd/kg dry wt. The re-use and/or landfilling of incineration residues may result in a long-term diffuse emission potentially contaminating groundwater, surface water and soil. The delayed cadmium emissions of the re-use of incineration residues have, however, not been quantified in this TRAR since the use of incineration residues is only allowed if the results of leaching tests are favourable.

Leachate is generated as a result of the expulsion of liquid from the waste due to its own weight or compaction loading (termed primary leachate) and the percolation of water through a landfill (termed secondary leachate). The source of percolating water could be precipitation, irrigation, groundwater or leachate recirculated through the landfill.

3.6.2.3 Conclusions About Environmental Impacts

- Conclusions about toxic and ecotoxic risks based on TRAR data are the following:
- From a global risks point of view, a ban of NiCd batteries is not relevant to reduce total human cadmium exposure because they do not represent a significant source of Cd emissions to the environment (they come mainly from other anthropogenic Cd emission sources: fertilizers, fossil fuels, iron and steel...). (TRAR conclusion)
- As for local risks, there is no strong argument to support a ban on industrial NiCd batteries, because they do not represent a significant source of Cd emissions to the environment (local risks are primarily linked to incineration and landfilling and most of industrial NiCd batteries are believed to be collected and sent to recycling). (BIO conclusions from TRAR data)
- On the contrary, as far as portable NiCd batteries and local risks are concerned, BIO calculation of characterisation risk factors from TRAR data does not permit to exclude the relevance of a ban on portable NiCd batteries (BIO conclusions from TRAR data):
 - no risk assessment has been performed regarding air emissions,
 - no conclusion can be drawn for additional risk in sediment compartment because existing cadmium concentration has already eco-toxicological effect,
 - for the other compartments, the existence or absence of local risk depend on local characteristics: in particular, incineration and landfill facilities in conformity with EU regulations and applying existing risk reduction measures have no local risk whereas others have local risks for fresh water ecosystems.

On the other hand, a ban option will not necessarily result in a no risk situation because two flows of spent NiCd batteries will still have to be treated after the ban is into force: batteries which will become waste after the ban and batteries discarded after having been hoarded⁵⁰.

High rate collection and recycling of portable NiCd batteries and / or enforcement of existing regulations about incinerators and landfill facilities are likely to be good alternatives to a ban with a view to reduce local risks.

Other environmental impacts can be mentioned.

Because the life expectancy of NiMH batteries in terms of number of cycles is between one third and one half that of NiCd, the number of cells for disposal would double or triple. And for domestic tools, it is often necessary to replace the entire tool because it is a sealed unit and the battery cannot be removed.

⁵⁰ 60% of rechargeable batteries are assumed being hoarded today by end users.

3.6.3 Feasibility

We now focus on the ban on portable NiCd batteries since the relevance to ban industrial batteries appear to be low from the TRAR. The **first question**, addressed in this chapter, is: **do substitute exist to replace portable NiCd batteries in case of ban?** The economic and social impacts are then analysed in the next chapter.

3.6.3.1 Overview of the Battery Market

3.6.3.1.1 Rechargeable Batteries Technologies

There is no unique battery chemistry which can combine optimum performance under all operating conditions, i.e. high temperature, low temperature, mechanical abuse, light weight, low volume, high rate discharge, low rate discharge, long cycle life, low self discharge, reliability, low maintenance, etc.

Among rechargeable batteries, lead-acid batteries of various designs dominate the industrial market. The largest group is the automotive starting, lighting and ignition (SLI) battery. There are various types of SLI batteries depending on climate conditions and application types such as trucks, cars and boats. Both vented (open) and sealed types are available.

In cycling applications such as traction and vehicular propulsion for electric trucks and industrial vehicles for uses in mining, railroads or submarines, where long cycle life is required, lead-acid batteries of a different design than the SLI batteries are used. In stand-by applications such as telecommunication, computer backup, emergency lighting and power backup systems, various types of vented or valve-regulated (VRLA) lead-acid batteries are used depending on the specific application.

Vented or sealed industrial NiCd batteries with pocket, sintered, fiber, or plastic-bonded electrodes are used in applications where the batteries are exposed to:

- temperature extremes,
- mechanical abuse,
- limited or no maintenance.
- demand for long service life,
- high reliability requirements.

Industrial NiCd batteries are used in railroad and mass transit applications due to their high durability and excellent resistance to mechanical and electrical abuse. Other applications for industrial NiCd batteries are for stationary installations where power reliability is the highest priority as life and great economic investments could be jeopardized by a power failure. Examples of such installations are hospital operating theaters, offshore oil rigs, backup power for large computer systems in banks and insurance companies, standby power in process industries, and emergency power systems in airports. Another important use for industrial NiCd batteries is in aviation applications where they are used mainly for aircraft starting and emergency power. Specialized uses in space and military applications are also important because of their high performance, long life and dependability.

Lead-acid batteries have always dominated the telecommunication market, particularly in large central station batteries. With the development of fiber optic systems and more decentralised distribution systems, the traditional valve regulated lead acid (VRLA) battery could not meet the demand requiring 99,9% reliability and long service life. The VRLA batteries therefore have been replaced by low maintenance, long life NiCd batteries of 80 and 125 Ampere-hours (Ah). It is interesting to note that, in this application, the industrial NiCd battery has been able to penetrate a traditional lead-acid market segment. The reason is that a NiCd battery was developed, which could meet the market demand of high reliability, low maintenance and long life in a wide temperature range, resulting in a cost per unit of performance that was superior to the lead-acid batteries being used.

The global market for consumer type rechargeable batteries has exploded during recent years as more and more electronic and portable devices are introduced in the market place. This rapid growth began in the 1980s with cordless devices such as shavers and phones and has now evolved into toys, household appliances, laptop and handheld computers, camcorders, cameras, memory back up, power tools, and, above all, cellular phones.

The consumer portable battery market has been dominated by sealed cylindrical NiCd batteries for many years. However, in applications where a high specific energy and low weight in a moderate temperature range are required, the NiMH battery is now the preferred battery chemistry. More recently, the Li-ion and, most recently, Li-polymer batteries are now penetrating this market segment, and will probably command a significant share of the rechargeable consumer battery market in the future. Sealed lead-acid batteries have only a portable market share of portable applications.

Sealed NiCd batteries still maintain their strong market position in applications which require:

- high power drains and drain rates,
- temperature extremes,
- long life.

For all rechargeable battery systems, there are market demands that can be met only by a specific battery chemistry and where the key factor is the most competitive cost per unit for a performance required to satisfy consumer expectation.

3.6.3.1.2 Market and Sales Data

Data from the following chapter were extracted from the TRAR (draft, February, 2003).

Portable rechargeable batteries are utilised for a wide variety of products and applications. The most important application fields are Cordless Power Tools (CPT), Emergency Lighting Units (ELU) and applications in various Electrical and electronical Equipment (EEE). Industrial applications of rechargeable batteries include military and space applications, transportation applications, power systems such as reserve power supply for industrial processes.

Portable Ni-Cd Batteries

For the breakdown of the market data by application, an in-depth analysis was performed for the European sales of portable Ni-Cd batteries in the three major applications area's: cordless power tools, emergency lighting and household and electrical electronic equipment (EEE).

The following table sums up the market data by application. Total annual market amounts at 12,700 tons in 1999.

Portable Ni-Cd batteries EU market, sales by application (million cells/year) reference year 1999

Electrical and Electronic Equipment (EEE)					
Application	Average weight/cell (g)	Sales (million cells/year)			
Household equipment	22	28			
Dust buster	48	12			
Toys	55	5			
Audio-Video	26	10			
Single cells & others	22	54			
Cordless phones	14	50			
Emergency lighting					
Application	Average weight/cell (g)	Sales (million cells/year)			
Emergency light	120	26			
	Power tools				
Application	Average weight/cell (g)	Sales (million cells/year)			
Cordless tool	41	138			
	Others				
Application	Average weight/cell (g)	Sales (million cells/year)			
Medical	20	10			
Military	40	5			
Average weight/unit	37.8				
Total sales		338			

Source: Wiaux (2000)

From country-by-country data, it can be concluded that approximately a maximum of 14,000 tonnes of portable Ni-Cd batteries is put on the EU-16 market (including Norway) in 1999.

Recent data given by industry indicate a decrease in the weight volume introduced on the market with respectively 11,930 and 10,995 tonnes/year for 2000 and 2001.

Industrial Ni-Cd Batteries

The European market for industrial batteries can be split into a number of well-defined sectors as follows:

- Standby, or stationary, applications: safety and back-up systems at airports, hospitals, power stations, offshore installations, etc.,
- Transportation: railways, metro cars, etc.,
- Aviation: starting of engines, oil board safety systems, etc.,
- Electric vehicles (EV).

The batteries within the two largest segments - standby and transportation - are used within specific country's infrastructures. The need for batteries for new installations is the largest during this infrastructure development phase. Batteries for standby applications are often purchased by equipment manufacturer (OEM) and delivered together with the equipment to the user. Many of these OEM's are situated in Western Europe while the users are situated in e.g. the Middle East and Far East. Thus, the batteries are purchased by and invoiced to a European customer, but they are very often re-exported to other parts of the world. In some of the Member states with important OEM'S, the re-export factor of standby batteries can be as high as 50 %.

Batteries for transportation and aviation purposes are to a higher extent delivered directly to the end user and the re-export factor is lower (15 %). The EV (Electric Vehicles) market is still at a low level. Main part of the EV nickel-cadmium is produced in the EU and is used within the EU.

The volumes of the different industrial Ni-Cd batteries for use within the EU market were estimated from data of the three major suppliers (representing more than 95 % of the market supply) with addition of an estimated volume of imported batteries (see following table).

Industrial Ni-Cd Batteries EU Market Sales (tonnes/yr)

Year	Industrial Ni-Cd battery (tonnes/year)
1995	3,242
1996	3,608
1997	3,625
1998	3,964
1999	3,697
2000	3,566

Sources: original references Saft, Exide and Hoppecke in Wiaux (2000, 2002)

From this table it is clear that the industrial batteries market have reached a stable level of 3,500 to 4,000 tons per year. Cross-validation with the ERM study shows the same magnitude (4,000 tons in 1995). About 3,700 tonnes of industrial Ni-Cd batteries is put on the EU-16 market (EU including Norway) in 1999.

3.6.3.1.3 Market Trends

Most of the data related to market evolution come from industry. No precise information was (made) available on how the Ni-Cd battery market is likely to evolve in the future.

Ni-Cd batteries can be classified into four lines of products according to their market applications: industrial batteries, Emergency Lighting units (ELU), Cordless Power Tools (CPT) and applications in numerous Electrical and Electronic Equipment (EEE).

The largest application field for Ni-Cd batteries and a growing market have become the CPT applications (separated between the Professionals and Consumer market). The ELU market is under a slight growth rate with higher market shares in countries like France, United Kingdom, Italy and Spain, by opposition to Germany where centralised units powered by lead-acid batteries are used. The EEE market, which has been the largest market segment for Ni-Cd batteries during the first half of the nineties, is declining. From 1995, Ni-Cd batteries have gradually being replaced on the market by other types of batteries like the Nickel-Metal Hydride, the Lithium-Ion and the Lithium-Polymer batteries. Industrial Ni-Cd batteries are continuously in competition with lead-acid batteries but forms a stable market. Market shares for the different applications for the years 1999 and 2000 are summed up in the following tables.

Distribution (% weight) of Ni-Cd Batteries Market Share by Application

Reference year 1999

Moloronoo your <u>no</u>	
Industrial	Portable CPT
22 % (Stable)	35 % (growing)
Portable ELU	Portable EEE
18 % (Stable)	25 % (Declining)

Source: Collect NiCad (2000)

Distribution (% weight) of Ni-Cd Batteries Market Share by Application Reference year 2000

Industrial	Portable CPT
24 % (Stable)	35 % (growing)
Portable ELU	Portable EEE
19 % (Stable)	16 % (Declining)
Specialities (Aviation, Industrial Comm. & Computing)	
6 % and growing	

Source: Collect NiCad (2002)

It can be concluded that the Ni-Cd market has increased significantly in the 80's to reach a more or less stable level in the late 1990's of around 13,500 tons/year for consumer/sealed portable nickel-cadmium batteries and 3,500 to 4,000 tons/year for the industrial nickel-cadmium battery market.

To date, no market projections are available for the amount of portable Ni-Cd batteries which will be put on the market in the future. The ERM study (2000) employed a positive common growth rate for all types of portable secondary batteries (+ 5-6%). However, since the market evolution is stated to be mainly technology driven and as there is confidential business implication, it is difficult to get any good specific estimate for the growth rate of Ni-Cd chemistry applications. Between 1996 and 1999, the portable Ni-Cd battery market in the EU seems to be oscillating around 13,000 -14,000 tonnes⁵¹. But recent figures for 2000 and 2001 indicate a decrease in sales. The industrial batteries remain at the level of 3,600 tonnes.

The reference year 1999 was chosen because this was the most recent year for which cross validation of the data provided by industry with those provided by Member States was possible.

3.6.3.1.4 Technological Evolution: a Market Reality

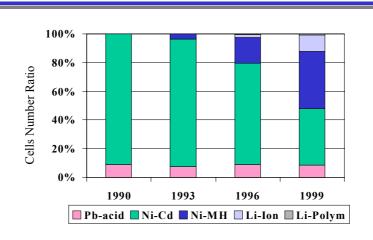
During the nineties, the rechargeable battery industry invested up to 5% of its turnover into R&D for the development of alternative sources of portable electrical energy (Source: SAFT).

For industrial rechargeable batteries, the commercial systems in competition remained the Lead-acid battery and the Nickel-Cadmium batteries. Prototypes of Nickel-Metal hydrides batteries and of Li-Ion batteries were announced in the Electric Vehicle applications but they did not reached industrial scale and this is not foreseen before an undefined period of time⁵².

For portable rechargeable batteries, the commercial systems in competition are basically five: Lead-acid, Nickel-Cadmium, Nickel-Metal Hydride, Lithium-Ion and Lithium-Polymer.

Market Evolution for Portable Rechargeable batteries in Europe

European Portable Rechargeable Battery Market Evolution as a % of cells numbers introduced on the EU market



Source: Collect NiCad

The data presented in this figure demonstrates that the rechargeable battery industry has been committed to very progressive technological development in which the offer to the end-user has been enlarged from two basic systems in 1990 (Lead-acid, Nickel-Cadmium) to five systems in the year 2000 (with the addition of Nickel-Metal Hydride, Lithium-Ion and Lithium-Polymer to the previously mentioned systems).

In the year 2000, the five systems are present on the market in a very competitive commercial context where each technology has found its own market share. It is important to realise that the most important actors in manufacturing rechargeable batteries are involved in the production of more than one type of system. This reality is presented in the next figure, where it can be observed that the manufacturing leaders, SAFT, VARTA, SANYO, MOLTECH, YUASA and PANASONIC are not only competing on the commercial scene but also internally to promote the best technology for a given application.

The Toyota RAV 4 has often been cited as an example of the electric vehicle powered by a NiMH rechargeable battery (marketed principally in California and not on offer by Toyota in Europe), providing a suitable alternative to Ni(Cd powered electric vehicles. However, Toyota Motor Corporation has discontinued production of the RAV4 Electric Vehicle worldwide in spring 2003.

Producers of Portable Rechargeable Batteries

Portable Rechargeable Battery Market

Companies

SAFT VARTA

i ecnnoic	ogicai ii	nnovatio	n Actors	3
Manufacturers	of Portabl	e Recharge	able Batter	ries
Pb-Acid	Ni-Cd	Ni-MH	Li-Ion	Li-Polymer
-	Y	Y	Y	-
Y	Y	Y	Y	-
-	Y	Y	Y	Y
Y	Y	Y	Y	Y
V	V	V	V	V

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Source: Collect NiCad

If the portable rechargeable battery industry would not have developed technical alternatives to Nickel-Cadmium batteries, the market of those batteries would probably be twice as large as it is during the year 2000 and even larger.

For industrial rechargeable batteries, the market has been distributed between two types, Leadacid and Nickel-Cadmium, for the last ten years. In the following figure, the manufacturers of Industrial Rechargeable Batteries are presented.

Producers of Industrial Rechargeable Batteries

Industrial Ni-Cd Battery Market

Technological Innovation Actors

Manufacturers of Industrial Rechargeable Batteries Industrial Production (neither pilot nor research level) - EV Batteries Excluded

Companies	Pb-Acid	Ni-Cd
SAFT	-	Y
HOPPECKE	Y	Y
VARTA	Y	-
EXIDE	Y	Y
FIAMM	Y	-
HAWKER (Oldham - UK)	Y	-
HONDA DENKI	-	Y
MARATHON (US)	Y	-
FURUKAWA	Y	Y

For Lead-Acid: OERLIKON, BANNER, YUASA, HITACHI...

Y:Manufacturer

Source: Collect NiCad

3.6.3.1.5 Technical Performance: a Broad Application Range

It is a theoretical view of the problem to claim that battery performances can be compared only on a Wh/kg basis (energy density). The reality is quite different and in their day-to-day commercial activity, companies that are offering the best services to their clients are in fact offering a variety of technologies in the field of portable rechargeable batteries. A broad range of technical characteristics is satisfied when a battery system finds its application in a piece of equipment.

Table on next page details various parameters and technical characteristics that are considered before making the final choice for one or other of the rechargeable battery systems.

The following parameters are compared in relation to the different battery systems:

- Energy density,
- Impedance/Current drain,
- Temperature range,
- Charge storage,
- Charge mode,
- Lifetime,
- Cycling capacity,
- Production cost,
- Production technology.

None of those parameters can be dissociated from the others. They all have an impact on the potentiality to apply a given battery technology in a selected application: costs versus performances are the parameters leading to the final selection.

The origin of this multi-criteria selection is found in the broad application ranges of electrical and electronic equipment satisfied by portable electrical energy sources. All these parameters such as energy, power, cycling capacity and others have to be evaluated simultaneously and not independently.

If one considers a mobile telephone, the lowest weight and the smallest size are desirable, but the current drain is characteristic of an electronic device (low current drain in the 10 milliamperes range). In this application, Li-Ion batteries are replacing advantageously Ni-MH and Ni-Cd for technical and design reasons.

For a cordless power tool, the first obvious requirement is power or high current drain characteristic. In this application, the highest power delivery is critical. In addition, this high power has to be available several tens of hundreds of times. The amperage requirement for a power tool is in the 10 amperes range or 1000 times higher than that for a portable telephone. Consequently in this application, even if Li-lon would be at the same price level as a Ni-Cd battery, the Li-lon battery would not be selected. Energy is not the key factor here, but power.

Lastly, the most decisive argument for the industrial application of rechargeable batteries is still the reliability in safety applications where Nickel-Cadmium systems offer a full warranty on their performances.

Comparison of the Technical Performances of Various Rechargeable Batteries

Technologies	Energy Density	Internal Impedance Current Drain	Charge Mode & Charger Cost (C.C.)	Temperature Range	Production Cost in % versus Ni-Cd	Long term Storage Capacity	Industrial Complexity
Lead-acid	Low 25-35 Wh/kg	Low High Current	Basic Avoid deep discharge C.C. = Low	Limited at 40 ° C by Water Evaporation	<50 scale effect	Good	Low Water based
Nickel-Cadmium	Medium Low 30-40 Wh/kg	Low High Current	Robust Accept Overcharge and Full Discharge C.C. = Low	No limitation	100	Good	Medium Low Water Based
Nickel- Met.Hydrides.	Medium High > 50 Wh/kg	Medium Amperage Limited	Sensitive Require electronic control C.C. = Medium	Limited below 0°C and above 50°C	130	Poor	Medium High MH are Pyrophoric Water based
Li-lon	High > 70 Wh/kg	High Low Amperage	Very sensitive Require electronic control C.C. = High	Limited below 0°C and above 40°C	>200	Good	High Lithium and organic solvents are flammable

3.6.3.1.6 Driving Forces for Technological Evolution

■ In Communication Equipment, Office and Household Appliances

The requirements for lower current drain characteristics from new electronic devices, the decreasing size and volume of communication equipment, the high volumetric energy of Li-lon for low current drain applications but also the higher added value of equipment are parameters influencing technological evolution.

The diversification of the mobile communication equipment, portable computers and visual communication equipment has required smaller sized rechargeable batteries.

In other areas where miniaturisation has not been critical, such as shavers, tooth-brushes and home mobile telephones, the Ni-Cd battery is still the preferred choice for its robustness in given operating conditions and basic technical requirements. Price plays an important role at this level of international competition.

A simple charger technology is required for Ni-Cd batteries. The charger technology for Ni-MH and Lilon is more sophisticated. It requires electronic control circuits to avoid overcharge and overdischarge.

In Cordless Power Tools

For high current drain applications, the cadmium electrode has proven to achieve optimum performances while the metal hydride electrode is more fragile.

The combination of optimum technical performances and price, offered to the end user, is critical. The wide range of power tool applications associated with safety aspects of a portable rechargeable battery is at the origin of the high market development rate of this application field which is satisfied at the best by the Ni-Cd system.

■ In Emergency Lighting Units

The Normalisation conditions for usage at low temperature (below minus 20°C) and high temperature (above 50°C) operating ranges make Ni-Cd batteries the preferred choice. In addition, a Ni-MH battery performs less well in permanent charge floating conditions except if it is equipped with a more sophisticated overcharge control system.

In Industrial Battery Applications

Wide range research and development work is underway to satisfy application programs in the uninterruptible power supply field as well as in areas such as safety for tunnels, transportation, industrial robots and electric vehicles...

3.6.3.2 Possible Substitution of NiCd Batteries

The following table presents, for each battery application, technologies available on the market. A cross means an available technology; a cross into brackets means a technology available but with a low market share.

Possible Substitution of NiCd Batteries

	battery technology available in the market					EU NiCd battery sales		
battery segment		application	NiCd	Lead-acid	Ni-MH	Li-ion	Li-polymer	(tonnes/year, 1999)
	household	-cellular telephones, -portable computers, -camcorders, -digital cameras, -remote control toys, - other small household appliances (small vacuum cleaners, shavers,)	X	x	x	X	X	3 600
portable batteries (< 1 kg)		cordless power tools	х		Х			3 950
g /		cordless power tools	х		х			1 800
	professional	emergency lighting systems (building, aircraft)	х	х				3 050
		medical equipment	х	?	?	?	?	200
industrial use (> 1 kg)	stationary	-power supply (hospital operating theaters, offshore oil rigs, standby power in industry, emergency power system in airports, large telecommunication station,), -power back-up (large computer systems in banks and insurance companies,)	(X)	х				2 600
	mobile	railways, aircraft (braking and security functions)	х	(X)				
	specialized	space and military applications (engine starting, emergency back-up functions)	х	?	?	?	?	200
electric		off-road vehicles	(X)	х				600
vehicles		on-road vehicles	х	(X)	x (pilot)	x (pilot)	x (pilot)	000

In <u>small-size batteries for consumers' applications</u> (cellular phones, portable computers,...), five battery technologies are currently used; Lead-acid, Nickel-Cadmium, Nickel-Metal Hydride, Lithium-Ion and Lithium-Polymer. The last two, although the most expensive ones, have technical advantages and their place on the market is growing.

In <u>small-size batteries for professional applications</u>, there are only two current technologies: Lead-acid and Nickel-Cadmium.

- For *professional cordless power tools*, the Nickel-Cadmium battery remains at the moment the only reliable technology; the TRAR indicates that lead-acid batteries are used in Germany, but we did not find no confirmation; Ni-MH batteries can be used but with severe technical⁵³ and economical⁵⁴ limitations.
- For *emergency lighting systems in buildings*, Lead-acid can be used. It is of low cost but because it presents low performances and low reliability, Nickel-Cadmium is generally preferred⁵⁵.
- In emergency lighting systems in aircrafts, the Nickel-Cadmium battery is also preferred for its reliability and its specific energy.

For <u>large-size batteries with industrial applications</u>, the market is shared between Lead-acid and Nickel-Cadmium.

- In stationary applications (power supply, power backup), Lead-acid is predominant due to its low cost. Nevertheless, the substitution by Nickel-Cadmium is under way, due to its higher performances. On the long term, the fuel cell would be a technology to take into account for stationary applications.
- In *mobile applications*, in railways and in aircrafts, Nickel-Cadmium battery remains the preferred technology, especially in critical applications (emergency breaking, emergency starting).

The market of <u>batteries</u> for the <u>electric vehicle</u> is shared between Nickel-Cadmium and Lead-acid. Lead-acid is mainly used in off-road vehicles whereas the Nickel-Cadmium has a predominance for on-road vehicles, Nickel-Metal Hydride, Lithium-Ion and Lithium-Polymer are currently produced at a pilot-scale level and are tested in road conditions. Probably, Nickel-Metal Hydride batteries would never reach the industrial-scale production for economic reasons⁵⁶. Lithium-Ion and Lithium-Polymer are the most promising technologies but have to be considered as long term candidates. Hybrid electric vehicles using fuel cells are currently evaluated but are not expected to reach the market before 10 to 20 years.

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Ni-MH cells are less suitable than NiCd for portable power tools because Ni-MH cells, unlike NiCd, cannot simultaneously be optimised to provide high capacity, high peak power and many deep discharges cycles. Moreover, Ni-MH batteries must be stored at a temperature between -10°C and 50°C, whereas NiCd may be stored at temperatures as low as -20°C (this may be important both for domestic users who often store tools in an unheated garage and professional users who store tools in vehicles).

The true cost of Ni-MH batteries would be between 30% and 40% higher than equivalent NiCd batteries. Furthermore, the through-life cost of Ni-MH batteries will also be much higher, because their life expectancy in terms of number of cycles is between one third and one half that of NiCd. Professional users will probably buy new battery packs (at a cost of typically 75 €); for domestic tools, it is often necessary to replace the entire tool because it is a sealed unit and the battery cannot be removed. It should be also noted that the shorter life cycle of Ni-MH cells would therefore double or triple the number of cells for disposal.

Emergency lighting systems are installed in building for the safety of people by providing adequate illumination on Escape ways, illuminating Safety signs, providing anti-panic lighting and lighting of high risk areas of power failure. A key consideration in choosing batteries for these self-contained emergency units is therefore reliability. At present time, the most reliable way to ensure that those criteria for emergency lighting units are met, is by using rechargeable batteries under permanent charge, which is not possible with either Ni-MH or Li-ion batteries. The limitations associated with lead-acid batteries are not well documented.

The Toyota RAV 4 has often been cited as an example of the electric vehicle powered by a NiMH rechargeable battery, (marketed principally in California and not on offer by Toyota in Europe), providing a suitable alternative to NiCad powered electric vehicles. However, Toyota Motor Corporation discontinued production of the RAV4 Electric Vehicle worldwide in spring 2003.

3.6.3.3 Conclusion About Feasibility

The following table presents, for each battery application, technologies available on the market. As the key objective of the battery directive is to prevent the release of hazardous substances to the environment, the following table indicates also viable substitutes of portable NiCd batteries other than lead-acid batteries (which contain lead, another hazardous substance). In the last column of the table, we indicate where commercially viable substitutes are available.

Portable NiCd Batteries Substitutes

battery segment		application	EU NiCd battery sales (tonnes/year)	
nortable	household	-cellular telephones, -portable computers, -camcorders, -digital cameras, -remote control toys, - other small household appliances (small vacuum cleaners, shavers,)	3 600	
portable batteries (< 1 kg)		cordless power tools	3 950	
G,		cordless power tools	1 800	
	professional	emergency lighting systems (building, aircraft)	3 050	
		medical equipment	200	
industrial use (> 1 kg)	stationary	-power supply (hospital operating theaters, offshore oil rigs, standby power in industry, emergency power system in airports, large telecommunication station,), -power back-up (large computer systems in banks and insurance companies,)	2 600	
use (Fing)	mobile			
	specialized	200		
electric		600		
vehicles		on-road vehicles	600	
		total	16 000	

Market segment whe	re a ban on the use of Cd feasible in 2003	in batteries is technically
Viable substitutes with modfied performances and cost are available	Viable substitutes other than lead-acid batteries are available, with modfied performances and cost are available	Viable substitutes other than lead-acid batteries are available with neither economic nor technical impact
YES	YES	YES
YES	YES	NO
YES	YES	NO
YES	NO	NO
?	?	?
YES	NO	NO
YES	NO	NO
?	?	?
YES	NO	NO
YES	NO	NO

A ban on batteries containing cadmium could be feasible for one market segment: households applications, except cordless power tools where significant negative technical impacts are expected. Other segments do not have substitutes other than lead-acid batteries.

Economic and social impacts of such a ban are discussed in the next sections.

Remark: an alternative to a ban is to establish effective collection schemes with high collection rates. This option is assessed in section 3.5 page 89.

3.6.4 Other Impacts

Caveats: As no facts were available during the short time of this study, we gathered in this section qualitative information from industry sources and established first order assessment of economic and social impacts for the NiCd batteries ban option, without pretending having covered the entire issue.

3.6.4.1 Market Structure

- Four types of industrial players are involved during the life of portable NiCd batteries:
- NiCd cells producers,
- assemblers of NiCd cells into packs,
- incorporators of NiCd packs into equipments,
- retailers.
- NiCd cells producers

SAFT is the last European producer, with two plants producing both portable and industrial NiCd batteries, one in France and one in Sweden, and plants recently acquired producing industrial NiCd batteries in Spain and Germany.

According to industry sources, in France and Sweden, SAFT yearly sales are 600-700 million Euros, approximately 2/3 for industry batteries segment and 1/3 for portable batteries segment. To produce both industrial and portable batteries, 2000 to 3000 persons are employed by SAFT.

SAFT produces primarily NiCd batteries (more than 85% of its yearly sales according to industry sources). It also produces alternative technologies (NiMH and Li-ion), mostly for niche markets.

Other producers (Varta, Panasonic, Moltech... - see table in section 3.6.3.1.4 page 164) either produce outside Europe (mainly Asia) or import portable NiCd batteries produced with low costs in China for instance.

Other industrial players

No factual information were available during the study about other industry stakeholders.

However, it is likely that they consist of various profiles of companies for the assembling process such as SMEs and cells producers integrating the assembling stage (upstream integration).

■ The introduction of the ban on portable NiCd batteries for households applications except cordless power tools would affect about 30% (weight) of portable NiCd batteries (3 600 t out of 12 600 t in 1999) and about 22% of total NiCd batteries (3 600 t out of 16 000 t in 1999). Sales impacts are likely to be different as pricing differ.

It is not easy to predict what would be the effects on the market structure:

Risk of side effect for the whole portable NiCd batteries industry

A ban on only one segment of NiCd rechargeable batteries is likely to be generalized to other NiCd segments, even if not required legally. Some actors may decide to anticipate a possible extension of the regulation or may simply misunderstand the actual scope of existing regulation. However, the existence of alternative technologies is a prerequisite for this generalization to arise.

Risk of side effect for part of the whole rechargeable battery industry

The economic balance of some industrial players may be modified: some could be affected by a loss of profitability since NiCd batteries would bring comfortable margins, at least in some cases (their entire industrial activity could then be affected); others, producing primary batteries, could benefit from the opportunity that a ban of some rechargeable batteries could represent for primary batteries.

Risk of increase in outsourcing outside Europe

SAFT may decide to develop its NiMH and Li-ion market share on segments other than niches. But the competition with low price NiMH and Li-ion batteries coming from China in particular may make difficult to reach a good return on investment and brings SAFT to outsource production outside Europe or import rechargeable batteries as other producers.

Risk of domino effect

Through a domino effect, importers, assemblers and incorporators will be affected too. SMEs may be more sensitive to a ban, in case they can not switch to other technologies (if any).

Risk of market distortion

The difficulty to implement an efficient and reliable control system (to guarantee that no NiCd batteries are imported with household equipments other than power tools for instance) could benefit to non EU producers and result in competition distortion.

3.6.4.2 Economic Impacts

Caveats: Considering the difficulty to predict the evolution that will affect the market, it is not possible to assess the overall economic impacts of a ban. Only partial data are provided below, focusing on macroeconomic impacts.

Costs due to higher pricing

Based on today pricing, a substitution of household portable NiCd batteries by other rechargeable technologies would result in an increase of the selling price per unit, due to the fact that Ni-MH and Li-ion batteries are more expensive than NiCd.

Furthermore, the through-life cost of Ni-MH batteries will also be much higher, because their life expectancy in terms of number of cycles is between one third and one half that of NiCd.

Potential Sales Impact of a Ban of Household Portable Batteries (Other Than Power Tools)

	NiCd batteries	Example: NiMH batteries
Assumptions		
Selling price (at current	4.2 Euros / unit	4.6 to 5.2 Euros / unit
market structure)		+ 10 to 30%
Number of cycles	Χ	X / 3 to X / 2
Quantities	Quantities replaced	Replacing quantities
	3 600 tonnes / yr	3 600 tonnes x 2 or 3 =
		7 200 to 10 800 tonnes/ yr
Weight	22 g / unit	22 g / unit
Calculation		
Sales	685 Million Euros / yr	1 510 to 2 680 Million Euros / yr
		i.e.
		+ 825 to 1 995 Million Euros / yr
		to be paid for by consumers

A substitution by Ni-MH batteries, which selling price is today 10 to 30% higher than NiCd depending in particular on the country where it is produced (a 10% difference in selling price would be for NiMH produced in China) and whose life expectancy is less than half of NiCd, could result in additional costs for consumers of 825 to 1 995 million Euros.

This constitutes an upper bound estimate. Most likely, market will adjust to a lower equilibrium.

Costs due to more waste to be treated

Two types of additional waste will generate additional costs:

- For batteries themselves: because the life expectancy of NiMH batteries in terms of number of cycles is between one third and one half that of NiCd, the number of cells for disposal would double or triple.
 - The corresponding cost has a range of 0 Euros (if enough recycling capacities exist with a zero cost as today) to 1.3 Million Euros (in case of disposal of 10 800 tonnes at 120 Euros / t).
- For domestic tools: it is often necessary to replace the entire tool because it is a sealed unit and the battery cannot be removed.
 - Average selling price of domestic tools may be assessed at 50 60 Euros. No data are available to assess the overall additional cost at the EU level.

Other costs involved

- Control system: the enforcement of the ban will require the creation of a control system, in particular for importation of equipment containing rechargeable batteries (without being sure of the efficiency and reliability of the control).
- Recycling activities: portable NiCd batteries are recycled in the same plants as industrial NiCd batteries. Because most industrial batteries are today collected and recycled and because the ban would target about 30% of portable batteries on which 60% are assumed being hoarded (and thus not recycled), the total NiCd quantities recycled will not be significantly affected.

3.6.4.3 Social Impacts

Job in the EU

Only qualitative inputs can be provided.

Some will be created to produce substitutes, as due to shorter life expectancy, more substitutes are necessary to replace a given number of NiCd batteries. New jobs could also be created to control the system.

Other jobs could disappear at the different stages (production, assembling, incorporation...).

As for location of new jobs, it is possible that a foreign outsourcing will occur for production, in favor to countries with lower labor costs (in particular China), at least for part of the jobs created.

In addition, it should be remembered that indirect jobs are generally considered being impacted in the same proportion as direct jobs.

Acceptability (homogeneity with other European policies)

EU has decided to phase out the use of mercury, lead and cadmium in the directives concerning endof life vehicles (2000/53/EC, and the commission decision⁵⁷ C(2002)2238 of 27 June 2002 amending annex II of Directive 2000/53/EC) and in the directive on the use of certain hazardous substances in electrical and electronic equipment (2002/95/EC).

A ban on NiCd batteries would be consistent with this policy.

Perception by stakeholders

A ban on only one segment of NiCd rechargeable batteries would possibly constitute a confusing message for downstream industrial stakeholders (assemblers, incorporators, importers, retailers), who could easily generalized to other NiCd segments, even if not required legally.

As stated above, some players may decide to anticipate a possible extension of the regulation or may simply misunderstand the actual scope of existing regulation. However, the existence of alternative technologies is a prerequisite for this generalization to arise.

4(2)(b)of Directive 2000/53/EC".

According to this decision: "Cadmium in batteries for electrical vehicles should be exempt until 31 December 2005 since, in view of present scientific and technical evidence and the overall environmental assessment undertaken, by that date, substitutes will be available and the availability of electrical vehicles will be ensured. The progressive replacement of cadmium should, however, continue to be analysed, taking into account the availability of electrical vehicles. The Commission will publish its findings by 31 December 2004 at the latest and, if proven justified by the results of the analysis, may propose an extension of the expiry date for cadmium in batteries for electrical vehicles in accordance with Article

3.6.5 Summary of NiCd Ban Option Impact Assessment

	Collection	Collection Recycling		Economics		Baseline scenario 2007		Environmental profile	profile			
	rate	plant input			Additional	ρV	Iditional local r	isks linked to	Additional local risks linked to Cd dissipative losses	sesso		Global
					global risks linked to Cd		Aquatic				Terrestrial	environmental impacts (global
					dissipative losses	Fresh water ecosystems	Benthic organims (sediment)	Micro- organisms in STP	Marine water ecosystems	Atmosphere	Soil ecosystems	warming, air acidification)
Industrial NiCd batteries	80-90% % of spent batteries	> 95% of collected		Recycling costs of			? (existing Cd		٥٠	د	No after 10 years	Benefits (impacts due to collection and
	20-25% of		Recycling	large and portable NiCd: 0 to 300 Euros / t	None (NiCd batteries do	°Z	concentration has already eco- toxicological effect)	o Z	(no toxicity data of cadmium in marine water)	(no toxicity data of cadmium in the air)	Yes after 50 years exposure	recycling process are lower than impacts avoided from production of virgin cadmium saved)
Portable NiCd batteries	Spent batteries 50-60% of spent batteries availalable for collection (~60% hoarded)	100% of collected	Collection disposal NiCd: ~120 Eu Incineration Sales of and landfill NiCd for househo except p except p (tryp: 3600 (tryp: 3800 (tryp: 380	Collection and disposal of portable NiCd: ~120 Euros / t and landfill NiCd for households uses except power tools: ~685 million Euros (hyp: 3600 t / 22 g/unit x 4.2 Euros/unit)		Yes / No The existence or absence of local risk depend on local characteristics: in particular, incineration and landfill facilities in conformity with EU regulations and applying existing risk reduction measures have no local risk whereas others have local risks for fresh water ecosystems	? (existing Cd concentration has already eco- toxicological effect)	Š	No (no emissions)	? (no toxicity data of cadmium in the air)	o Z	c.

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Policy options		-	Impact Assessment	
	Technical feasibility	tiy Economic impacts	Environmental impacts	Social impacts
in 1999	666			
Ban on industrial NiCd (and electrical vehicles)		No viable substitute other not assessed because no viable substitute than Ld-acid	No benefits when considering risks linked to Cd dissipative losses (primarily linked to incineration and landfilling and most of industrial NiCd are believed to be collected and sent to recycling)	not assessed because no viable substitute
Ban on portable NiCd for professional 9 000 t uses and households	No viable substitute other than Ld-acid or with technical impacts	le other sid or not assessed because no viable substitute nical s	not assessed because no viable substitute	not assessed because no viable substitute
Ban on portable NiCd for households uses 3 600 t except power tools		Costs due to higher selling price of substitutes: + 825 to 1 995 million Euros per year Costs due to more batteries to be treated (1): + 0 Euros to 1.3 million Euros costs due to more frequent equipment acid with no major technical impacts system Costs to implement and monitor a control system Risk of unfair competition (in case of lack of efficiency and reliability of control system)	Risks linked to Cd dissipative losses: - for incinerators and landfill facilities in conformity with European regulation: no impact - for incinerators and landfill facilities not in conformity with European regulation: risk still exist until all spent NiCd batteries (including those hoarded (2)) are discarded . Other impacts: - number of batteries for disposal would double or triple (1) - waste due to more frequent equipment replacement (1)	Employment: - D jobs created – jobs lost > 0 ? - New jobs location: possibility of an outsourcing outside Europe for production of substitutes - Acceptability (homogeneity with other European policies): high - Perception by stakeholders: risk of generalisation to other NiCd batteries not legally concerned by the ban

(1) The life expectancy of NiMH batteries in terms of number of cycles is between one third and one half that of NiCd. So the number of cells for disposal would double or triple. And for domestic tools, it is often necessary to replace the entire tool bec (2) about 60% of rechargeable batteries are considered being hoarded

3.7 OPTIONS ABOUT STAKEHOLDERS' RESPONSIBILITY

- Preliminary remark: we do not pretend to cover the entire issue about producers' responsibility in this study. However, it seemed necessary to elaborate a little bit about the issue because different concepts are used by stakeholders and impacts to be assessed depend on the type of responsibility considered.
- It seemed useful to first define the concept by distinguishing three types of responsibility:
- Legal responsibility: who is legally responsible for reaching the targets set up in the directive?
- Financial responsibility: who is responsible for covering the costs of collection, sorting and recycling?
- Organisational responsibility: who is responsible for organising collection, sorting and recycling?

As a matter of fact:

- A directive can define stakeholders' responsibility either only at the legal level or both at the legal and financial level or even at the organisation level as well.
 - *Remark*: it should be noted that the more levels defined in the directive, the less the subsidiary principle respected.
- The economic, environmental and social impact depend on the type of responsibility which is defined as shown hereafter.
- For each type of responsibility, two main options exist:
- Producers' responsibility, where the obligation falls on producers,
- Shared responsibility, where the obligation is shared between producers and other stakeholders (mainly municipalities and retailers).

We found worthwhile to add another options for both the financial and organisation responsibilities that we called 'partial shared responsibility' in order to be able to distinguish between to different levels of split possible between stakeholders. As a matter of fact, in a shared responsibility, the producers' responsibility may begin at collection facilities or only later after sorting for instance. There are also cases where producers reimburse to municipalities part of their collection costs.

Possible Options for Stakeholders' Responsibility

Financial responsibility (1)

Organisational responsibility

responsibility		
Policy option 2: about	legal and financial responsibility	
Possible types of stakeholders	'responsibility in a directive or in nation	al implementation
L1 - Producers' responsibility Obligation for producers to set up and operate a take back in view of recycling products they put on the market.	F1 - Producers' responsibility Producers are fully responsible for covering all costs (they directly pay for them or reimburse total municipalities expenses).	O1 - Producers' responsibility It is likely to result in the creation of a collection system with its own logistic
L2 - Shared responsibility Obligation for producers to take back and recycle what is	PC C T S R Producers Others	PC C T S R Producers Others
collected by other stakeholders (municipalities, retailers).	F2 - Partial shared responsibility Producers cover costs for recycling and - transport costs from collection facilities as well as sorting, - or reimburse part of their costs to other stakeholders.	O2 - Partial shared responsibility Municipalities (and retailers) take care of pre-collection and collection and producers of other stages.
	PC C T S R Producers Others Others Others Others	PC C T S R Producers ? ?
	F3 - Shared responsibility Producers cover costs for recycling (and maybe sorting). Municipalities (and retailers) cover other costs.	O3 - Shared responsibility Producers take care of recycling (and maybe sorting) and municipalities (and retailers) of others.
	PC C T S R Producers ?	PC C T S R Producers ?

NB: a large number of combinations between different types of legal responsibility, financial responsibility and organisational responsibility are theoritically possible and exist in the framework of other directives (see next table).

(1) PC = pre-collection (containers...), C = collection, T = Transport, S = sorting, R = recycling

Legal responsibility

Policy option 1: only about legal

Possible scopes for stakeholders' responsibility in the directive

Stakeholders' Responsibility - Example of Other Directives

Legal	Financial	Organisational	Example of existing
responsibility	responsibility	responsibility	directives

Scope for stakeholders' responsibility in directive

Policy option 1: only about legal	Packaging directive
Policy option 2: about legal and financial responsibility	WEEE directive ELV directive

Types of stakeholders' responsibility in national implementation

	F1 - Producers'	O1 - Producers' responsibility	Packaging directive: A, D
L1 - Producers' responsibility	responsibility	O2 - Partial shared responsibility	Packaging directive: B
	F2 - Partial shared responsibility	O3 - Shared responsibility	WEEE directive: Sw (1)
L2 - Shared	F2 - Partial shared responsibility	O2 - Partial shared responsibility	Packaging directive: Dk, F, Fi, It, Sp
responsibility	F3 - Shared responsibility	O3 - Shared responsibility	Packaging directive: NL, UK WEEE directive: NL (1)

⁽¹⁾ prior to WEEE directive implementation

■ The following table attempts to summarise the economic, environmental and social impacts that can be expected for each option. These impacts do not concern only batteries but the analysis performed is relevant for other types of waste.

If a directive defines only legal responsibilities, no major differences can be expected between producers' and shared responsibility for the three categories of impacts considered.

Some impacts are more related to the financial responsibilities and others to the organisational responsibilities.

Compared to a producers' organisational responsibility, a shared organisational responsibility:

- Is likely to allow more easily an optimisation of waste collection by municipalities and thus a reduction of total costs and of environmental impacts.
 - However, in case of partial shared financial responsibility where producers reimburse partly municipalities expenses, municipalities may have less incentive to optimise their costs and these benefits of shared responsibility principle may not exist.
- is more favourable to local jobs creation (proximity principle).

Compared to a producers' financial responsibility, a shared financial responsibility:

- from the economic point of view, is more favourable to producers and less to municipalities and retailers of course, and more favourable to end users and less to tax payers (because all tax payers may pay, not only end users as consumers).
- is more favourable to local jobs creation (proximity principle).

And a producers' financial responsibility:

- has no major economic impact on municipalities and on tax payers and is thus more favourable to the polluter-pays principle (end users will pay total costs as consumers),
- is likely to be more favourable to the design of products more environmentally friendly because producers may try to design product integrating end-of-life considerations in view of reducing endof-life costs),
- is more favourable to the internalisation of waste management costs in purchasing price of products, as the integrated product policy developed at the EU level may give priority in the future.

Impact Assessment of Policy Options About Stakeholders' Responsibility

Policy options						드	Impact Assessment	sment					
Stakeholders' responsibility	Collection and re efficiency	Collection and recycling efficiency		Econor	Economic impacts	w		Environmental impacts	impacts		Soci	Social impacts	
	For waste whose recycling is economically balanced	For waste whose recycling is not economically balanced	Total costs (Euros / t collected)	Paid for by producers	Paid for by municipaliti	Paid for by end users	Paid for by tax payers	Waste management	Eco-design of products	Number of jobs (4)	Proximity principle	Acceptabili with oth With oth Polluter-pays principle (3)	Acceptability (homogeneity with other policies) Internalisation of costs of waste management in wrinciple (3) purchasing price of products (7)
Legal responsibility													
Producers' responsibility	to comi oly	C					o do spacao	Danande on etabahaldare' financial raenonaihilito	Willidianona				
Shared responsibility	NO III bacı	·-						ימאקוסוטקט ווומווטמו א	Sponsibility				
Financial responsibility		'											
Producers' responsibility			Likely to be more impacted by organisational responsibility than by financial responsibility: - if producers are responsible for	Less favourable to producers	No impact to municipaliti es	Less favourable to end users (will pay for total costs as consumers)	No impact	Likely to be more impacted by organisational responsibility than by financial responsibility as for total costs: - if producers are responsible for	More favourable (even more in case of individual responsibility) (6)	More tayourab the favourab to favourab the favourab transfer from the favou	More impacted by organisational responsibility than by financial responsibility: more favorable for local jobs if organised by municipalities	More favourable (consumers will pay for total costs)	More favourable
Partial shared / Shared responsibility			collection, a dedicated collection system is likely to be created. - if municipalities are responsible for collection, they can optimise it with other waste management (5).	More favourable to producers	Less favorable to municipaliti es	More favourable to favourable to favorable to (because all municipaliti tax payers tes consumers)	Less favourable to tax payers tax payers tax payers all tax payers may pay, not only batteries consumers)	collection, a dedicated collection system is likely to be created. -if municipalities are responsible for collection, they can optimise it with other waste management (5).	Less favourable	Less N favourab fc	More favourable for local jobs	Less favourable (costs shared between tax payers and consumers)	Less favourable

⁽¹⁾ or retailers
(2) if municipalities optimised collection
(3) exisBng folicly n telligence Service
(4) including in social enterprises which have been active for many years in Europe in waste management
(5) this authorogasemesy leaved it Etotel nor pendial coopings of the higher incentive to design products integrating end-of-life considerations
(6) the higher financial responsibility for producers, the higher incentive to design products integrating end-of-life considerations
(7) forecast policy (Integrated Product Policy)

4 CONCLUSION

4.1 SUMMARY OF THE IMPACTS OF POLICY OPTIONS

4.1.1 Quantitative Policy Options About Total Batteries

- When considering the baseline scenario for 2007, the highest policy options to be studied for all spent batteries, a collection rate of 70-80% and a recycling plant input of 90%, are already reached due to the fact that:
- 80 to 95% of spent starter batteries, which represent about 65% of all spent batteries, are believed to be collected and more than 95% of them sent to a recycling plant,
- 80 to 90% of spent industrial batteries, which represent about 20% of all spent batteries, are believed to be collected and more than 95% of them sent to a recycling plant.
- No major additional environmental impacts are thus expected for policy options about all batteries.
- Regarding economic impacts, the setting up of mandatory targets will require to implement monitoring systems for all types of batteries, in particular starter batteries and industrial batteries where statistics do not exist at all in most countries today. This will generate costs, without being certain of the reliability of the measurements considering the high levels already reached.
- As for social impacts, job would be created with the implementation of monitoring systems.

4.1.2 Quantitative Policy Options About Starter Batteries

■ In the baseline scenario for 2007, 80-95% of spent starter batteries are believed to be collected and more than 95% of them sent to a recycling plant. We would be between the 80-90% and 90-100% policy options to be studied for collection rate and above the highest policy options for recycling.

It should be noted that no statistics exist at the European level and in most countries. But where data are available, the highest values of the range are reached⁵⁸. The lowest values are assumed to reflect the situation in countries where starter batteries collection would be less developed.

- Economic impacts
- Baseline scenario: lead recycling is financially self sufficient.
- Economic impacts are mostly independent from the level of collection rate (for the recycling plant input considered 75%⁵⁹). They are rather linked to their mandatory aspect: having mandatory targets will involve costs to monitor, without being certain of measurement reliability (because high results are believed to be already achieved).
- Other additional costs are likely to be not significant, even for countries where starter batteries recycling is less developed (because lead recycling is financially balanced).

It is possible that the quantities collected declared by MSs include batteries not only from 4 wheel passengers cars but also from 2 and 3 wheel vehicles as well as from professional and industrial vehicles (agricultural vehicles, trucks, buses, military vehicles...), which are not necessarily included in batteries sales declared. In that case, this difference in scope would result in an overestimation of collection rate.

If recycling targets higher than 90-95% of collection (i.e. higher than those considered here) would be considered, market efficiency could be hurt. As a matter of fact, this could oblige the industry to reduce the temporary storages they use as a hedging effect, which could affect their capacity to adjust when facing low lead prices. The risk is that lead recycling could become no more financially self sufficient, which would oblige producers to create a collective system to finance recycling.

- Environmental impacts
- Baseline scenario:
 - Positive consequences of recycling: most of lead (heavy metal) is already diverted from waste.
 - Negative consequences of recycling: environmental damages linked to collection, transport and re-processing (in particular to air) are higher than benefits brought by virgin material savings.
- Positive consequences of recycling increase with collection and recycling targets increase (the higher the collection and recycling targets, the higher the lead diverted from waste).
- Negative consequences of recycling decrease with recycling targets increase (for a given collection target, the higher recycling target, the lower negative consequences of recycling: recycling benefits increase more than transport negative impacts).
- Social impacts
- As for economic impacts, social impacts are mostly independent from the level of collection rate. They are rather linked to their mandatory aspect: having mandatory targets will involve the creation of a monitoring system, with new jobs.

4.1.3 Policy Options About NiCd Batteries

4.1.3.1 Quantitative Options About NiCd Batteries

■ In the baseline scenario, industrial NiCd batteries already reach the highest collection target (80-90% of spent batteries).

But they only represent 1/5th of total spent NiCd batteries and collection rate of portable NiCd batteries is estimated at 20-25% in the baseline scenario.

To reach the total targets contemplated for NiCd batteries (60-70% or 70-80% or 80-90%), targets 10 points lower than for total spent NiCd batteries would be necessary for portable NiCd batteries (50-60%, 60-70%, 70-80%).

This is technically possible, but will require both:

- current domestic hoarding behaviours to be reduced significantly,
- refractory persons to participate to separate collection.

As a matter of fact, with current level of domestic hoarding (estimated at 60% of spent rechargeable batteries), collecting 50-60% of spent portable NiCd batteries means collecting more than what is assessed being available for collection.

■ In view of collecting portable NiCd batteries, the directive could either adopt collection and recycling targets focusing on portable NiCd batteries or on all portable batteries.

It is not easy to compare these scope options in terms of collection efficiency because results vary in a large range on the ground. Most of member states who launched a collection system following the current directive implementation decided to collect all portable batteries (A, B, D, F, NL, Sw). 17% to 62% of all spent portable batteries are collected according to country (systems more or less

developed, different stakeholders responsibility, different equipments...). Two others (Dk, Nw) focused on portable NiCd and collect 40-50% of spent portable NiCd batteries.

The question should be asked if schemes focusing on portable NiCd batteries can reach policy targets under consideration. As a matter of fact, despite very high financial incentives for collectors to collect since 1996, only 43% are collected in Denmark.

Economic, environmental and social impacts are worthwhile to assess for both scope options.

It is even necessary to distinguish between 3 schemes, because for a given scope option, countries have still different possibilities to implement the directive which will generate different impacts.

Possible Scope Options for the Directive and Possible Schemes at National Level

	Ро	ssible schemes at nationa	al level
Possible scope options for the directive	Scheme 1 – Collection and recycling of portable NiCd batteries	Scheme 2 – Collection and recycling of all portable batteries	Scheme 3 – Collection of all portable batteries and recycling of portable NiCd
Collection and recycling targets focusing on portable NiCd batteries or on all portable batteries	x	x	x
Collection and recycling targets covering all portable batteries		x	

Economic impacts

Scheme 1 – Collection and recycling of portable NiCd batteries:

- For countries which have already adopted this scheme (Dk, Nw) and for countries which have developed no scheme till now, it is not relevant to assess the additional costs because it is possible that this scheme does not allow to reach policy targets under consideration.
- For countries which have already adopted scheme 2 (A, B, F, NL, Sw) or 3 (D⁶⁰),
 - Some of them already reached the highest option (70-80% of spent batteries): no impacts are expected.
 - For others, collection could develop with no major additional costs.

Scheme 2 – Collection and recycling of all portable batteries:

For countries which have already adopted this scheme, several of them are expected to reach the lowest target contemplated (50-60% - maybe some could be between 60-70%) (for some of them, the implementation of the WEEE directive which would give about 5 additional points could help). For the others, they may still be at about 30% of spent batteries, with high domestic hoarding.

For countries which have adopted scheme 1 or no scheme, very low collection rate will be reached in 2007.

Germany is actually between scheme 2 and 3 since not only NiCd is recycled but also other small batteries, those whose recycling cost is judged not being too high (67% of what is collected in 2003 is recycled)

- The economics of collection and recycling of all portable batteries is impacted by the following parameters:
 - Choice of collection scheme (without being able to associate a type of collection to a level of cost) and recycling technologies (higher cost in dedicated plants compared to other technologies): our calculation were based on ranges to take these variations into consideration.
 - Economies of scale which were considered to affect recycling cost (for dedicated plants only) and administration costs (for administration cost, a step function was considered with economies of scale in between).
 - Important increase of communication expenses with the collection rate (in order to encourage households and professional users to reduce hoarding behaviors and participate to separate collection).

The economic model built results in the following shape:

- Up to a certain level of collection rate estimated near 40-50% of spent batteries, the costs remain quite constant, due to compensation of communication costs increase and economies of scale of both administration and recycling costs.
- After this threshold, a step of increase of administration costs is assumed, so the still increasing communication costs would not be compensated any more: the costs would increase faster with collection rate.
- Remark: the threshold appears to be near a collection rate of 40-50% of spent batteries, which correspond to about 60-75% of spent batteries available for collection when considering the current hoarding behaviors. Such level of collection rate is reach today in Belgium and Netherlands with no significant collection rate increase over the last years although already relatively high costs. Considering a high cost increase above that level seems then to be coherent with the situation on the ground.

Cost per tonne collected:

- A 10 point increase of recycling plant input (e.g. from 50-60% to 60-70%) results in an increase of 10 to 55 € / t collected, due to the fact that additional tons recycled are recycled at an average cost of 300-700 € / t of portable batteries entering a recycling plant (depending on the type of recycling technology and the economies of scale) instead of 90 € / t of batteries disposed of.
- For a constant recycling input plant, a 10 point increase of collection rate results in an increase of about 100-150 € / t collected for relatively low collection rates (e.g. 30 to 50% of spent batteries), and more than 1000 € / t collected for high collection rates (from 50 to 100%)⁶¹.

Overall budget concerned

In the baseline scenario 2007, a budget of 60 to 75 million Euros is already dedicated to separate collection and recycling of about 32-40 kt of portable batteries (collection rate of 20-25% of spent batteries).

A target of 50-60% of spent batteries in the directive would require a budget of 215-285 million Euros, i.e. additional costs of 140-225 million Euros (extra costs are assessed at 345-420 million Euros in case of a 60-70% target and 475-570 million Euros for 70-80%).

This is because of both communication and administration costs:

⁻ communication costs regularly increase as collection rate increases. For example, to double collection rate from 30 to 60% of spent batteries (45% to 85% of spent batteries available for collection with current level of hoarding), PR and communication budgets are estimated to be multiplied by 10 to avoid domestic hoarding (i.e. from 250 to 2500 € / t collected).

As for administration costs, economies of scale are observed until about 50 – 60% of collection rate, then a step of increase is considered being needed to ensure collection of higher quantities.

- Euros cents per unit sold:
 - The collection and recycling cost in € cent / unit sold does not vary much function of recycling plant input rate, for a given collection rate (maximum 0.8 € cent / unit sold).
 - For a given recycling plant input, costs vary from about 2 € cents / unit sold (30-40% collection rate) to 11 € cents / unit sold (60-70% collection rate) and about 17 € cents / unit sold (80-90% collection rate).
 - In case of producers' responsibility, these costs would be paid for by producers. They are likely to be transferred to consumers.
 - Sale prices vary a lot for a same type of battery: from 60 to 150 € cents / unit for an alkaline battery for instance
 - Collection and recycling costs thus represent 1.5 to 25% of the sale price depending on the level of collection objective.
 - In case of shared responsibility⁶², collection equipment and communication costs are considered being paid for by public authorities and / or retailers. Costs paid for by producers would then vary from about 1.5 € cents / unit sold (30-40% collection rate) to about 4.5 € cents / unit sold (60-70% collection rate) and about 5.5 € cents / unit sold (80-90% collection rate)... They would represent 1 to 9% of the sale price depending on the level of collection objective.
- Cost per tonne of all portable spent batteries

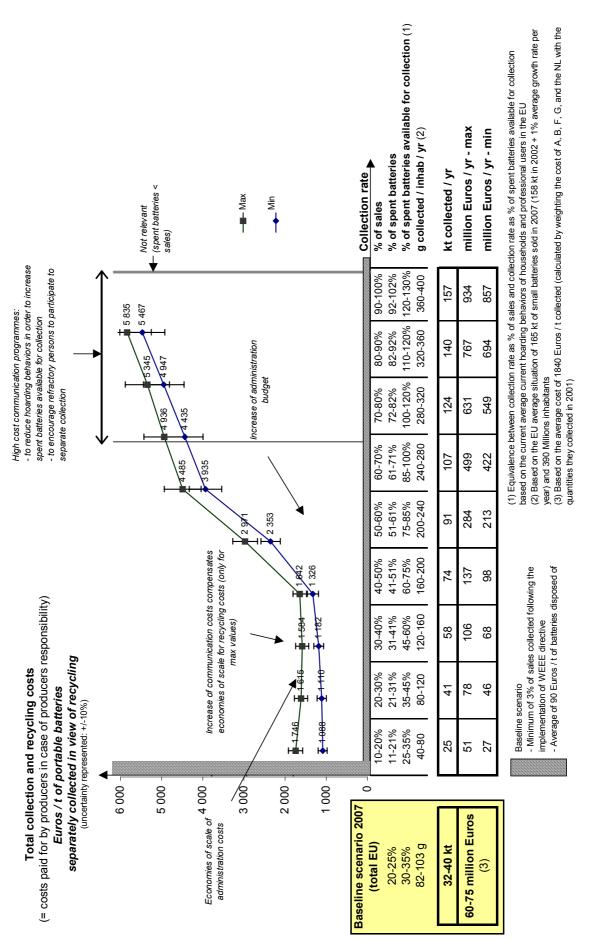
For countries where no separate collection exist (cost of 120 Euros / t of batteries collected with MSW and disposed of), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is 10-15 times higher for 50-60% collection rate to about 30 times for 70-80% collection rate.

The cost quantified here corresponds more to a partial shared responsibility because logistics is accounted for producers and only collection equipments and communication are deduced from what producers would have to pay. In cases where B | Ogistics is epald for the ynouncie of the covered by producers could be lower. 187.

Portable Batteries - Total Collection and Recycling Costs Function of Collection Rate (orders of magnitudes)

Euros / tonne collected

Collected batteries sent to recycling: 90 - 100%



Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- The difference considered here compared to scheme 2 is that only NiCd (and other batteries which can be recycled at a low cost, even a 0 cost) are recycled.
 - It is considered that 15% of collected portable batteries are sent to recycling, at an average cost of $100 \text{ Euros} / t^{63}$.
 - Scheme 3 presents costs which are lower than scheme 2 of about 100-250 Euros /t collected.
- For countries where no separate collection exist (cost of 120 Euros / t of batteries collected with MSW and disposed of), the cost per tonne of spent batteries (thus the total budget per year) for collection and treatment is about 11 times higher for 50-60% collection rate to 25 times for 70-80% collection rate.

Environmental impacts

Scheme 1 – Collection and recycling of portable NiCd batteries:

- The separate collection and recycling of portable NiCd batteries has positive environmental consequences for all the environmental indicators examined (dissipative losses of Cd, CO2 emissions, SOx emissions, NOx emissions, primary energy consumption), irrespective of the collection and recycling rates. As collection and recycling rates increase, the predicted environmental benefits are maximised.
- Remark: no data were available to assess the environmental consequences of other NiCd recycling technologies (metal plants, electric arc furnace...). They are likely to significantly differ from recycling in dedicated plants (different proportions of metals recovered, specific environmental advantages or disadvantages...).

Scheme 2 – Collection and recycling of all portable batteries:

 It was not possible to assess the overall environmental balance of this scheme since there is no LCA data available to conclude if the environmental consequences of collection and recycling of portable batteries other than NiCd are positive or negative.

Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- The separate collection of portable batteries in view of recycling portable NiCd batteries only (other portable batteries are disposed of) has positive environmental consequences for all the environmental indicators examined except NOx emissions, irrespective of the collection and recycling rates.
- For NOx emissions, the higher the collection rate and recycling plant input, the lower the damage (the environmental benefit of recycling increasing more than the NOx emissions due to transport).
- Remark: no data were available to assess the environmental consequences of other NiCd recycling technologies (metal plants, electric arc furnace...) as mentioned above.

-

with economies of scale (recycling cost = 0 Euros / t for 50-60% collection rate and above)

Social impacts

Two indicators have the same tendencies whatever the scheme is:

- Gender employment: waste management are not unfavorable to equal gender employment.
- Modification of end users behaviors: the higher the collection objectives, the higher necessary hoarding decrease.

Scheme 1 – Collection and recycling of portable NiCd batteries:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 140-160 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: potential negative impact on the perception of batteries by consumers ('some would be dangerous others not').
- Perception of waste management by end users: possible confusing message with other waste management policies⁶⁴.

Scheme 2 – Collection and recycling of all portable batteries:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 2000-2400 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: No difference between batteries in the perception by users.
- Perception of waste management by end users: Messages homogeneous with other waste management instructions to citizens⁶⁵.

Scheme 3 – Collection of all portable batteries and recycling of portable NiCd:

- Job creation at the EU level (if all countries would adopt this scheme): the current number of jobs would be multiplied by about 1.2 for 50-60% collection rate to about 2 for 70-80% collection rate (hypothesis: current level of employment is assessed being around 1600-2000 persons for collection and recycling of 20-25% of portable NiCd).
- Perception of batteries by users: No difference between batteries in the perception by users.
- Perception of waste management by end users: Messages homogeneous with other waste management instructions to citizens. But high risk to discourage end users from participating to waste separation⁶⁶.

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³⁴ Contrary to other waste, in the battery sector, recycling would be justified only by level of hazard.

Similarly to other waste, in the battery sector, separate collection is promoted independently of the hazardous content of waste.

⁶⁶ when they realise that most of separately collected waste are disposed of instead of being recycled

4.1.3.2 NiCd Batteries Ban Option

Environmental impacts

- From a global risks point of view, a ban of NiCd batteries is not relevant to reduce total human cadmium exposure because NiCd batteries do not represent a significant source of cadmium emissions to the environment (Cd emissions come mainly from other anthropogenic emission sources: fertilizers, fossil fuels, iron and steel...). (TRAR conclusion)
- As for local risks, there is no strong argument to support a ban on industrial NiCd batteries, because they do not represent a significant source of Cd emissions to the environment (local risks are primarily linked to incineration and landfilling and most of industrial NiCd batteries are believed to be collected and sent to recycling). (BIO conclusions from TRAR data)
- On the contrary, as far as portable NiCd batteries and local risks are concerned, BIO calculation of characterisation risk factors from TRAR data does not permit to exclude the relevance of a ban on portable NiCd batteries (BIO conclusions from TRAR data):
 - no risk assessment has been performed regarding air emissions,
 - no conclusion can be drawn for additional risk in sediment compartment because existing cadmium concentration has already eco-toxicological effect,
 - for the other compartments, the existence or absence of local risk depend on local characteristics: in particular, incineration and landfill facilities in conformity with EU regulations and applying existing risk reduction measures have no local risk whereas others have local risks for fresh water ecosystems.

On the other hand, a ban option will not necessarily result in a no risk situation because two flows of spent NiCd batteries will still have to be treated after the ban is into force: batteries which will become waste after the ban and batteries discarded after having been hoarded⁶⁷.

High rate collection and recycling of portable NiCd batteries and / or enforcement of existing regulations about incinerators and landfill facilities are likely to be good alternatives to a ban with a view to reduce local risks.

 Other environmental impacts of a ban can be mentioned. Because the life expectancy of NiMH batteries in terms of number of cycles is between one third and one half that of NiCd, the number of cells for disposal would double or triple. And for domestic tools, it is often necessary to replace the entire tool because it is a sealed unit and the battery cannot be removed.

Feasibility

A ban on batteries containing cadmium could be feasible for one market segment: households applications, except cordless power tools where significant negative technical impacts are expected. Other segments do not have viable substitutes other than lead-acid batteries.

Households applications other that cordless power tools represented 3 600 tonnes in 1999, i.e. about 30% (weight) of portable NiCd batteries and about 20% of total NiCd batteries.

^{60%} of rechargeable batteries are assumed being hoarded today by end users.

Other impacts

Economic and social impacts are difficult to assess because first no factual information were available and secondly the effect of a ban on the market structure (mainly the four industrial stakeholders: producers, assemblers, incorporators, retailers) is difficult to predict:

Risk of side effect for the whole portable NiCd batteries industry

A ban on only one segment of NiCd rechargeable batteries is likely to be generalized to other NiCd segments, even if not required legally. Some actors may decide to anticipate a possible extension of the regulation or may simply misunderstand the actual scope of existing regulation. However, the existence of alternative technologies is a prerequisite for this generalization to arise.

Risk of domino effect

Through a domino effect, importers, assemblers and incorporators will be affected too. SMEs may be more sensitive to a ban, in case they can not switch to other technologies (if any).

Risk of market distortion

The difficulty to implement an efficient and reliable control system (to guarantee that no NiCd batteries are imported with household equipments other than power tools for instance) could benefit to non EU producers and result in competition distortion.

As for macroeconomic impacts:

- Some of them were roughly quantified:
 - Costs due to higher pricing of substitutes: based on current prices, a substitution by more expensive Ni-MH batteries could result in additional costs for consumers of 825 to 1 995 million Euros (this large range reflects two elements: first, NiMH selling price is today 10 to 30% higher than NiCd⁶⁸ and NiMH life expectancy is one third to one half that of NiCd). Most likely, the market will adjust to a lower equilibrium.
 - Costs due to more waste to be treated: the doubling or tripling of the number of cells for disposal⁶⁹ would result in additional costs between 0 Euros (if enough recycling capacities exist with a zero cost as today) to 1.3 million Euros (in case of disposal of 10 800 tonnes at 120 Euros / t).
- Others can be qualitatively mentioned, mostly:
 - Costs due to more frequent equipment replacement: for domestic tools, it is often necessary to replace the entire tool when the battery is over because it is a sealed unit and the battery cannot be removed. The shorter life expectancy of NiMH batteries would then generate higher costs related to equipment purchase and WEEE management.
 - Costs to implement and monitor a control system, in particular for importations of equipment containing rechargeable batteries (without being certain of its expected efficiency and reliability).

Concerning social impacts:

- Employment:
 - Jobs are likely to be created, first at the production stage since 2 to 3 times more substitutes are today necessary to replace NiCd (due to lower life expectancy) and also to control the system.
 - Others could disappear at the different stages (production, assembling, incorporation, distribution) due to possible reorganisation of industrial and commercial activities.

Depending in particular on the country where it is produced; a 10% difference in selling price would be for NiMH produced in China.

⁶⁹ The life expectancy of NiMH batteries is between one third and one half that of NiCd as mentioned above for environmental impacts.

- Indirect jobs are generally considered being impacted in the same proportion as direct jobs.
- As for new jobs location, the possibility of a foreign outsourcing for production, in favor to countries with lower labor costs (in particular China), at least for part of the jobs created, can not be excluded from information available.
- Acceptability (homogeneity with other European policies): a ban on NiCd batteries in the Battery
 directive would be consistent with other recent directives (end-of life vehicles directives and
 directive on the use of certain hazardous substances in electrical and electronic equipment).
- Perception by stakeholders: a ban on only one segment of NiCd rechargeable batteries would possibly constitute a confusing message for downstream industrial stakeholders (assemblers, incorporators, importers, retailers), who could easily generalized to other NiCd segments, even if not required legally.

4.1.4 Policy Options About Stakeholders' Responsibility

- If the directive defines only legal responsibilities, no major differences can be expected between producers' and shared responsibility for the three categories of impacts considered (economic, environmental, social). As a matter of fact, impacts are more related to the financial responsibilities or the organisational responsibilities.
- Compared to a producers' organisational responsibility, a shared organisational responsibility:
- is likely to allow more easily an optimisation of waste collection by municipalities and thus a reduction of total costs and of environmental impacts.
 - However, in case of partial shared financial responsibility where producers reimburse partly municipalities expenses, municipalities may have less incentive to optimise their costs and these benefits of shared responsibility principle may not exist.
- is more favourable to local jobs creation (proximity principle).
- Compared to a producers' financial responsibility, a shared financial responsibility:
- from the economic point of view, is more favourable to producers and less to municipalities and retailers of course, and more favourable to end users and less to tax payers (because all tax payers may pay, not only end users as consumers).
- is more favourable to local jobs creation (proximity principle).

And a producers' financial responsibility:

- has no major economic impact on municipalities and on tax payers and is thus more favourable to the polluter-pays principle (end users will pay total costs as consumers),
- is likely to be more favourable to the design of products more environmentally friendly because producers may try to design product integrating end-of-life considerations in view of reducing endof-life costs),
- is more favourable to the internalisation of waste management costs in purchasing price of products, as the integrated product policy developed at the EU level may give priority in the future.

4.2 LIMITS OF THE STUDY AND FURTHER RESEARCH WORK TO BE PERFORMED

■ We encountered an important lack of statistics (sales, quantities collected, quantities recycled) mostly for starter batteries and industrial batteries other than NiCd.

Besides, choice between collection rate definitions still need to be made. The elaboration of methodologies to estimate them and monitor quantities arising may help to make the decision.

- According to information provided to BIO in the framework of the study, separate collection would not be well developed in accession countries. But information received is very partial at that stage. Further investigation would be necessary in order to describe more accurately the situation in accession countries.
- No system to accredit battery recycling facilities exists today. The analysis of the advantages and disadvantages of systems based on best available technology (BAT) principles and systems based on best available technology not entailing excessive costs (BATNEEC) principles would be necessary given that the different recycling technologies (mostly dedicated plants, metal plants, EAF) are likely to present different profile in terms of Recovery rate (proportion of metals which can be recovered), costs and environmental impacts and benefits.
- Regarding environment impact assessment, the lack of LCA data about portable batteries other than NiCd do not allow to conclude about the environmental consequences of their recycling. LCA study has to be carried out.

For NiCd, LCA are only available for their recycling in dedicated plants. No data are available for other recycling technologies (metal plants, electric arc furnaces...) whose environmental profiles are likely to significantly differ from dedicated plants.

- As for NiCd collection and recycling as well as collection step of other portable batteries, the simplified LCA performed in this study are based on data extracted from existing studies (ERM, 2000 and Environmental assessment of battery systems in life cycle management, C.J. Rydh, 2001). However, ERM data used for emission factors about transport are 5 times lower than data currently used by most of LCA studies. To obtain more reliable figures, further LCA work is necessary.
- Monetarisation of environmental impacts

Externalities are the costs imposed on society and the environment that are not accounted for by the producers and consumers, i.e. that are not included in market prices. They include damage to the natural and built environment, such as effects of air pollution on health, buildings, crops, forests and global warming; occupational disease and accidents; and reduced amenity from visual intrusion of plant or emissions of noise.

In this study, no monetarisation of environmental impacts was performed:

- First, existing results from ERM study can not be used directly in the present study since we recalculated environmental impacts.
- Secondly, to monetarise environmental impacts, we should have had to select a set of cost-factors (no ready-for-use database about external cost factors exist today in such a macro-economic and

LCA-context⁷⁰) and carry out calculation for the different battery segments and policy options under consideration (collection and recycling rates). This was not compatible with the short duration of the study.

 Most importantly, the benefit to reduce cadmium dissipative losses through the implementation of a collection and recycling system would not have been monetarised by lack of data. A considerable biais would have been introduced and as a result, it would not have been of great help for decision makers.

Further research work are necessary in that area.

■ The conclusions we were able to draw from the TRAR encountered the same limits as those mentioned in the TRAR, in particular the lack of data about atmospheric toxicity of cadmium.

BIO Intelligence Service

Monetarisation methods have been developed for years (and until quite recently, independently from LCAs). See Bio Intelligence Service study for recent results in that field: 'Study on External Environmental Effects Related to the Life Cycle of Products and Services', February 2003, DG Environment

APPENDIX 1: CONTACT PERSONS

Member States

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Accession Countries

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Hungary	József Kelemen		Ministry of Environment	KelemenJo@mail.ktm.hu
Latvia	Ilze Donina	Senior Desk Officer	,	phone:+371-7026515 fax:+371-7820442 ilze.donina@vidm.gov.lv

Industry

		CONTACT NAME	ACTIVITY	ADDRESS	TEL/FAX/EMAIL
EBRA	European Battery Recycling Association	Emmanuel BEAUREPAIRE			Tel. 33 (0) 1 53 45 84 67 Fax. 33 (0) 1 53 45 84 83 ebra@ebrarecycling.org beaurepaire@ces-pa.com
ЕРВА	European Portable Battery Association	Raynald DALLENBACH Rachel BARLOW	Chair of Government Policy Group of EPBA	Avenue Marcel Thiry, 204 B-1200 Brussels Belgium	Tel.: 32 2 774 96 02 Fax: 32 2 774 96 90 eyam.epba@eyam.be
EUROBAT		Alfons WESTGEEST Jurgen FRICKE	Secretary General	Eurobat Secretariat Avenue Marcel Thiry 204 B-1200 Brussels	Tel: +32 / 2/ 774 96 53 Fax: + 32 / 2 / 774 96 90 eurobat@eyam.be
CollectNiCad		Jean-Pol WIAUX		Titalyse SA Route des Acacias, 54 bis CH 1227 Carouge Geneva Switzerland	Tel. 00 41 22 342 27 67 Fax. 00 41 22 342 20 79 Mobile. 00 41 79 689 32 19 titalyse@bluewin.ch

Collection and Recycling Organisations

ORGANISATIONS	CONTACT NAME	TEL/FAX/EMAIL
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GRS - Germany	Jurgen FRICKE	Tel.: +49 40 237788
SCRELEC - France	Jeannine MICHAUD	Tel. +33 1 56 28 9251 jeanninemichaux@screlec.fr
STIBAT - Netherlands	Jan BARTELS Sander BROEAS	Tel. +31 79 3632090 jan.bartels@stibat.bl sander.broeas@stibat.nl

APPENDIX 2: FACT-SHEETS ABOUT COLLECTION SCHEMES OF PORTABLE BATTERIES EXISTING IN EUROPE

The following fact-sheets are included:

- Austria UFB,
- Belgium BEBAT,
- France SCRELEC,
- Germany GRS,
- Netherlands STIBAT.

Portable Batteries Main characteristics Austria UFB, 2001 Collection: Country Financial responsibility: Shared responsibility Scope General purpose batteries recycling: Metal plants A/ Quantities and Results Reached 3 251 tons Sales Spent batteries (assumption) 3 169 tons Spent batteries available for collection (assumption) 1 794 tons Collected quantities 1 440 tons Collection rate 44% of sales 45% of spent batteries 80% of spent batteries available for collection 179 g/inhabitant/yr Quantities entering a recycling plant 1 440 tons Recycling plant input 100% of collected B/ Responsibility and Organisation - No mandatory targets at the begining; recent objectives: 65% of collection rate by 2005 - Starting date of separate collection and recycling: 1991 (12 years old system) - Collection points: 7000 collection points (about 1100 inhab / collection point) C/ Costs Euros / t Cents / C.1 2001 situation collected battery sold (1) 1113 2,0 Source: EPBA, Nov 2001 C.2 Fees Cents / kg sold 90 Source: CollectNiCad, June 2003 (1) Hypothesis: average weight of small batteries = g 40

Main Characteristics

Collection: Bring back system to various collection points
Financial responsibility: Consumer responsibility (3)
General purpose batteries recycling: Dedicated plants of all ZnC and Alk batteries

Country Scope



A/ Quantities and Results Reached

 Sales
 3 955 tons

 Spent batteries (assumption)
 3 745 tons

 Spent batteries available for collection (assumption)
 2 632 tons

 Collected quantities
 2 368 tons

 Collection rate
 60% of sa

60% of sales 63% of spent batteries

90% of spent batteries available for collection

228 g/inhabitant/yr

Quantities entering a recycling plant 2 368 tons

Recycling plant input 2 300 tons

B/ Responsibility and organisation

- At the begining, high mandatory targets to be reached quickly (collection rate = 75% of batteries sold; threat of a high penalty: 80 cents / unit not collected). Because they were not reached (and considered not reacheable), they were revised. New targets: 60% in 2002 and 65% in 2004
- Starting date of separate collection and recycling: 1996 (7 years old)
- Collection points: a total of about 20 000 collection points (500 inhab / collection point); about 20% of collection points are located in super and hyper markets as well as schools and about 80% in municipal collection points; about 80% of quantities collected are collected with 20% of collection points available; 3 plastic bags per year are mailed by BEBAT to households they can use to store batteries and bring them back to collection points (they also allow to participate to a lotery).

Paid for by consumers (via producers)

Euros / t Cents /

- Collection: about 5000 collection points are collected automatically with an optimised time schedule and the others are collected when they call BEBAT
- Bulking up depot: 3 exist in Belgium
- Sorting: 1 sorting plant (one of the 3 bulking up depots); a partial sorting is also performed in another bulking up depot

- Sorted flows and destination

ZnC & Alk batteries (high or no Hg content)

NiCd batteries
Small lead acid batteries
Button cells

Recycling in dedicated
1 000 Euros / t
400 Euros / t
2 Recycling, F
400 Euros / t
8 Recycling, B
50 - 100 Euros / t
4 000 Euros / t
9 Recycling, B
4 000 Euros / t
9 Recycling, B

Button cells Recycling, B
NiMH batteries Recycling, F
Li & Li-ion batteries Storage, B

Budget

Approximative sorting, transport and recycling costs

(Euros / ton entering a recycling plant)

C/ Costs

C.1 2002 situation

_	kEuros	collected	battery sold (
Variable costs	5 221	2 205	5,3
Collection points (equipment)	132	56	0,1
Collection (logistic)	592	250	0,6
Sorting Transport	582	246	0,6
Recycling	1 279	540	1,3
Provision	268	113	0,3
Marking cost	2 368	1 000	2,4
Fixed costs	5 988	2 529	6,1
tion of plastic bags to households	1 206	509	1,2
Other PR & communication	2 721	1 149	2,8
Administration	2 061	870	2,1
Total	11 209	4 733	11,3

Paid for by local authorities or retailers

nul

C.2 Financial fees paid for by consumers (via

Distribut

producers) to BEBAT

NB: BEBAT operates on a per unit basis

Cents / battery sold Cents / kg sold ZnC & Alk batteries 12,39 428

Curso / t

Dudge

NiCd batteries 12,39 138

Source: BEBAT, July 2003

C.3 Costs evolution in the past

NB: the table presents total costs **except marking costs** (which correspond to the refund to producers of their expenses to mark batteries put on the market) because it is specific to Belgium

	t collected	collected	kEuros
1998	1 562	5 055	7 896
1999	1 834	5 092	9 339
2000	2 105	4 872	10 256
2001	2 325	3 806	8 849
2002	2 368	3 733	8 841

Source: BEBAT, July 2003

From 1998 to date:

- communication expenses increased then stabilised,
- collection expenses decreased due to the optimisation of collection circuits and time schedule,
- quantities collected regularly increased.

C.4 Expected costs evolution in the future

PR & communication expenses are planned to decrease because the maximum collection rate is considered to be reached; economies of scale are likely to happen for ZnC & alkaline batteries recycled in dedicated plants when more quantities arise in Europe (up to 600-700 Euros / t)

- (1) Hypothesis: average weight of small batteries = g 40
- (2) slightly negative if no sorting
- $(3) \ Belgium \ is \ the \ only \ MS \ where \ consumers \ are \ legally \ in \ charge \ of \ the \ financial \ responsibility.$

Main Characteristics

Collection: Bring back to sale & municipal collection points Financial responsibility: Partial shared responsibility General purpose batteries recycling: Dedicated plants of all ZnC & Al batteries

Country France Scope SCRELEC - 2002

A/ Quantities and Results Reached

Sales 25 245 tons 2001 Spent batteries (assumption) 24 274 tons 2001 Spent batteries available for collection (assumption 9 239 tons 2001 Collected quantities 2001 4 139 tons Collection rate

16% of sales

3 985 tons

17% of spent batteries

45% of spent batteries available for collection 69 g/inhabitant/yr

Quantities entering a recycling plant

Recycling plant input

Recycling rate (based on material output)

96% of collected 50 - 60% of material collected

B/ Responsibility and Organisation

- Mandatory targets since 2003: minimum of 30% of sales in 2006; no mandatory targets before
- Starting date of separate collection and recycling: 2001 (2 years old system)
- Collection points: two main systems exist, about 50% of batteries are collected through SCRELEC (collective scheme) and 50% through retailers (individual basis); about 13 000 collection points managed by SCRELEC and 10-15 000 collection points in super and hyper markets (a total average of 2000-2500 inhab / collection point)
- Collection: collection points collected when they call SCRELEC
- Bulking up depot: none
- Sorting: 2 plants (+ 2 small)
- Sorted flows and destination ZnC & Alk batteries Recycling in dedicated plants, F 1 000 Euros / t Approximative transport and NiCd batteries Recycling, F 300 Euros / t Small lead acid batteries Recycling, F 1 000 Euros / t recycling costs (Euros / ton

Button cells Recycling, F 2 600 Euros / t NiMH batteries Recycling, F 0 Euros / t entering a Li batteries Recycling with general purpose, F 2 000 Euros / t recycling plant)

Li-ion batteries Recycling, F 1000 Euros / t

C/ Costs

C.1 2002 situation

Paid for by producers Euros / t Cents / battery collected sold (1) Variable costs

Valiable costs	1 0 10	1,1
Collection points (equipment)		
Collection (logistic)	457	0,3
Sorting	լ 152	0,1
Transport	ſ	
Recycling	1 000	0,7
Fixed costs	790	0,5
PR & communication	290	0,2
Administration	500	0,3
Total	2 400	1,6
· ·	•	

Paid for by local authorities or retailers no data available

C.2 Financial fees paid for by producers

Cents / kg sold ZnC & Alk batteries 46 NiCd batteries Small lead acid batteries 130 NiMH batteries 175 Li batteries 91 Li-ion batteries Source: CollectNiCad, June 2003

(1) Hypothesis: average weight of small batteries = g 40

Main Characteristics

Collection Bring back system mainly to sale points Financial responsibility: Producer responsibility
Mostly metal plants (except higher Hg-conten General purpose batteries recycling: batteries which are disposed of)

Scope GRS - 2002

A/ Quantities and Results Reached

29 882 tons 28 732 tons Spent batteries (assumption) Spent batteries available for collection (assumption) 17 490 tons Collected quantities 11 256 tons Collection rate

39% of spent batteries

64% of spent batteries available for collection 137 g/inhabitant/yr

67% of collected

Recycled quantities (entering a recycling plant) Recycling plant input

B/ Responsibility and organisation

- No mandatory target
 Starting date of separate collection and recycling: 1998
- Collection points: about 160 000 collection points at sale points (installed by GRS) + about 30 50000 municipal collection points (i.e. a total of about 410 inhab/ collection point). 44% of all batteries collected by GRS Batterien came from the trade sector. The proportion of batteries collected from industry was 29%
- Bulking up depot: none
- Sorting : 3 plants (+ 1 under development) (overall capacity: 13000 tons)

- Sorted flows and destination Low or free Hg-content ZnC & Alk bat. Metal plants, D, F, A 180 - 700 Euros / t for transport and recycling

NiCd batteries Recycling, D. F. n.a. Small lead batteries Recycling, D n.a. Recycling, D, F Recycling, D Button cells n a NiMH batteries n.a. Li batteries Recycling, D n.a. Li-ion batteries Storage, F n.a.

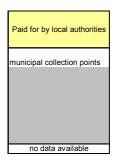
Higher Hg-content Zn & Alk batteries & Disposal, D

90 euros /t for transport and disposal mix batteries

C/ Costs

C.1 2002 situation

		Paid for	by pr	oducers
_		Euros		Cents /
_		t collecte	d	battery sold (1)
Variable costs	?	598		
Collection points (equipment) Collection (logistic)		?	150	
Sorting Transport		7	150	
Recycling (4)		?	268	
Disposal (5) Fixed costs	?	517	30	
PR & communication Administration		517 7	267 250	
Total		1 115		1,7



According to GRS, expenditures include, in addition to operating costs, the costs of public relations, the service centre and administration. Research and development also involved considerable expenditures in 2002

Source: for total costs: Success monitor - GRS Batterien, Hamburg, March 2003; for costs split: BIO assumption

C.2 Financial fees paid for by producers

ers	Cents / kg sold
ZnC & Alk batteries	40
NiCd batteries	51
Small lead acid batteries	27
NiMH batteries	24
Li batteries	78
Li-ion batteries	21
Source: C	ollectNiCad, June 2003

C.3 Cost evolution in the past

	t collected	Euros / t collect	te
1999	8 336	972	
2000	9 100	1 169	
2002	11 256	1 115	

Source 1999 & 2000 data: EPBA, June 2003: 2002 data: GRS

According to GRS, the specific costs in 2002 (1 115 Euros / t) were 5% lower than in 2001 (1 174 Euros / t).

C.4 Expected costs evolution in the future

According to GRS, costs for AlMn and ZnC batteries would come down to 100 - 200 Euros / t and more than 70% of all sorted batteries will be sent to recycling.

(1) Hypothesis: average weight of small batteries = g 40

(4) Hypothesis: 67% of collected quantities are recycled at an average cost of 400 Euros / t

(2) slightly negative if no sorting (3) A range of 180 to 700 euros /t entering a recycling plant

(5) Hypothesis: 33% of collected quantities are disposed of at an average cost of 90 Euros / t

Main characteristics

Collection:	Bring back system, with small chemical waste
Financial responsibility:	Partial shared responsibility
General purpose batteries recycling:	Metal plants + dedicated plants

Scope STIBAT, 2002

A/ Quantities and Results Reached

A/ Quantities and Results Reactied			
Sales	5 899 tons	2001	
Spent batteries (assumption)	5 751 tons	2001	
Spent batteries available for collection (assumption)	2 276 tons	2001	
Collected quantities	1 876 tons	2001	
Collection rate	32% of sales		
	33% of spent batteries		
	82% of spent batteries available for collection		
	116 g/inhabitant/yr		
Quantities entering a recycling plant	1 876 tons	2001	
Recycling plant input	100% of colle	ected	

B/ Responsibility and Organisation

- High mandatory targets: 80% in 1996 and 90% in 1998
- Starting date of separate collection and recycling: 1995 (8 years old system)
- Collection points: each citizen have received a KCA box at home and bring back the content (batteries mixed with small chemical waste) to about 10 000 collection points managed by STIBAT (sale points, about 4 000 schools, tent camps...) and 500-600 municipal collection points (about **1 500 inhab** / collection point). Some retailers may add some containers but they are not legally obliged to take back batteries.
- Bulking up: 1 central depot
- Sorting: 5 or 6 sorting plants

C/ Costs Paid by producers Euros / t Cents / battery C.1 2002 situation collected sold (1) Variable costs ? 1 550 Collection points (equipment) Collection (logistic) 450 Sorting 200 Transport Recycling 900 Fixed costs ? 1 968 PR & communication 1 568

Paid by local authorities

Source for total costs: EPBA, June 2003; for costs split: BIO assumption

C.2 Financial fees paid for by producers

Cents / kg of batteries sold 65
Source: CollectNiCad, June 2003

Administration

Total

3 518

4.5

NB: unit fees actually vary according to the weight of each battery unit

C.3 Costs evolution in the past

	t collected Euros / t collected		
1998	2 533	2 842	
1999	2 000	4 867	
2000	2 000	3 664	
2001	1 876	?	
2002 & 2003		3 518	

Source for 1998 to 2000 data: EPBA, June 2003 for collected quantities and Nov 2001 for costs

According to STIBAT, quantities collected are decreasing following public authorities cost cutting for KCA waste collection (less collection points, less trucks to collect, less communication).

C.4 Expected costs evolution in the future

According to STIBAT, cost increase are expected, in particular for communication, to compensate less and less involvment from public authorities.

(1) Hypothesis: average weight of small batteries = g

40

APPENDIX 3: EU SECONDARY LEAD SMELTERS

Country	Secondary Smelter	Lead capacity (t)
Austria	BMG Metall und Recycling	32,000
Belgium	Campine	45,000
	Fonderie et Manufacture de Metaux	15,000
	Umicore	200,000
France	Affinerie de Pont Sainte Maxence	45,000
	Metal Blanc	23,000
	Societe de Traitements Chimique des Metaux	20,000
	Societe de Traitements Chimique des Metaux	30,000
Germany	Berzelius Metall*	120,000
	BSB Recycling	40,000
	Metaleurop Weser*	90,000
	Metalhutten Hoppecke	12,000
	Muldenhutten Recycling und Umwelttechnik	45,000
	Varta Recycling	40,000
Italy	EcoBat (Paderno Dugnano)	50,000
	EcoBat (Marcianise)	40,000
	Ecological Scrap Industry	10,000
	Me.Ca. Lead Recycling	20,000
	Piombifera Bresciana	20,000
	Piomboleghe	20,000
Portugal	Sonalur	20,000
Spain	Derivados de Minerales y Metales	6,000
	Metalurgica de Gormaz	50,000
	Perdigones Azor	22,000
	Oxivolt	20,000
Sweden	Boliden Bergsoe	50,000
United Kingdom	Britannia Refined Metals	35,000
	H J Enthoven	85,000

^{*} These plants treat both primary and secondary feedstocks

Source: Eurobat, July 2003 – Primary source: "World Directory 2003: Primary and Secondary Lead Plants" published by the International Lead and Zinc Study Group, London – modified to reflect recent closures and additional data

Total number of smelters which process scrap batteries: 28

Total lead production capacity of the 28 plants: 1,210,000 mt