Consumer batteries not worth recycling, says DTI report

THE FORTHCOMING EC Directive on battery recycling should be limited to industrial and car batteries, together with the small amount of consumer batteries containing lead or cadmium, according to a study by consultants ERM for the Department of Trade and Industry (DTI).[1] Meanwhile, a separate study for the European Commission says a ban on nickel/cadmium (NiCd) batteries is not only feasible but possible before the proposed deadline of 2008.

A draft proposal for a Directive on batteries was issued in 1997 (ENDS Report 271, p 41). Within two years of its implementation, 75% of all spent consumer batteries would have to be collected, including at least 75% of those containing cadmium or lead, plus 95% of all industrial and car batteries, including at least 95% of those containing cadmium or lead. For both categories, 55% of the batteries separately collected would have to be recycled.

A final proposal for the Directive is expected from the Commission next year. To help it prepare a regulatory impact assessment of the proposal and inform its negotiating position, the DTI commissioned ERM to examine the costs and environmental benefits of a range of collection and recycling rates for consumer, industrial and car batteries.

The study assessed a range of collection and recycling scenarios for the three broad categories of battery. Three types of collection scheme were considered for consumer batteries - kerbside, a bring system, and the return of batteries to retail outlets.

Consumer batteries: ERM estimates that the amount of disposable consumer batteries – mainly zinc carbon and alkaline manganese – in the UK will rise from around 17,500 tonnes to 21,000 tonnes in the next five years. Arisings of rechargeable consumer batteries – mainly NiCd types – are projected to increase from 2,300 tonnes to 3,900 tonnes. The current recycling rate for consumer rechargeables is just 5%, while virtually no consumer disposable batteries are recycled.

Although progressively higher collection and recycling rates reduce the amount of batteries entering incinerators or landfills, the environmental impact of this waste "in an increasingly more tightly regulated sector...is hard to ascertain," says ERM. On the other hand, achieving high rates would lead to "significant" extra costs and a range of environmental impacts only partly offset by the benefits of recycling.

Assuming that mercury levels are low enough to allow batteries to be used in electric arc furnaces, the annual cost of kerbside battery collection and recycling tagged onto existing kerbside schemes for other recyclables is estimated to be 14 million Euros for the study's most challenging scenario – 75% collection and 60% recycling. A bring system is estimated to cost slightly more – 17 million Euros – but a take-back scheme would cost 111 million Euros.

A bring system would struggle to meet even a 30% collection target, while a combined kerbside and bring system would be needed to reach 75%. However, ERM points out that there is "no evidence...that a 75% collection rate can be achieved nationally at current levels of awareness and participation."

According to the life-cycle assessment methodology used by ERM, "the overall effect is for environmental impacts to increase as a higher proportion of consumer batteries are collected and recycled" – though this is partly due to the impacts associated with some of the collected batteries not being recycled.

Kerbside collection will incur environmental impacts "considerably in excess" of those associated with bring or take-back methods even if there is an existing kerbside scheme, says ERM, because households would need special containers for batteries.

Industrial and car batteries: Between 2000 and 2005, the quantity of waste industrial batteries – almost entirely lead acid batteries – will increase from 4,000 tonnes to 5,500 tonnes, while the quantity of lead acid car batteries is projected to drop slightly from 112,000 tonnes to 109,000 tonnes. Current recycling rates for car batteries and industrial lead acid batteries are around 90% because of demand from secondary lead smelters.

There would be virtually no additional costs for meeting the proposed collection and recycling targets for lead acid batteries as current rates have already reached this level. Nor would there be extra costs for industrial NiCd batteries if, as ERM assumes, the targets for batteries containing cadmium or lead are treated as applying to the total for both types added together.

However, if the targets are interpreted as applying separately to industrial NiCd batteries and lead acid batteries, the collection rate for industrial NiCd batteries would have to be 90%, of which 55% would have to be recycled – double the current recycling rate of 25%. ERM does not say whether this is possible but notes that a higher recycling rate could be achieved.

As with consumer batteries, the report says that all the environmental impacts increase as collection and recycling rates rise except for the diversion of metals from disposal.

Overall, ERM believes there is "little evidence" that the environmental impacts – "already mitigated by controls on waste management facilities" - associated with batteries entering the waste stream are significant. However, if current recycling rates were to fall, the amounts of lead and cadmium entering the waste stream "might require this conclusion to be revised."

ERM also claims that the environmental benefits of banning NiCd batteries would be largely duplicated by the effect of introducing recycling targets - without specifying how high these would have to be.

Meanwhile, a study for the European Commission's Environment Directorate by Stockholm University[2] has concluded that the proposed ban on NiCd batteries from 2008 seems "to offer a very wide margin for the transition to alternatives." An earlier date "would probably be more effective", with the exception of NiCd batteries for emergency power systems in hospitals and aircraft.

The study says that lithium-ion and nickel metal-hydride (NiMH) batteries are now standard in lap-top computers and mobile phones and will soon challenge NiCd batteries in the cordless power tools market, where Japanese tool manufacturer Makita already uses NiMH batteries for all of its products. NiMH batteries are also being used in typical NiCd battery applications such as emergency lighting, toys and home appliances.

NiCd battery producers are lobbying hard against the ban. They have offered a voluntary commitment to finance collection and recycling of 75% of portable and 95% of industrial NiCd batteries by 2003.

[1] Analysis of the environmental impact and financial costs of a possible new European Directive on batteries, from DTI Environment Directorate, Bay 425, 151 Buckingham Palace Rd, London SW1W 9SS.

[2] Substitution of rechargeable NiCd batteries at http://europa.eu.int/comm/environment/waste/nicd.htm

Department of Trade and Industry

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

November 2000

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

November 2000

Reference 6576

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For and on behalf of
Environmental Resources Management

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Position: ____________________________

Date: ____________________________

CONTENTS

E1 EXECUTIVE SUMMARY

E1.1 BACKGROUND

The introduction of a new European Commission Directive for Batteries and Accumulators is anticipated, and this is likely to have a range of obligations for Member States. The requirements of the proposed Directive are expected to impose financial costs associated with additional separation, collection and transport activities, as well as with the recycling process and the disposal of residues. There will also be revenue streams associated with the sale of materials recovered from recycled batteries.

The Directive is proposed for the purpose of securing environmental gains, largely associated with the control of hazardous substances in batteries currently disposed of in mixed wastes, but also in connection with the use of recovered, rather than virgin, materials. However, there will be environmental impacts accruing from the 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 proposed Directive, will be achieved at the price of increases in financial costs, offset by material revenues and avoided disposal costs, and a change in the balance of environmental impacts due to additional recycling and collection activities. The balance between the effectiveness of controlling hazardous substances and additional costs (in the broadest sense, ie including environmental impacts) accruing is likely to vary according to battery type and to the level of collection, separation and recycling required and achieved in practice.

ERM, with support from *Save Waste and Prosper (SWAP)*, were commissioned by the Department of Trade and Industry to carry out a study to assist the Department in preparing a Regulatory Impact Assessment and to inform the UK's negotiating stance during the passage of the proposed Directive. The study's aims were:

- to review the battery and accumulator market in the UK;
- to undertake an assessment of the balance of financial and environmental costs and benefits of a range of scenarios for the collection and recycling of batteries; and
- to assess the implications of the expected qualitative requirements of the proposed Directive.

E1.2 BATTERY LEGISLATION

E1.2.1 Existing Legislation

There are three principal EC Directives in existence that relate specifically to batteries and accumulators, in particular those containing mercury, lead and cadmium.

Directive 91/157/EEC harmonises national legislation on the treatment and disposal of batteries containing hazardous substances. It requires batteries containing more than 25mg of mercury, 0.025% cadmium by weight and 0.4% lead (ie lead acid batteries, cadmium-containing consumer and industrial batteries, and mercuric oxide batteries) to be separately collected for disposal and recycling where possible.

The 1991 Directive made provision for the development of a marking system for batteries covered by the legislation. Detailed arrangements were subsequently set down in Directive 93/86/EEC.

A further requirement of the 1991 Directive was a prohibition on the marketing of alkaline manganese batteries containing more than 0.025% mercury by weight (1). Additional marketing restrictions on batteries containing mercury were subsequently imposed by Directive 98/101/EC, prohibiting the marketing of batteries and accumulators containing more than 0.0005% of mercury by weight, and of 'button cells' containing more than 2% of mercury by weight.

The resulting substitution of mercury-containing batteries has led to around 98% of primary general purpose batteries falling outside the scope of the 1991 Directive. Nevertheless, these batteries also contain a range of other substances, some of which, notably zinc, lithium and nickel, may be classified under the hazardous waste list in certain circumstances.

E1.2.2 The Proposed Directive

The proposed Batteries Directive which the Environment Directorate-General seems likely to bring forward is currently at the interservice consultation stage within the Commission and its contents have not therefore been made public. The Directive appears likely to set targets for the collection and recycling of consumer, automotive and industrial batteries, accompanied by restrictions on batteries containing cadmium and provisions on battery and appliance marking and appliance design.

In particular, the proposed Directive is likely to specify the following collection and recycling targets for batteries, to be achieved by 2003 at the earliest:

- collection targets of 75% of the weight of all spent consumer batteries, including at least 75% by weight of those containing cadmium or lead;

(1) And 0.05% for alkaline manganese batteries for prolonged use in extreme conditions.

- collection targets of 95% of the weight of all spent industrial and automotive batteries, including at least 95% by weight of those containing cadmium or lead; and
- a recycling target of 55% by weight of all separately collected spent batteries.

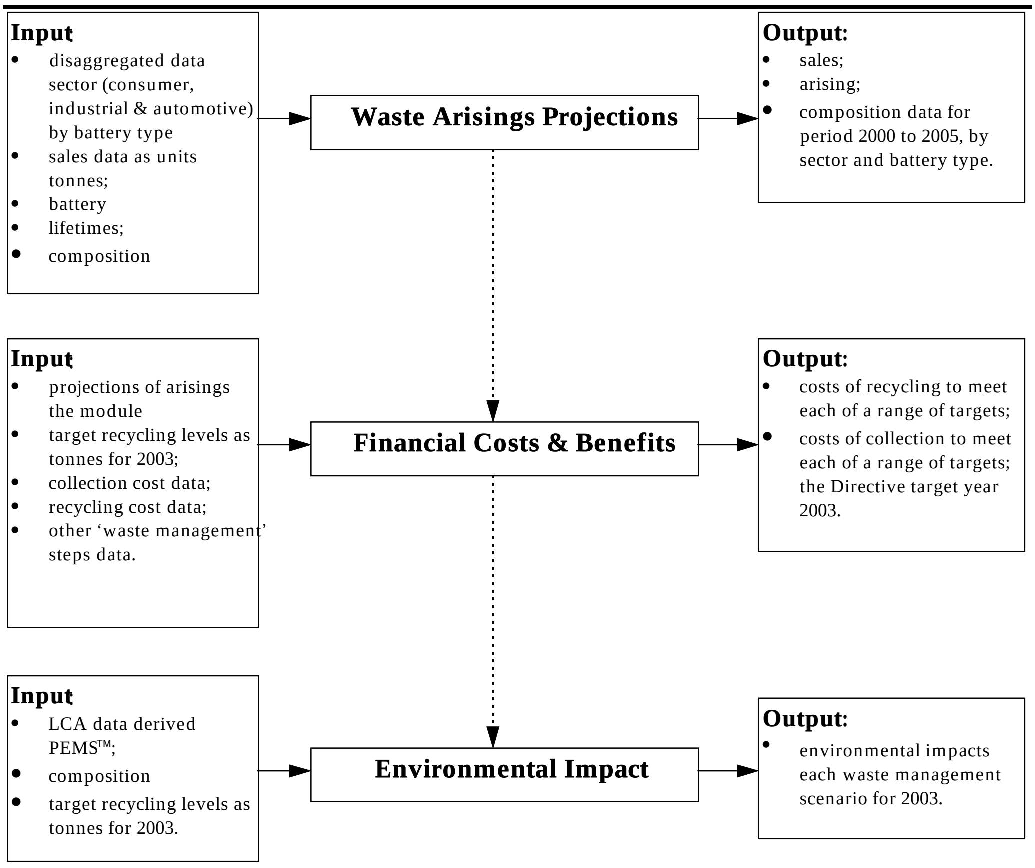
E1.3 BATMOD MODEL

To allow the flexible assessment of the financial and environmental costs of collection and recycling scenarios, a model, BATMOD, was developed by ERM which combines modules to:

- predict sales for each battery type (consumer, industrial and automotive);
- estimate waste arisings and material masses from battery sales;
- model the financial costs and benefits of collection and recycling scenarios; and
- estimate the environmental impacts associated with the collection and recycling of batteries in each scenario.

These apparently distinct elements are brought together in BATMOD in the form shown in *Figure E1.1*.

Figure E1.1 Model Structure and Relationships



E1.4 Battery Markets and Waste Arisings

Through discussions with battery and appliance manufacturers, industry associations, battery collection operators and battery reprocessing organisations, the following information has been compiled [1]:

- profiles of the UK consumer, automotive and industrial battery manufacturing sectors;
- data on recent UK sales of the common batteries within the consumer, automotive and industrial categories; industry forecasts of future battery sales; and
- information relating to battery characteristics, including composition, lifetime and weight.

Estimated arisings of waste consumer primary, consumer secondary, automotive and industrial batteries for the period 2000 to 2005 are shown in *Figure E1.2*, *Figure E1.3*, *Figure E1.4* and *Figure E1.5* respectively.

Waste Arisings Sensitivity

Battery sales data, estimated market growth rates, battery weights, battery composition and battery lifetime all influence the estimates of waste arisings. These parameters have all been determined in discussions with key manufacturers and trade organisations, with the best available data used in making the projections made in this report. Nevertheless, the information used is clearly subject to error, and it is not possible to quantify the uncertainties associated because of the lack of ranges of data. We recommend that our results are regarded as best estimates.

The results of the modelling carried out are comparatively robust to reasonable variation in the input values for battery lifetime and sales growth rates. Battery lifetime is a more critical issue than sales growth rate for estimating waste arisings in the short term, and is more important for consumer batteries, with short lifetimes, than for industrial and automotive batteries. In a changing market, battery lifetime influences the quantity batteries in the waste stream and is a key factor in the precision of any calculated collection and recycling obligation. Further information on hoarding and lifetimes would be valuable in developing an equitable and justifiable methodology for calculating any obligation.

Although the data on weight and composition are also subject to error, the mass of materials in the waste stream is clearly proportional to variation in composition and weight. The data used in this report are typical or average weights and composition for specific battery types made available by the industry.

(1) Discussions took the form of meetings, telephone conversations and written communications.

Figure E1.2 Waste Portable Primary Consumer Battery Forecasts 2000-2005

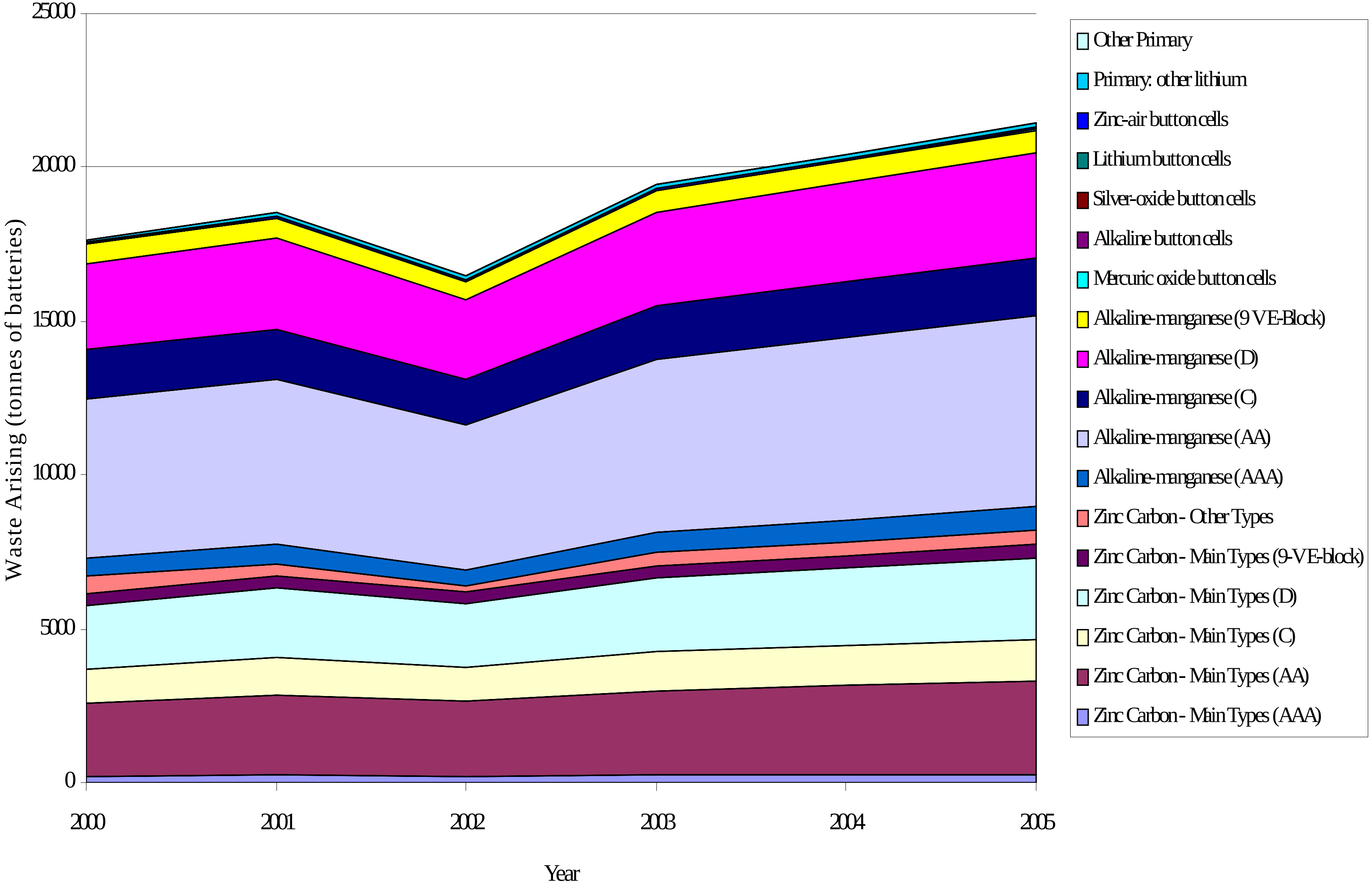


Figure E1.3 Waste Portable Secondary Consumer Battery Forecasts 2000-2005

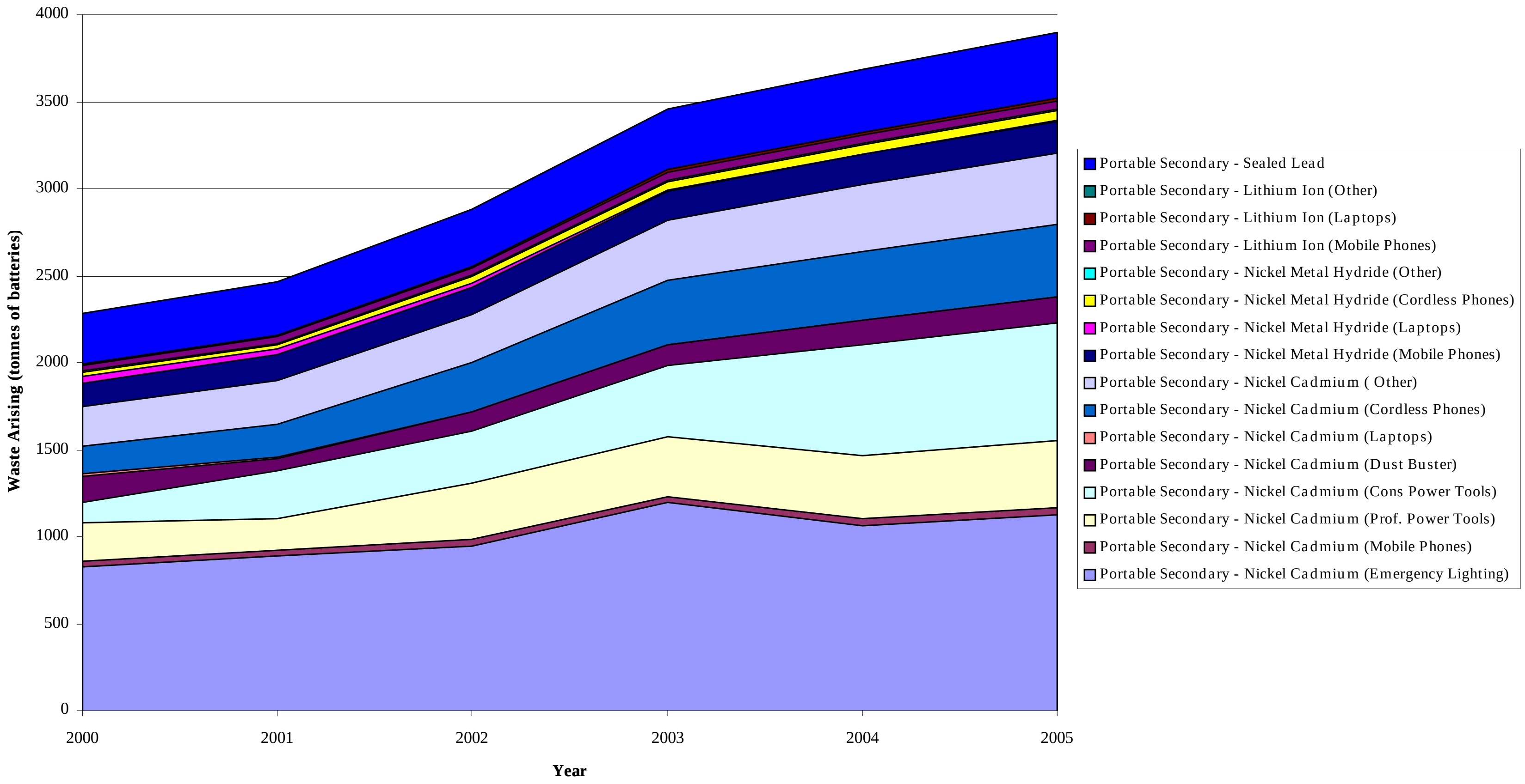


Figure E1.4 Waste Lead Acid Automotive Battery Forecasts 2000-2005

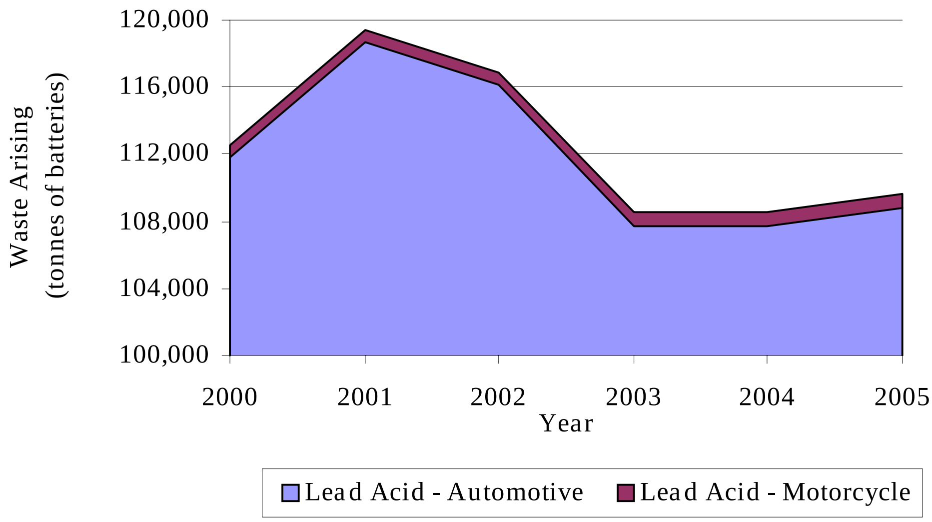
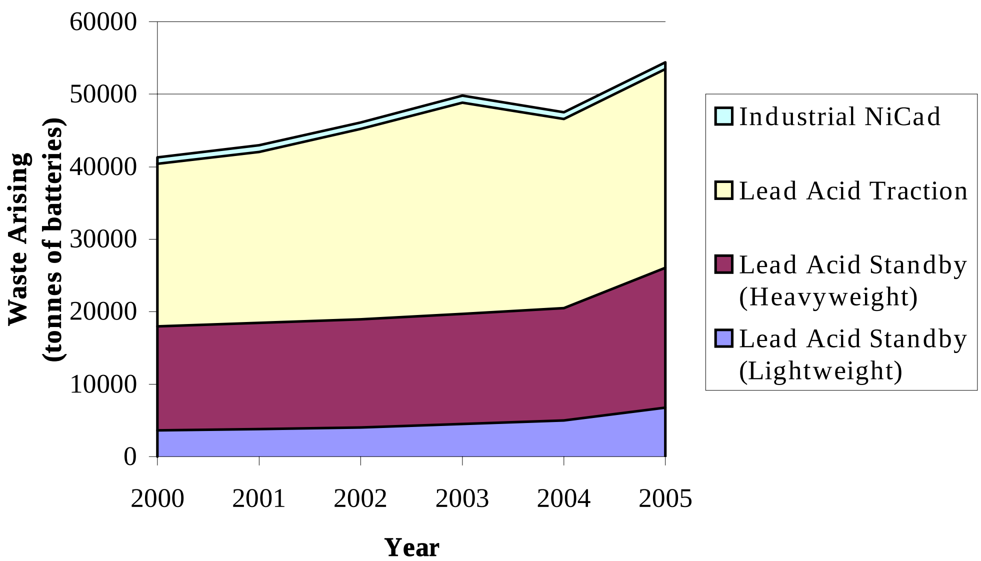


Figure E1.5 Waste Industrial Battery Forecasts 2000-2005



E1.5 Modelling Collection and Recycling Scenarios

In order to assess the environmental impact and financial costs and benefits of the possible new Directive, a number of collection and recycling targets of which the Directive might be comprised were assessed. In combination, these result in 15 'scenarios' for consumer batteries, and nine 'scenarios' both for industrial batteries and for automotive batteries, as shown in *Table E1.1*. In each case, the targets are assumed to apply to 2003, the earliest year in which the Directive might be required to be implemented.

The tonnages of batteries requiring to be both collected and recycled under each scenario are shown in *Table E1.2*. The collection target applies to the quantity of batteries arising as waste in a given year. The recycling target is a percentage applied to those batteries which are collected. Therefore, there is an overall 'recycling rate' which reflects the combination of the two targets and is the product of the two targets (eg 40% collection target & 40% recycling target = 16% overall recycling rate). The overall recycling rate is therefore the quantity of batteries entering reprocessing facilities divided by total arisings.

Table E1.1 Collection and Recycling Targets for Battery Types

Battery Types	**Collection Targets**	**Recycling Targets**
Consumer	30%, 40%, 50%, 60% & 75%	40%, 50% & 60%
Industrial	50%, 75% & 95%	40%, 50% & 60%
Automotive	80%, 90% & 95%	85%, 90% & 95%

Table E1.2 Scenario Recycling Targets (tonnes)

		Collected Percentage							
Sector	Recycling Target	30%	40%	50%	60%	75%	80%	90%	95%
Consumer	40%	3163	4217	5272	6326	7908			
Consumer	50%	3954	5272	6590	7908	9885			
Consumer	60%	4744	6326	7907	9489	11 861			
Industrial	40%			9962		14 942			18 927
Industrial	50%			12 452		18 678			23 659
Industrial	60%			14 942		22 414			28 391
Automotive	85%						73 834	83 063	87 678
Automotive	90%						78 177	87 949	92 835
Automotive	95%						82 520	92 835	97 993

Data on the financial costs and environmental impacts of battery collection and recycling activities were collected from a large number of operators in the UK and elsewhere. These include dedicated battery collection schemes, those which collect batteries alongside other materials, and recycling facilities which can accept:

- general purpose batteries (via two different recycling options);
- button cells (excluding silver oxide button cells);
- NiCd and NiMH consumer batteries;
- NiCd industrial batteries; and
- lead acid batteries.

Three types of collection scheme were considered for consumer batteries, based on a kerbside collection approach, a bring system using civic amenity sites or household waste collection centres, and a takeback approach based on the return of spent batteries to a network of retail outlets. Kerbside collection of consumer batteries is assumed to be an additional activity, rather than incremental to an existing kerbside scheme for source-separated wastes, unless otherwise stated. Collection schemes for industrial and automotive batteries were based on the existing infrastructure, and, for the purposes of environmental assessment, the storage and transport requirements were assumed to be analogous to the consumer bring system.

E1.6 CURRENT BATTERY RECYCLING ACTIVITY IN THE UK

An understanding of the extent of current battery collection and recycling in the UK is vital in assessing the financial costs and environmental impacts of the likely collection and recycling requirements of the proposed Directive. To this end, battery associations, UK collection and recycling organisations were contacted to establish the current routes for battery collection and to quantify the collected weights by battery type. The assumed 2003 baseline recycling rates for each of the battery types are summarised in *Table E1.3*.

Table E1.3 Summary of 2003 Baseline

Battery Type	Battery Sub-Type	Anticipated 2003 Recycling Rate
Consumer	Portable primary batteries	< 1%
	Portable rechargeable batteries	5%
	Total consumer	**< 2%**
Automotive	**Automotive lead acid batteries**	**90%**
Industrial	Industrial lead acid batteries	90%
	Industrial NiCd batteries	25%
	Other industrial batteries	None
	Total industrial	**90%**

E1.7 FINANCIAL COSTS

The forecast costs for collecting and recycling the target battery quantities for each scenario are described below for consumer, industrial and automotive batteries. These costs are forecast for 2003 and are given in Euros at 1999 prices.

Results Uncertainty

There are a number of sources of potential error which give rise to uncertainty in the predicted costs of the collection and recycling scenarios. Uncertainty has been reduced as far as possible through the use of the best available data sourced from the industry, and through the choice of reasonable modelling assumptions. Uncertainties associated with predicting waste arisings, which strongly influence the predicted costs, are discussed in *Section E1.4*.

Few consumer batteries are collected and recycled at present, and there are likely to be errors in extrapolating from costs for existing small-scale schemes, and in transposing European costs to the UK. Furthermore, there are insufficient data to assess whether there are likely to be economies of scale in meeting the proposed Directive's targets, and constant returns have been assumed in our model.

The cost data used in the model for lead acid batteries, ie automotive batteries and the majority of industrial batteries, were drawn from the whole of the lead smelting industry and from major battery collection operators. As current recycling activity is similar to the collection and recycling scenarios examined, the data can be regarded as reasonably robust and transferable, with economies of scale broadly captured. Nevertheless, uncertainty over the price of lead and discontinuities in the model make precise estimates of the costs of the recycling of lead acid batteries problematic. Although a smaller proportion of NiCd batteries are currently recycled, it is sufficient for these costs also to be regarded as reasonably robust.

Although it has not been possible to assess the uncertainty surrounding the predicted financial costs of the collection and recycling scenarios examined, other than through alternative scenarios for EAF/non-EAF, UK or European data and or additional or incremental kerbside collection for consumer batteries, these potential errors should be borne in mind whilst considering the results. We recommend that the predicted costs of the scenarios presented in the report are considered as best estimates.

E1.7.1 Consumer Batteries

The estimated costs for collecting and recycling consumer batteries are dependent on the approach adopted for battery collection, on the specific collection and recycling targets assessed and on whether mercury levels are sufficiently low for the electric arc furnace (EAF) route to be employed. The predicted costs for kerbside collection are also dependent on whether or not additional infrastructure is required. The estimates quoted assume that additional infrastructure is required, except where stated in sections dealing with incremental kerbside collection.

UK Data

The predicted annual financial costs increase as the collection and recycling targets are raised, with the range of costs between the least and most demanding scenarios (30% collection & 40% recycling and 75% collection & 60% recycling) as follows (costs for 2003 in 1999 prices based on UK data and net of revenues from recovered materials):

Kerbside collection and recycling	20 - 49 million Euros with EAF or 21 - 96 million Euros without EAF;
Bring collection and recycling	7 - 17 million Euros with EAF or 8 - 65 million Euros without EAF; and
Takeback collection and recycling	44 - 111 million Euros with EAF or 45 - 159 million Euros without EAF.

The kerbside and bring collection systems would rely on the expansion of existing waste management infrastructure, with collection 'socks' or 'piggy-back' bins at the household and storage / bulking bins at civic amenity sites, materials recovery facilities and transfer stations. A takeback collection system would require new infrastructure at retail outlets, and the associated costs would fall on the private sector.

Collection costs are the more significant proportion of the total costs of kerbside and takeback systems, particularly where the EAF route is possible. Collection costs represent approximately 85 - 97% of total costs for kerbside- and takeback-led systems and approximately 55 - 70% of total costs for a bring system.

Incremental Collection Costs

Where battery collection at kerbside can be assumed to be incremental to a wider kerbside collection system for source-separated consumer wastes, the collection and recycling costs are predicted to be from 6 - 14 million Euros for the least to the most demanding scenario if EAF is feasible, or 7 - 61 million Euros if it is not. These estimated costs are between approximately 30% and 60% of those where we assume that the full kerbside collection costs fall to batteries. This again reflects the importance of the collection step. Costs of kerbside collection on this basis are comparable with the bring system approach, where much of the burden of transport falls upon the householder. However, kerbside collection, where it is available to the consumer, is likely to be a more reliable means of achieving the collection targets.

European Data

The forecast costs of the kerbside system based on European data are more than those based on UK data. The higher costs reflect more intensive collection activity, that many schemes focusing on batteries don't benefit from the marginal costs of adding battery collection to other source-separated consumer wastes and the higher costs of the intensive publicity / advertising which has accompanied these schemes. These advertising costs can represent over 50% of annual expenditure.

The forecast costs for takeback schemes based on European data are broadly similar to those based on UK data. There is some divergence at the small scale, because of the higher costs associated with small scale, immature pilot schemes in the UK which have only received very low quantities of batteries.

Kerbside collection and recycling	30 - 122 million Euros with EAF or 31 - 169 million Euros without EAF; and
Takeback collection and recycling	23 - 117 million Euros with EAF or 24 - 165 million Euros without EAF.

The financial costs of collection and disposal of consumer batteries which are currently disposed in mixed wastes are not considered in the modelling approach. However, as increasing quantities of batteries are collected and recycled the costs attributed to residual waste will fall, partially offsetting the costs of collection and recycling presented above.

Nevertheless, these avoided costs are likely to be insignificant in comparison with the total costs of collection and recycling / disposal. The costs of battery collection and disposal in residual waste might be expected to be a maximum of around 90 Euros per tonne in 2003, including the Landfill Tax. By comparison, the predicted financial costs of collection and recycling vary considerably, but even the lowest are in excess of 1100 Euros per tonne, for high collection and recycling rates, and where costs for batteries are incremental to a wider kerbside collection scheme. Even assuming the lowest collection and recycling costs therefore, the offset residual disposal charges would represent a maximum of under 10% of total costs incurred, and in most cases less than 5%.

E1.7.2 Industrial Batteries

The total predicted annual financial costs of both collecting and recycling industrial batteries range from 5 million Euros to 11 million Euros, depending on the specific scenario targets for collection and recycling rates (50% collection & 40% recycling - 95% collection & 60% recycling). The costs of collection dominate the total costs as with consumer battery recycling.

Where they are currently not recycled, the majority of industrial batteries are likely to be separately collected and disposed to special waste landfill in the baseline scenario. Consequently, there may not be any additional costs of meeting any targets associated with separate collection and transport. If this is assumed to be the case, the only possible additional costs would be those of recycling, since the collection and transport of waste batteries would be occurring in any case. The baseline level of recycling industrial batteries is currently around 90%, well in excess of the scenarios examined, and there would therefore be no additional costs associated with meeting the Directive's targets.

The estimated costs of recycling industrial batteries in each of the scenarios, separate from collection costs, ranges from a net profit of 2 million Euros to a cost of 3 million Euros, depending on the scenario targets involved. Our economic model predicts a net cost for the higher levels of collection and recycling, based on a smelted lead price of 400 Euros t^{-1}. However, there is considerable uncertainty in extrapolating from the capital and operating data provided to ERM, and in separating costs for industrial and automotive lead acid batteries. Given the estimated current recycling rate of approximately 90%, our estimates suggest that the lead resmelting industry is currently making a loss, and the estimates across all scenarios reflect the narrow margins of the secondary smelting industry at recent prices for lead.

E1.7.3 Automotive Batteries

The estimated annual financial costs of both collecting and recycling automotive batteries range from 12 million Euros to 13 million Euros, depending on the combination of targets. Collection costs associated with storage and transport represent the greater proportion of total costs, and costs increase in proportion to a rising collection rate. We believe the significant majority of these costs are being incurred currently as a result of the existing collection infrastructure for automotive batteries and the baseline recycling rate of approximately 90%.

The predicted financial costs of recycling automotive batteries, separated from the collection costs, vary between a slight profit and slight loss, depending on the volumes recycled (a net profit of approximately 0.5 million Euros to a net cost of approximately 0.3 million Euros). These costs have been calculated using a revenue for smelted lead of Euros $400t^{-1}$. There are uncertainties involved both in using this figure in the face of a volatile lead price, and in extrapolating from the capital and operating costs provided by lead smelters to ERM [1]. Our economic model suggests that, at the current recycling rate of 90%, and at a lead price of Euros $400t^{-1}$, the industry is just breaking even. Clearly, however, the estimates reflect the very low margins of the industry at this price for lead and the risk of this becoming negative at any lower price.

Currently, 90 - 95% of automotive batteries are believed to be collected and recycled, which equates to a predicted cost of c 12.9 million Euros. Given this baseline, there will be no significant additional costs associated with meeting the scenario targets. Although it is recognised that a proportion of automotive batteries do enter the municipal waste stream (in particular, motorcycle batteries), this is thought to be small, and these batteries would not need to be captured in order to meet the collection and recycling targets specified.

E1.7.4 UK Cost Breakdown

The total predicted costs of the collection and recycling of batteries have been broken down according to population as presented in *Table E1.4*.

(1) Steps on the known cost curve complicate prediction of the financial costs of the scenarios examined.

Table E1.4 ***Proportion of Collection and Recycling Costs for the UK, Scotland, England and Wales and Northern Ireland (Euro per annum, 1999 prices)***

Country	Consumer	Industrial[1]	Automotive[2]
England and Wales	3.5 - 138.8	0.44 - 8.0	8.0 - 10.6
Scotland	0.4 - 13.8	0.04 - 0.8	0.8 - 1.1
Northern Ireland	0.1 - 4.4	0.02 - 0.2	0.2 - 0.3
UK	4 - 157	0.5 - 9	9 -12

E1.8 ENVIRONMENTAL IMPACT

The environmental impacts of the battery collection and recycling scenarios were predicted using a life cycle assessment (LCA) approach, with foreground data on collection and recycling activities collected, wherever possible, from operators. Background information, for example on energy and raw materials, was drawn from the PEMS™ software.

There is a complicated environmental trade-off in the scenarios examined, in addition to that with financial costs. As collection and recycling rates increase, the heavy metals in batteries are progressively diverted from waste. Clearly, this is most effective when the recycling rate is maximised and batteries are not simply collected for separate disposal. However, as collection rates increase, other environmental impacts examined, such as global warming and resource depletion, also increase. These impacts are associated with the demands and activities of battery collection (eg containers, transport etc.), and are offset only to a limited extent by the avoided impacts associated with the recovery of materials through recycling.

Results Uncertainty

Although we have used 'real' data wherever possible, these characterise the activities of the facilities concerned, and there are potential errors in extrapolating to other facilities for which these may not be fully representative (ie due to age, location, licensing conditions etc.). This is more problematic for consumer batteries, which, for the most part, are not currently collected and recycled in the UK, than for automotive and lead acid industrial batteries, which are. Furthermore, there are potential errors associated with estimating waste arisings (see *E1.4*) and with assumptions regarding the life cycle system which also introduce uncertainties.

It has not been possible to obtain and manipulate ranges of data which would enable the uncertainty surrounding the estimates of environmental impact to be assessed, although the key sources of the environmental impacts are

(2) These costs are however unlikely to be incurred due to the existing collection and recycling infrastructure which meets the EC's predicted target levels.

identified and certain key assumptions for consumer batteries are addressed individually. Therefore, we believe it is important to recognise that there is a margin of error associated with the results presented, and we recommend that the results are recognised to be best estimates.

The predicted environmental impacts for the collection and recycling scenarios for the three battery types are explained below.

E1.8.1 Consumer Batteries

The predicted environmental impacts for kerbside collection are based on the assumption that additional infrastructure is required, except where stated. In each of the collection and recycling scenarios, regardless of collection system, the quantities of the key heavy metals in total wastes diminish as collection and recycling rates go up. The extent to which the metal quantities in wastes are reduced depends on the recovery percentages at reprocessing plants (a varying proportion is recovered in each case), but generally between 30% and 40% more is diverted from waste between the highest and lowest target scenarios.

By contrast, most of the other environmental flows and impacts increase as collection and recycling increase. These increases are associated with the increased transport requirements for collecting batteries and sending them to reprocessing and with the materials required to enable collection through the provision of containers.

Environmental performance associated with each collection target improves as the recycling target is raised, due to the net benefits of the recovery of metals. However, once the impacts of collection and recycling are aggregated, the energy benefits of battery recycling with respect to metals recovery are outweighed by the demands of collection and transport. Consequently, the overall effect is for environmental impacts to increase as a higher proportion of batteries are collected and recycled. It should be noted that this is partly due to the 'wasted' environmental impacts associated with collecting batteries which are then disposed, rather than recycled.

The environmental benefits associated with recycling are greater when the electric arc furnace (EAF) route is assumed to be available, because mercury levels are sufficiently low, than when it is not. However, the difference is small in comparison with the environmental impacts associated with collection and transport.

The dominance of the impacts associated with collection holds whatever the collection system modelled. However, the environmental impacts of takeback are higher than for bring, by a relatively small margin in most cases, but with a more considerable difference for non-renewable resource depletion. This inconsistency is a consequence of the different balance of transport and material requirements in each case. Both bring and takeback are predicted to have significantly lower environmental impacts than kerbside systems due to kerbside's need principally for more, and less efficiently used, containers, but also greater transport requirements.

We do not expect any significant amount of dedicated trips to be undertaken by householders to deliver spent batteries under the bring and takeback approaches. Those visits would be made in association with shopping trips and the disposal of other wastes. As a result, the delivery of batteries to central sites is achieved 'free' of environmental impacts for this transport step.

Incremental Kerbside Collection

Our assessment of the environmental impacts of kerbside collection of consumer batteries is based on the assumption that additional infrastructure is required, rather than collection being achieved through existing kerbside collection of source-separated recyclables. If battery collection at kerbside could be assumed to be incremental to an existing scheme, the environmental impacts associated with transport would be reduced.

However, the contribution of transport to the overall environmental impact of kerbside collection is between 2% and 9% for most impacts (although it is higher for nitrous oxide and ozone depletion), with the total impact dominated by the remainder of the collection infrastructure, principally household bins and 'socks'. We believe that these additional bins and 'socks' would be required at the household even where a kerbside collection already exists and the transport associated impacts can assumed to be incremental. Consequently, kerbside collection of consumer batteries will incur environmental impacts considerably in excess of those associated with the bring or takeback approach whether there is an existing infrastructure or not.

E1.8.2 Industrial and Automotive Batteries

Broadly, the environmental impacts of collection and recycling scenarios for industrial and automotive batteries show a similar form to those for consumer batteries. The metals in batteries remaining in waste are progressively reduced as the collection and recycling rates are increased. For industrial batteries, the scenarios divert between 20% and 57% of the cadmium and lead in batteries from waste. For automotive batteries, the scenarios divert between 68% and 90% of the lead in batteries from waste.

In the UK, the recycling rate for both industrial and automotive lead acid batteries is approximately 90%, and this is taken to be the baseline for 2003. Consequently, the collection and recycling targets of which the proposed Directive might be comprised do not result in the diversion of more lead from waste. Indeed significantly more lead in industrial batteries is diverted from waste in the baseline than in the scenario with the most demanding targets (with 3029 tonnes of lead remaining in waste in the baseline, compared with 13 027 tonnes in waste for the 95% collection & 60% recycling scenario). The most demanding targets for automotive batteries result in the diversion of an additional 175 tonnes of lead over the baseline (7058 tonnes remaining in waste in the baseline compared with 6882 tonnes in the 95% collection & 95% recycling scenario).

The current recycling rate for industrial NiCd batteries is approximately 25%, and this rate is used as the baseline for 2003. Of the potential collection and recycling targets examined, most result in the diversion of more cadmium from waste, with the highest targets resulting in the diversion of 57% of cadmium from waste, as opposed to the baseline 25% (24.72 tonnes of cadmium remaining in waste in the 95% collection & 60% recycling scenario, compared with 43.11 tonnes remaining in waste in the baseline).

The remaining environmental impacts, associated with resource, and particularly energy, consumption increase as the collection and recycling rates are raised across the range of scenarios. For the baseline, these environmental impacts are broadly the same as for the scenarios with the same collection rate (ie 95% for industrial batteries and 90% for automotive batteries) because collection dominates total environmental impacts.

E1.9 COST-EFFECTIVENESS

The conflicting trends of the different environmental impacts are better appreciated in graphs of the changes in impact against cost. The cost-effectiveness of the different collection and recycling scenarios for the battery types (and kerbside, bring and takeback systems for consumer batteries) is complex because of the range of impacts estimated. An example cost-effectiveness graph for consumer batteries is shown in *Figure E1.6*. This is annotated to show the five collection rates (30%, 40%, 50%, 60% & 75%) on a cost-effectiveness curve for the eutrophication impact (tonnes), and the three separate recycling rates (40%, 50% & 60%) at the 75% collection rate on a cost-effectiveness curve for zinc levels in waste (tonnes).

Figure E1.6 ***Example Cost-Effectiveness Graph***

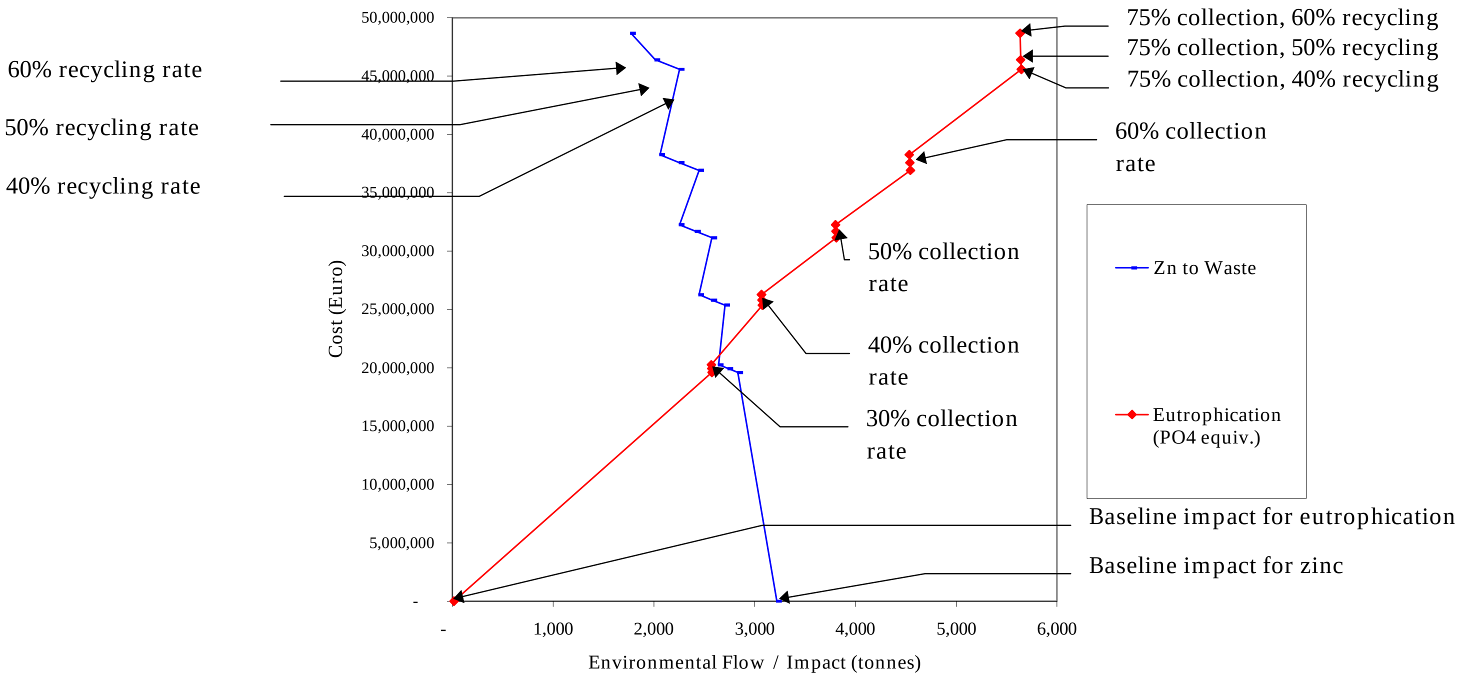


Figure E1.7 through to *Figure E1.17* show the trade-off between benefits, in terms of metals diverted from waste and both financial costs and environmental impacts. For consumer batteries, the graphs use financial costs assuming the availability of the electric arc furnace (EAF) recycling route, which leads to lower costs, and slightly lower environmental impacts, than if mercury levels were too high to allow this option. These graphs also show the impacts associated with a baseline of no collection and recycling of consumer batteries.

The cost-effectiveness results are similar for all the battery types and the three collection approaches for consumer batteries. The metallic components of batteries are increasingly diverted from wastes as costs increase across the range of collection and recycling scenarios. The curves for the metals are generally stepped as the scenarios move from one collection level to another and those batteries are recycled.

All the other environmental impacts show a deterioration in performance across the range of scenarios considered, with increasing costs, and collection and recycling of batteries is, for these impacts, counter-productive. For a given collection rate, a series of recycling rates are reflected in the short arms of the curves with three points (ie three recycling rates at each collection rate). In the case of consumer batteries, these lean slightly to the left, indicating environmental benefits sustained with increasing cost, albeit that this is insufficient to counteract the environmental costs of collection. The same is true only for global warming potential and non-renewable resource depletion for automotive batteries, and only for global warming potential for industrial batteries. The other impacts demonstrate an increase with increasing recycling rate, indicating that there are no benefits associated with the scenarios examined for the proposed Directive.

The cost-effectiveness approach shows that successively higher collection and recycling rates achieve diversion of metals from waste, but this is at the cost of increasing other environmental impacts over the full range of scenarios examined. For a given collection rate, high levels of recycling bring environmental benefits for consumer batteries, but these are outweighed by the impacts of collection. For industrial and automotive batteries, benefits of higher recycling rates at a given collection level are restricted to global warming potential and non-renewable resource depletion.

Figure E1.7 Cost-Effectiveness of Kerbside Collection & Recycling of Consumer Batteries with EAF (a)

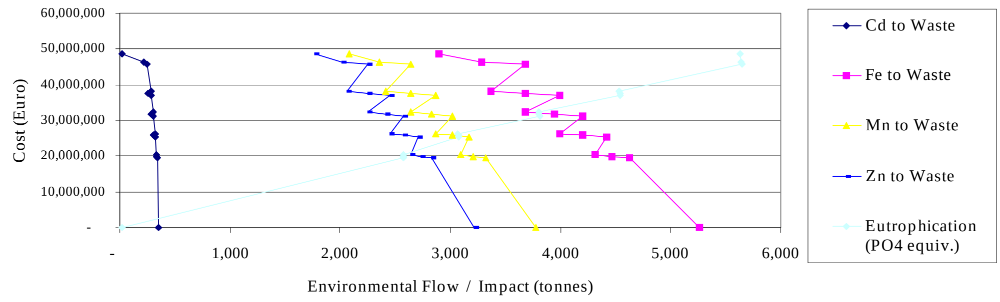


Figure E1.8 Cost-Effectiveness of Kerbside Collection & Recycling of Consumer Batteries with EAF (b)

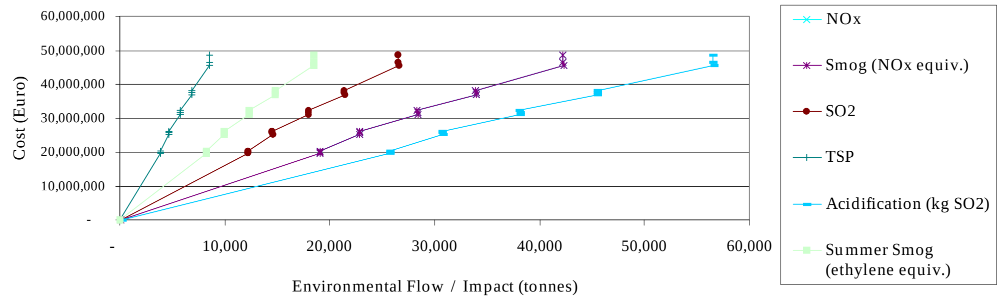


Figure E1.9 Cost-Effectiveness of Kerbside Collection & Recycling of Consumer Batteries with EAF (c)

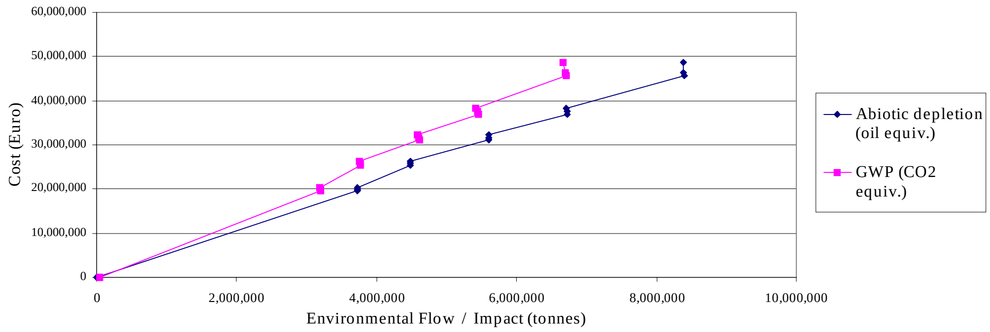


Figure E1.10 Cost-Effectiveness of Bring Collection & Recycling of Consumer Batteries with EAF (a)

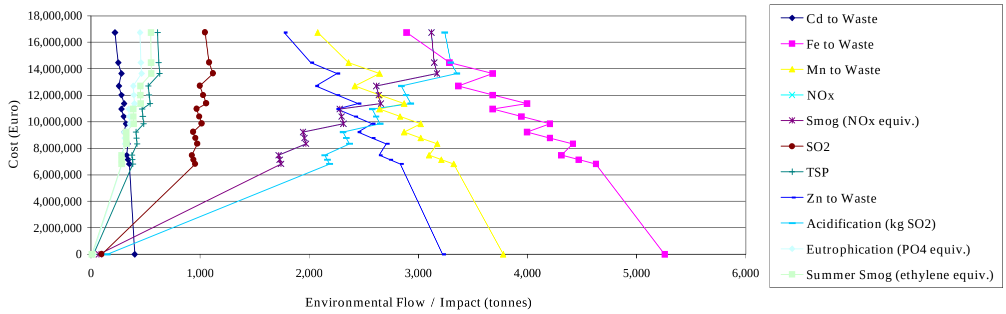


Figure E1.11 Cost-Effectiveness of Bring Collection & Recycling of Consumer Batteries with EAF (b)

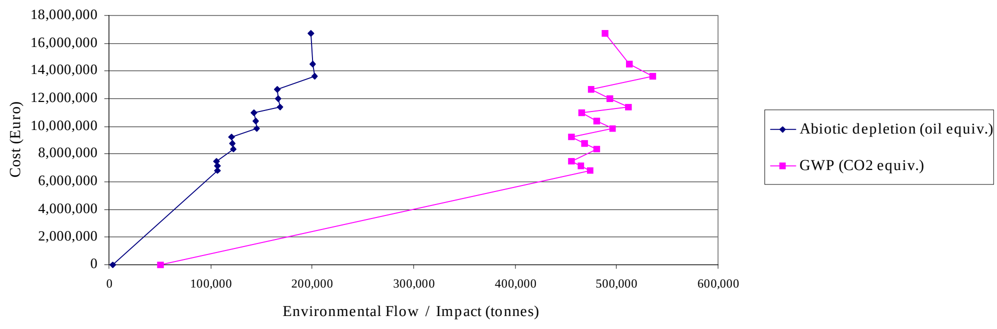


Figure E1.12 Cost-Effectiveness of Takeback Collection & Recycling of Consumer Batteries with EAF (a)

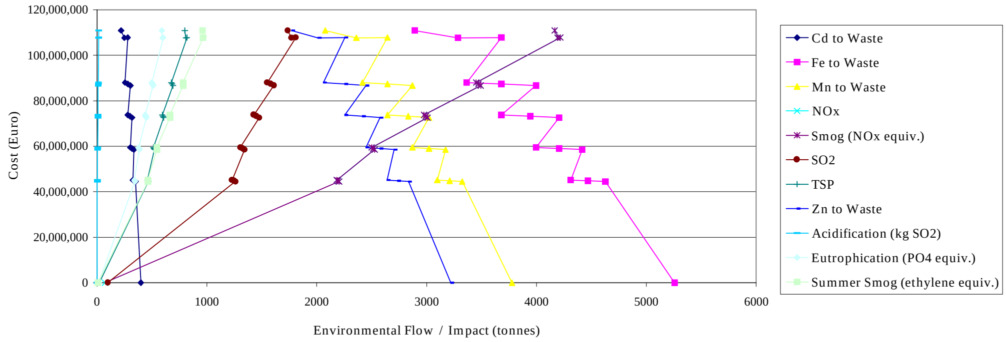


Figure E1.13 Cost-Effectiveness of Takeback Collection & Recycling of Consumer Batteries with EAF (b)

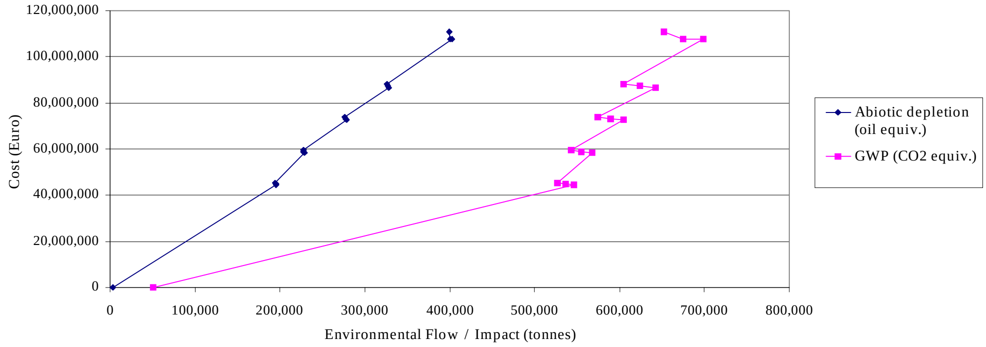


Figure E1.14 Cost-Effectiveness of Collection & Recycling of Industrial Batteries (a)

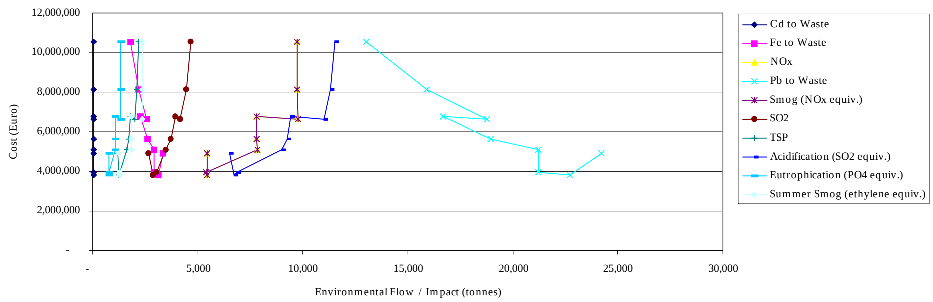


Figure E1.15 Cost-Effectiveness of Collection & Recycling of Industrial Batteries (b)

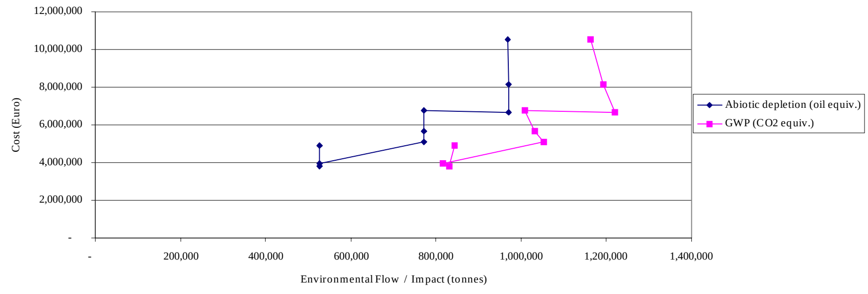


Figure E1.16 Cost-Effectiveness of Collection & Recycling of Automotive Batteries (a)

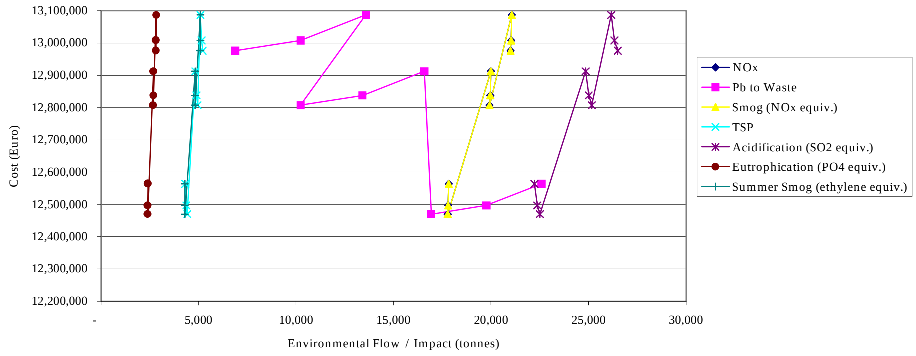
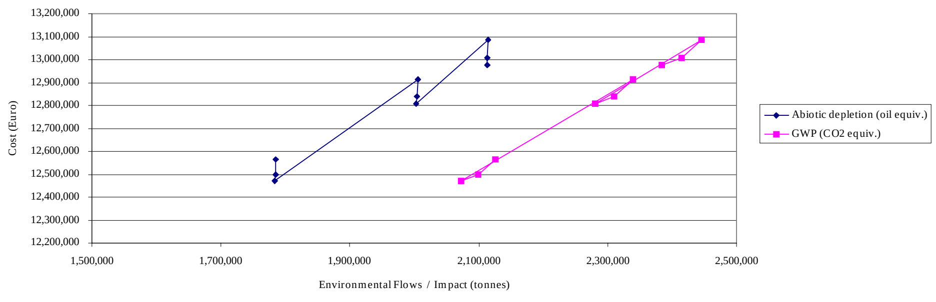


Figure E1.17 Cost Effectiveness of Collection & Recycling of Automotive Batteries (b)



E1.10 IMPLICATIONS OF OTHER FORTHCOMING DIRECTIVES

A number of other proposed Directives will influence the environmental impacts of batteries, regardless of the proposed Batteries Directive. Directives on end-of-life vehicles (ELVs) and on waste from electrical and electronic equipment (WEEE) will introduce requirements for collection of equipment containing batteries, and for the removal and separate treatment of those batteries.

Furthermore, changes to the waste management regulatory framework, including the Landfill Directive, Integrated Pollution Prevention and Control (IPPC) and the proposed Incineration Directive, will influence the environmental impacts of batteries which continue to be disposed, either to landfill or, in mixed municipal solid waste, to waste combustion.

The draft WEEE Directive, in particular, would have a significant impact on the collection of batteries in the UK. It would require the separate collection of a substantial percentage of electrical equipment which contains batteries, of which a significant proportion is currently disposed of to landfill as part of municipal solid waste. The draft Directive would also require the removal and separate treatment of the batteries this equipment contains.

The implications of this forthcoming legislation are likely to include a reduction in the release to the environment of materials in batteries remaining in the waste stream, even without a specific Batteries Directive. The effect of the legislation on the wider environmental impacts associated with the management of battery-containing wastes is beyond the scope of this report.

E1.11 CONCLUSIONS

This study has assessed the likely financial costs and environmental impacts for the UK for the collection and recycling of waste consumer, industrial and automotive batteries. A number of scenarios, combining collection and recycling rates which might feature in the proposed Batteries Directive, were examined.

The results are relatively complex, and reveal there to be trade-offs both between the estimated financial costs and the reduction of materials in batteries remaining in waste and between these levels of materials in waste and other environmental impacts such as global warming, resource depletion, air acidification, ozone depletion and eutrophication. Our principal conclusions from the study for battery collection and recycling in the UK are as follows.

Current Practice

- In the UK, the current collection and recycling rate for consumer batteries is low, with the exception of silver oxide button cells. However, for automotive and industrial lead acid batteries, the overall recycling rate is c. 90%, and, given the uncertainties in calculating the rate and the problems associated with guaranteeing the collection of batteries, it is unlikely that targeting a higher rate for these battery types through a Directive would be practicable.
- At current prices for smelted lead, and the prices paid by smelters for waste batteries, the economics of recycling lead acid batteries are fragile. The impact of a further drop in lead prices is debatable. But without an additional economic stimulus, for example a levy, or unless lead acid

batteries being treated as a waste for which a disposal fee is charged, the overall recycling rate would be likely to drop, and may do so in any case because of the reduced incentive for collection from diffuse sources.

Environmental Impact

- For all battery types, constituent metals are progressively diverted from wastes as the collection and recycling rates (and hence the overall recycling rates) rise.
- All other environmental impacts examined increase as collection and recycling rates rise. These impacts are principally associated with increasing collection and transport requirements.
- At a given collection rate, and for consumer batteries, all environmental impacts are reduced as the recycling rate increases. It is more environmentally effective, therefore, to recycle as great a proportion of collected batteries as possible.
- For automotive and industrial batteries, the conclusion above holds true only for the diversion of materials in the batteries from waste and for global warming and non-renewable resource depletion.
- There is little evidence to suggest that there are significant environmental impacts associated with the materials in batteries which currently report to waste in the UK. The level of materials in batteries which report to waste is heavily dependent on the level of recycling for industrial and automotive batteries currently achieved. Should lower recycling rates for these batteries occur in the future, the quantities of lead and cadmium which would report to waste as a result might require this conclusion to be revised.
- The impacts of batteries reporting to waste are likely to be strongly mitigated by other legislation, including the Landfill Directive, the End-of-Life Vehicles Directive, the draft Waste Electronic and Electrical Equipment Directive, the proposed Incineration Directive and the IPPC regime, in the absence of the proposed Batteries Directive.

Logistics

- Achieving the collection rates for consumer batteries examined in this report would be problematic. On existing evidence of collecting other recyclable materials in the UK, a 'bring' approach would struggle to meet the lowest rates, whilst a combined kerbside and bring system would be required to approach the highest rates. There is no evidence in relation to other recyclable materials that suggests that a 75% collection rate can be achieved nationally at current levels of awareness and participation. The involvement of the public in separation of consumer batteries from the waste stream will require consistent and continuous publicity, and participation is likely to build over time.
- The collection and recycling rates for industrial and automotive batteries examined in this report are being achieved at present. However, these are

dependent on the price paid to collectors for waste lead acid batteries by the smelters. Further falls in the price of smelted lead may jeopardise the overall recycling rate of around 90%, particularly because of the reduced incentives to small and itinerant collectors.

- Restrictions on the use of nickel cadmium batteries as proposed by the Commission are likely to be complicated by the number of applications which have strong grounds for exemption. The environmental benefits of any restriction would also be largely duplicated by the effect of collection and recycling targets discussed above, and these benefits are subject to the same conclusions previously discussed.

Costs

- There are unlikely to be significant additional costs associated with the collection and recycling of automotive and industrial batteries for those scenarios examined at current prices for smelted lead. The overall recycling rate for these waste streams is already high. Costs are dominated by collection and transport, with the recycling of lead acid batteries close to break even at a lead price of Euros 400 t^{-1}.
- The additional costs of collecting and recycling consumer batteries are significant. Collection and transport costs dominate the costs of recycling for most scenarios examined. A bring collection system would be less expensive than a kerbside collection or takeback approach. If the collection of batteries were to be incremental to existing kerbside collection initiatives for other materials, the costs would be closer to those for bring. Collection and recycling costs would exceed Euros 1100 per tonne even in the most favourable circumstances.
- The financial costs of recycling consumer batteries are strongly influenced by whether the electric arc furnace (EAF) route is available for recycling. This depends on mercury levels being sufficiently low in a sorted batteries and confirmation of the indications that EAF facilities are prepared to accept a continuous sorted battery feedstock.
- The implications of the proposed WEEE Directive for the implementation of the proposed Batteries Directive will be particularly significant. Accurate estimates of the quantity of WEEE which is likely to be collected and recycled in the UK, and the methods of collection, in the years before and after the 2006 date set in the draft WEEE Directive, are currently not available. This makes it impossible to generate accurate estimates of the likely effect of the WEEE Directive on the costs and environmental impacts of the proposed Directive on Batteries and Accumulators. It is appropriate only to make assumptions about the likely scale and nature of collection of batteries within WEEE under the proposed WEEE Directive, and to make rough estimates of the implication of this for the estimates of cost and environmental impact accruing to the proposed Batteries Directive. Nevertheless, it is fair to conclude that the WEEE Directive may result in a small decrease in the estimated costs of collection of consumer batteries. The costs of recycling the batteries would be unchanged, but some of these costs would fall on producers of EEE.

Summary

- For consumer batteries, where the current recycling rate is close to zero, progressively higher collection and recycling rates reduce the materials in these batteries which report to waste, where they have an impact, in an increasingly more tightly regulated sector, the significance of which is hard to ascertain. By contrast, achieving such rates would lead to significant additional costs and a range of additional environmental impacts, associated with collection, transport and the recycling process, which are only offset to a limited extent by the benefits of recovery in materials through recycling.
- For industrial and automotive batteries, the collection and recycling rates in the proposed Directive are currently being achieved through the market for secondary lead, it is unlikely that any higher rate for lead acid batteries could be practicably achieved or reliably measured. A higher collection and recycling rate for industrial nickel cadmium batteries could be achieved. Recycling industrial and automotive batteries avoids the disposal to landfill of the materials they contain, particularly lead and cadmium, whilst incurring other environmental impacts associated with collection, transport and the recycling process.
- The benefits of the proposed Batteries Directive will rest principally with the diversion of materials from wastes, where the avoided impacts, already mitigated by controls on waste management facilities, are uncertain. An assessment should be carried out to determine the likely scale and significance of these avoided impacts, and they should be explicitly balanced against both the risks associated with the other environmental impacts which will be incurred and the costs of collection and recycling before the proposed Directive can be justified.
- We believe the benefits of the proposed Directive rest principally with the greater guarantee of high rates of recovery for industrial and automotive batteries that it would bring. Recovery of these batteries ensures that lead and cadmium are diverted from waste, maintaining the high level of recycling currently achieved for lead acid batteries. The benefits of extending the Directive to consumer batteries are tenuous, since the environmental significance of disposing of the majority of the materials they contain is hard to ascertain. If the Directive were restricted to industrial and automotive batteries and lead- and cadmium-containing consumer batteries, and implemented through a bring or takeback approach for these batteries, it would be easier to justify on the grounds of environmental impact and cost-effectiveness.