# Battery Recycling

*A battery is a portable power source, converting chemical energy into electricity. Within the last few decades, there has been a phenomenal growth in the number and diversity of products available. In industrialised countries, many homes will contain many pieces of equipment which depend on batteries for power to operate. Transistor radios, central heating timers, alarm clocks, door-bells, portable car vacuum cleaners, toys, computers, gas lighters, watches, torches, calculators, power tools (even battery-operated pepper grinders!) - seem to have become essential items for many people.*

*Batteries are indispensable when electricity supplies are unpredictable. Many computer networks use back-up battery systems, to avoid data loss in the event of a power cut. Renewable energy sources, such as wind turbines and solar power units, often use batteries to store excess electricity which can be used in the absence of wind or sunshine.*

*Different types of battery*

*The basic component of any battery is a cell (or a series of connected cells) in which electrodes react with chemicals (the electrolyte) to produce electricity. There are two general classes of batteries, primary and secondary.*

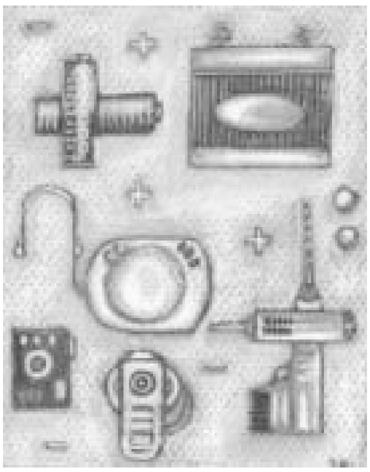
*primary batteries*
*These are intended to be used only once. The chemicals they contain undergo an irreversible reaction to produce electricity. When the reaction is complete, the battery is 'dead' and cannot be used again. The most common types of primary batteries are zinc-carbon and alkaline-manganese and small 'button' cells (usually mercuric oxide, silver oxide or zinc-air). Primary batteries are those found in radios, torches, cameras.*

*secondary batteries*
*These can be recharged, using an external source of electricity to reverse the chemical reaction. The most common type of secondary battery is the lead-acid type used in vehicles. Smaller secondary batteries based on nickel-cadmium (Ni-Cd) are widely used in, for example, power tools, mobile telephones and portable computers.*

*New battery chemistries, such as nickel metal hydride (NiMH) and Lithium ion (Li-ion), perform extremely well in applications such as computers - but cannot deliver high current levels. This means that they are not suitable for power tools. However, although these newer systems are more expensive, they are beginning to displace the earlier battery types.*

*Consumption*

*The recent proliferation of battery-powered products has led to a sharp increase in the consumption of rechargeable batteries worldwide. In France, around 26,000 tonnes per annum (tpa) of primary cells (excluding 2,500 tonnes of automotive lead-acid starter batteries) were sold in 1998, comprising 720 million batteries. Of these, more than 200 million were zinc-carbon, more than 400 million alkaline-manganese and around 85 million button cells. Additionally, some 2,000 tonnes of rechargeable batteries were sold.*



*In Europe, the total Ni-Cd market in 1999 reached 240 million cells, weighing more than 10,000 tonnes (see Table 1, page 2 for details of battery applications).*

*In Germany, up to 38,000 tpa of batteries were sold in 1997.*

*In Japan, the sales of Ni-Cd batteries has declined since 1994, as new battery types have entered the market. In 1998, 1.5 billion portable rechargeable batteries went on sale in Japan.*

*In Britain, more than 600 million batteries were sold during 1997 (see Table 2, page 3 for details). The UK consumption of lead-acid batteries for use in vehicles is around ten million pa. Although this is less than two per cent of the total number of batteries sold, these units comprise more than 80 per cent of the total weight.*

*Because batteries are individually so small and widely dispersed, it is a challenge to prevent them from entering the waste stream, where they may pose potential environmental risks. In Britain, household waste has been found to comprise 0.1-0.2 per cent by weight. Currently, around 20-40,000 tonnes of batteries in UK waste each year.*

*The Danish Environmental Protection Agency has reported that Ni-Cd batteries are the most substantial source of cadmium pollution, expected to account for*

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up to 90 per cent of future human exposure to the metal in Denmark.

If batteries are to be kept from potentially polluting disposal routes, they need to be recycled. This involves collection, sorting, transport and processing. If recycling batteries is to be sustainable, the process must be effective in recovering materials so that they may be used again. The process must also be environmentally sound and economically viable.

Collection

One collection option is battery banks, in public buildings or retail premises. These are often set up to collect one type of battery but a number of types are usually deposited because of the difficulties faced by the public in distinguishin between the different types. Schemes based on voluntary collection seldom achieve high levels of recovery.

Exchange schemes operated by retailers is a well-established option for lead-acid batteries, enabling collected batteries to be returned to manufacturers using the existing network.

Collection within broader household hazardous waste recovery programmes is another option, though participation rates can be less than five per cent. A better rate has been achieved in Denmark using a regular mobile collection.

In the UK, collection system introduced by the London Borough of Sutton highlighted some of the real problems associated with battery recovery. Initially, all batteries were accepted by the scheme, which relied on a network of collection points at public libraries and council offices. Later, as the mercury content in general purpose batteries fell to negligible levels, the municipality focused on Ni-Cd cells. The recycling company in France would not accept consignments contaminated with other battery types, so staff and the public needed effective training over what was acceptable. The introduction of special waste regulations raised prospects of licensing difficulties. The scheme ceased to be well publicised and public participation declined.

The countries where the highest rates of recovery are seen are those where mandatory take-back systems have been put in place. In Germany, battery legislation passed in 1998 obliges producers and importers to take back all spent batteries, whether or not they contain hazardous substances. The agency GRS Batterien provides the mechanism for battery recovery and recycling, on payment of an appropriate fee by producers. Around half a million collection boxes were distributed nationally. During the first year of the GRS scheme, 10,000 tonnes of spent batteries were recovered. It is expected that overall battery recycling rates in Germany will rise from 25 per cent in 2000 to 70 per cent in 2005.

Recycling

The main advantage of battery recycling is the environmental benefit arising from a reduction in the primary production of materials and energy, and lower emissions of mercury, lead and cadmium from landfills and waste incinerators.

Trials by the European Portable Battery Association (EPBA) indicate that general purpose (alkaline-manganese and zinc-

Table 1 Nickel cadmium battery market - Europe (1999)

| Application | Sector share by volume (per cent) Total = 240 million cells | Sector share by weight (per cent) Total = 10,500 t |
|---|---|---|
| Single cells (retail) | 15 | 8 |
| Emergency lighting | 15 | 29 |
| Cordless tools | 24 | 30 |
| Cellular telephones | 1 | 0.5 |
| Other cordless | 10 | 5 |
| Home appliances | 12 | 11 |
| Toys | 2 | 3 |
| Audio & video | 21 | 14 |
| Total | 100 | 100.5 |

Source: European Portable Battery Association

carbon) batteries, with no added mercury, can be recycled successfully in the metals industry. About 55 per cent of the weight of a general purpose battery is recyclable.

A number of specialised plants now recycle batteries using the technique of pyrolysis . The Batrec process in Switzerland, for example, extracts most metal compounds in batteries, without generating toxic emissions. Spent batteries are heated in the absence of air (at 300 -750$^{o}$C). The mercury evaporates, is condensed and recovered. Other metallic components can be recovered in a subsequent induction furnace stage of the Batrec process. More than half of the materials in spent batteries can be recovered in this type of facility (see Figure 1, page 4).

In most countries, general purpose batteries are not collected for recycling as technologies such as those used in Switzerland (designed to deal with mercury - a poisonous and volatile element) are

Table 2 UK battery sales* (1997)

| Battery type | | Number of batteries sold (million) |
|---|---|---|
| PRIMARY CELLS | Zinc-carbon | 211 |
| | Alkaline-manganese | 328 |
| | Button cells | 53 |
| | lithium | 4 |
| | Other primary cells | <1 |
| SECONDARY CELLS | | 5.4 |
| TOTAL (PRIMARY + SECONDARY) | | 601.4 |

*excludes batteries installed in new appliances
Source: AEA Technology (1999)

*not considered viable due to their high energy consumption and high operating costs.*

*Lead-acid batteries have a good recycling rate. In the UK, 95,000 tonnes were processed in 1997, equivalent to about 90 per cent of sales. However, recent figures have fallen due to a decline in the price of lead, and tighter emission regulations.*

*Recycling silver oxide batteries is also currently economically viable, although as with lead - acid types the economics of recycling fluctuate according to the changes in the metals market.*

*The EPBA has developed a two-stage plan for recycling all types of small batteries.*

*Step one is to eliminate mercury from the products. The cost of recycling alkaline manganese and mercuric oxide batteries presently stands at £2,000/tonne. If the mercury content is eliminated, the cost falls to £125/tonne. Now, all general purpose batteries sold by EPBA members in Europe are mercury free, but batteries containing up to 0.025 per cent mercury continue to be imported into the Community, and account for about two per cent of the market. For batteries to be recycled in the metals industry, their mercury content must not be more than 5 parts per million, so any delay in introducing legislation to prohibit mercury will delay the time at which batteries can be recycled in the metals industry.*

*Step two, following four years after step one, will be to collect and recycle all batteries.*

*Sorting*

*Before batteries can be recycled the many different types must be sorted according to chemistry. A number of automatic sorting systems have been developed. One sorting system in Germany is an X-ray method, where spent batteries are monitored as they fall through the sorter.*

*Another classification method is through image analysis, where cameras photograph battery labels. After sorting to the same size and shape the batteries are fed (six per second) and photographed as they fall. They are then sorted into eight fractions from a conveyor belt using an electro-magnetic ejection system. Accuracy is said to be better than 98 per cent.*

*An alternative system was developed by the EPBA and is operating in Rotterdam, the Netherlands. Spent batteries are fed from a hopper into a range of graded vibrating sieves and are manually sorted for packs and non-battery waste. A combination of electronic sensors and high speed weighing detects and sorts into different chemical types.*

*In Japan a colour coding system by chemistries has been introduced to help consumers sort Ni-Cd , NiMH and Li-ion batteries.*

*Finance & legislation*

*Legislation concerning the manufacture and disposal of batteries differs widely. Many governments have set high targets for recovery which are rarely attained. The Netherlands set a goal of 90 per cent recovery, but has yet to achieve much more than 60 per cent. In America, nine states have banned batteries from landfills, but enforcement is very difficult.*

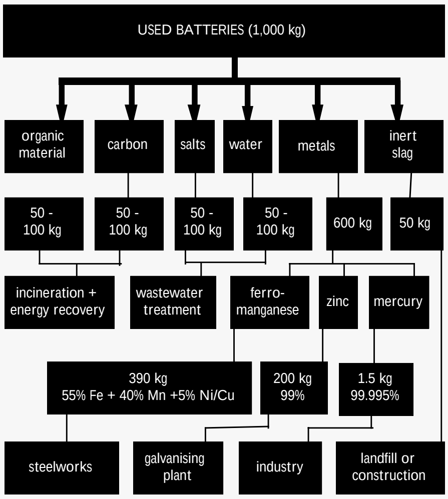
*The collection, storage, sorting and recycling of batteries incurs costs, and the question of who should pay arises. For most battery types, the cost of recycling exceeds the revenue that can be obtained.*

*In Germany , mandatory collection of all batteries has been required since October 1998. Customers must return spent batteries to trade or municipal collection centres which must accept them free of charge. Transportation costs are borne by manufacturers and importers, who must ensure that they are properly disposed of or recycled. The German system is estimated to cost US$18-28 million pa, or US$0.02 per battery.*

*In Denmark, a voluntary collection scheme was achieving 50 per cent recovery. The Government wished to improve collection of Ni-Cd batteries and introduced an eco-tax in 1996. The tax, levied on producers and importers, is US$0.8-5, depending on battery size.*

*The charge directs demand away from Ni-Cd batteries as the price becomes comparable to NiMH/Li-ion products. In 1998 the tax yielded US$ 4 million, which funds*

*Figure 1 Materials recovery from spent batteries*




*Source: Batrec (1999)*

*collection. A bonus of US$16.6 per kilogram of battery provides an incentive for enterprises to start collecting batteries.*

*Belgium's Bebat organisation was formed in 1995 to organise spent battery collection. 380 companies have joined, so qualifying for an exemption from an eco-tax of 0.6 Euro per battery. Bebat functions through a network of retail outlets (13,000), schools and youth clubs (5,000), civic amenity sites (600) and others (1,500). Collection rates set for 1996-98 (40-60 per cent) were achieved, and Bebat predicted the target for 1999 (67.5 per cent) would probably be met.*

*Current European legislation set limits on the mercury content of batteries and specified marking requirements.*

*Proposed amendments to the EU Batteries Directive might require a recovery rate of 75 per cent, and a total ban on cadmium. This is opposed by industrial groups such as the EPBA (mainly on the grounds that there are applications for which there are no readily available, cost-effective substitutes for Ni-Cd batteries).*

*In less developed countries, the market for rechargeable batteries is expected to expand rapidly as demand for electronic products grows; the majority of battery types could end up being disposed of in areas with no suitable infrastructure.*

## *Conclusion*

*Our lives are more battery-powered than ever, and the convenience of so many items which need low levels of power to work has improved our lives.*

*Some batteries contain particularly toxic metals, for which there used to be no satisfactory replacement. However, new technologies mean that there are safer alternatives, and legislation has generally kept pace to reduce risks through exposure to high levels of poisonous components.*

*Some batteries used in industry and commerce operate in a closed loop (with virtually total recovery and recycling). However, in the wider public sector thousands of millions of batteries are sold, used and discarded each year. Their small size, coupled with a difficulty in distinguishing between between types, make it difficult to achieve high collection rates.*

*Policy experiments with legislation, voluntary agreements and economic instruments (such as eco-taxes and levies) have been introduced in recent years, providing valuable experience in planning effective recovery and recycling policies and practices.*



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