Battery Management – Selected Country Case Studies

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1 Background and Objectives

Batteries have become an integral part of our everyday lives and from the simplest to the most complex machines. The concept behind the battery, the conversion into electrical energy of chemical energy through a controlled chemical reaction, was pioneered by Alessandro Volta in 1792. This seemingly simple invention laid the foundations for a revolution that transformed electrical energy through mobility and convenience [1].

The two main categories of battery are primary (single-use or "disposable") batteries that are used once and discarded and secondary (rechargeable) batteries which may be charged are discharged upto 1,000 times depending on conditions. Common types of single-use batteries include alkaline; zinc carbon; lithium; silver oxide; and zinc air. Common types of rechargeable batteries include Nickel Metal Hydride (NiMH); Nickel Cadmium (NiCd); lead acid batteries; and Lithium Ion (Figure 1) [1].

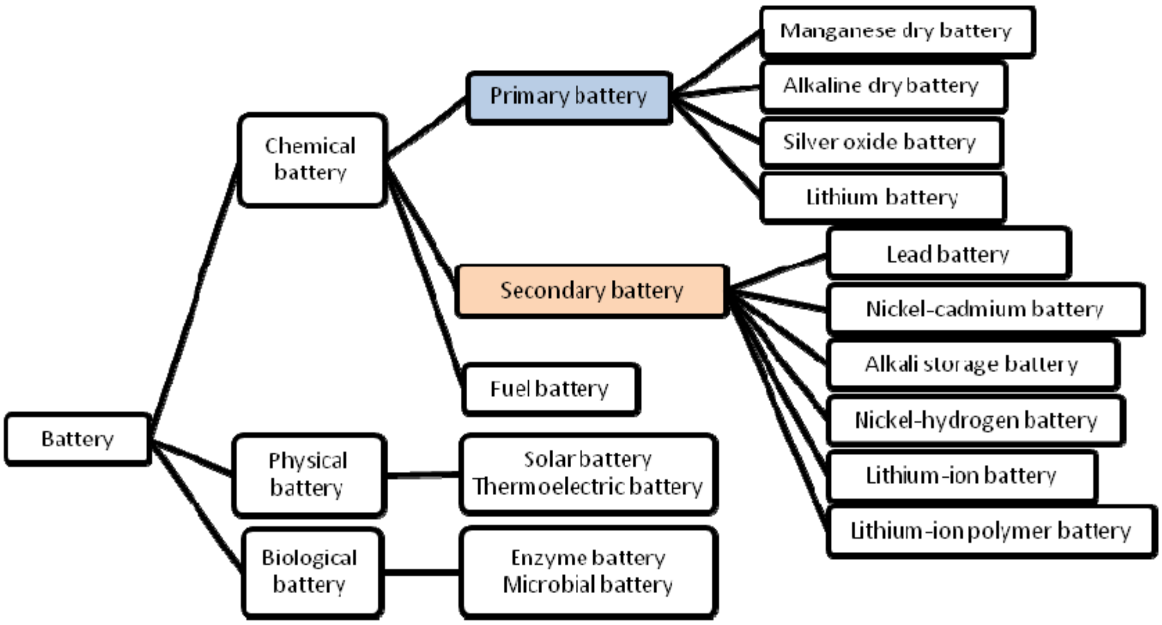

Figure 1: Type of batteries (Source: Glascock et al. 2012 [1])

The production of secondary batteries now far exceeds that of primary batteries thanks to the growing popularity of consumer electronics, information and communications products (Figure 2). Nickel-cadmium batteries have had the longest production history with annual demand once exceeding a billion units. However, their memory effect together with human and environmental hazards[1] resulted in their gradual replacement by nickel-metal hydride batteries (Figure 2). Manufacturers of electronic goods had to adapt their products accordingly. More recently lithium-ion batteries have largely replaced nickel-metal hydride batteries because of the demand for ever lighter and thinner electronic products [1] (Figure 2).

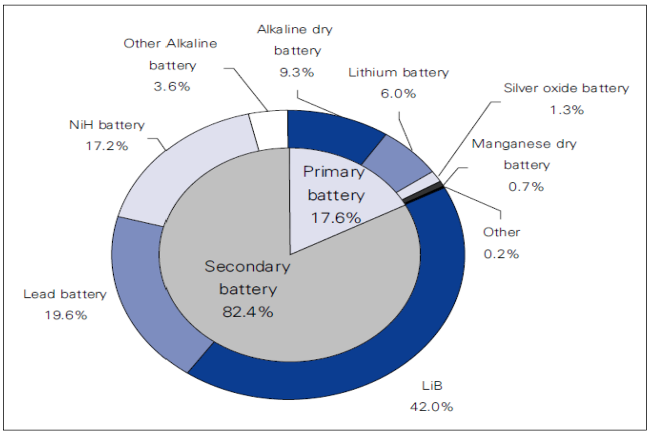

Figure 2: Primary and secondary battery production worldwide (Source: Glascock et al. 2012 [1])

Despite their widespread and growing use, batteries and accumulators are potentially very polluting when they become waste or are recycled, because of the hazardous metals, particularly.

Mercury, lead and cadmium, they contain. Most lead, Ni-Cd and batteries containing mercury are classified as hazardous waste. Zinc, copper, manganese, lithium and nickel are also commonly used in batteries. All these metals can constitute environmental hazards either by leaching into the soil and water after land disposal or via emissions to air and ash when batteries are remelted, incinerated or treated in other thermal processes.

At the same time batteries are can be important sources of secondary materials [2]. Valuable metals such as nickel, cobalt and silver can be recovered if batteries are properly recycled. Approximately 80% of the world's lead production is used for making batteries [3]. Recycled lead is a valuable commodity for many people in the developing world and the recovery of used lead-acid batteries (or ULAB) is a viable and profitable business. When done properly recycling can reduce pollution and improve resource efficiency.

Unfortunately lax environmental and occupational health regulations often mean recycling of lead batteries in developing countries is a heavily polluting process. The Basel Convention restricts the transboundary shipment of used lead batteries but there is still a large legal – and illegal – export market for used lead batteries from industrial countries to developing countries for cheap recycling The impact on the export of ULABs from the United States for recycling in Mexico is a classic example and is illustrated in another case study on Lead Battery Recycling in Mexico.

In many developing and transition countries, lead acid batteries are still recycled in densely populated urban areas with the lead smelted in the open air and with little (if any) pollution control resulting in high levels of worker exposure. This allows contaminates the environment and has even caused the deaths of children around lead smelting operations [4].

As a result of the high levels of contamination[2] but recognising the economic importance of lead acid battery recycling Technical Guidelines for the Environmentally Sound Management of Waste Lead-acid Batteries have been produced by the Basel Convention [5]. These guidelines contain detailed descriptions and programmes for the safer recycling of lead acid batteries which can also be applied, to some extent, to the management and recycling of other batteries.

The most effective way to address the environmental pollution associated with battery use and treatment has been demonstrated to be the introduction of mandatory policies and regulations relating to the manufacture[3], collection, recycling and disposal of batteries and accumulators.

The key is controlling of the material flow of batteries with the establishment of recycling targets and the development of a framework for funding collection schemes. Some example case studies are presented below which be adapted for other countries.

2 Approach, Achievements and Results

2.1 The European Legal Frame and Approach to Battery Management

European Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC7 was adopted with the intention of harmonising national measures concerning batteries and accumulators and waste batteries and accumulators

The primary objective of this Directive is to minimize the negative impact of batteries and accumulators and waste batteries and accumulators on the environment, thus contributing to the protection, preservation and improvement of the quality of the environment [6].

The Directive applies to all batteries and accumulators placed on the European Union market apart from those fitted to equipment used to protect essential national security interests.

The Directive includes a limit value for cadmium and mercury in batteries; defines the battery label requirements including special labelling indicating the lead, mercury and cadmium levels; specifies recovery goals for portable battery waste; bans waste industrial and automotive batteries from landfill or incineration; and requires the producers to be registered in each Member State. The Directive prohibits the placing on the market of certain batteries and accumulators containing mercury or cadmium. Mercury is allowed only in button cells with a mercury content of no more than 2 % by weight.

The Directive also promotes the collection and recycling of waste batteries and accumulators and improved environmental performance of all operators involved throughout the life cycle of batteries and accumulators, e.g. producers, distributors, end-users and those directly involved in the treatment and recycling of batteries and accumulators.

The Directive lays down minimum rules for operating national collection and recycling schemes, and in particular rules on how producers, or third parties acting on their behalf, must finance these schemes (Article 16).

As regards producer responsibility, producers of batteries and accumulators and producers of other products incorporating a battery or accumulator are responsible for the waste management of batteries and accumulators that they place on the market.

To avoid 'free-riders', each EU Member State are required to keep a register of producers who place batteries on the national market (Article 17).
In order to achieve a high collection and recycling rate for waste batteries and accumulators so as to achieve a high level of environmental protection and material recovery, the Directive sets a minimum collection and recycling targets for the Member States. The overall target set is that 25 % of all waste portable batteries should be collected by 2012 and 45 % by 2016 (Article 10(2)). Unlike waste portable batteries, waste industrial and automotive batteries are large, their users are professionals, and they are mainly collected by specialists, due to their economic value. As a result, nearly 100 % of industrial and automotive batteries are already being collected.

2.1.1 Emphasize on Extended Producer Responsibility

In the European Union, extended producer responsibility is mandatory within the context of the Waste of Electric and Electronic Equipment (WEEE), Batteries, and End of Life Vehicles (ELV) Directives, which put the responsibility for the financing of collection, recycling and responsible end-of-life disposal of WEEE, batteries, accumulators and vehicles on producers.

A project led by BIO Intelligence Service „Development of guidance on Extended Producer Responsibility (EPR)" was launched in October 2012 as part of the framework contract on Sustainable Management of Resources (FWC ENV.G.4/FRA/2008/0112). The study seeks to identify good EPR schemes for different waste streams (e.g. ELV, WEEE, Batteries, Packaging, Paper, and Used Oil) and to prepare detailed case studies which could serve as a guide for improving the effectiveness of such schemes. This should allow the Commission to formulate new proposals to optimise EPR schemes. The objective of the project is to describe, compare and analyse different types of EPR systems operating in the EU to identify best practices. The final project report was published in 2014 and revealed great discrepancies in performance indicators at the EU-28 level, where the collection rates vary from 5 % (MT) to 72 % (CH) and in average fees paid by producers, which vary from €240 (FR) to €5,400 (BE) per tonne of batteries put on the market, the unit used in order to make different kinds of tariffs comparable (fees are set by product unit in some MS and according to weight in others). The report promotes the examples of best practice in following countries: Austria, Belgium, Denmark, France, Netherlands and Switzerland.

2.1.2 Country Approach Germany

Germany has taken the leading in battery collection in Europe and has already almost achieved the 45 % collection rate the Directive requires by 2016. Almost half of all waste batteries are collected at retailers and nearly 30 % are taken back from companies and private sector collectors.
The collection scheme is simple: Battery producers are legally obliged to collect their products from the consumer and GRS Batterien Foundation[4] ('GRS') supply containers nationwide, and at no cost, to retail outlets, local authorities, public institutions and commercial end users for battery collection and transport. GRS then transports the filled containers to sorting facilities where they are sorted according to their electrochemical class so that valuable materials such as iron, manganese and nickel can be recovered and the metals lead and cadmium can be reused in battery production.
In 2011 GRS started the G2-Infoforum together with the 'ear' foundation (stiftung elektro-altgeräte register) – a series of events promoting information exchange between manufacturers and distributors. To assist German municipal collection partners and to encourage citizens to recycle batteries GRS developed a toolkit and communication materials. To improve the regional collection of waste batteries they focused on a national campaign called „Batterien – da steckt mehr drin" ("There is more in batteries") together with an educational initiative in kindergartens. To support this, a film and information materials on their website explains the battery collection system to consumers.
The 2012 collection target set by the German Battery Act was 35 % [7] while GRS reported a collection rate of 44 %.

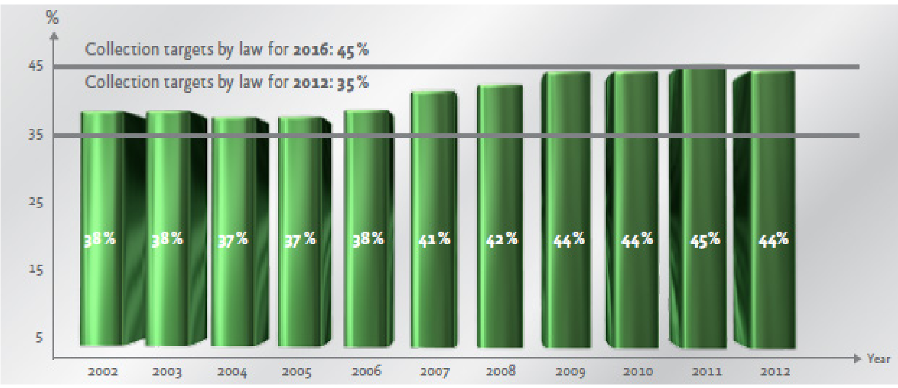

Figure 3:
Collection rate 2002 – 2012
(GRS Batterien –
Annual Review Report, 2012 [8])

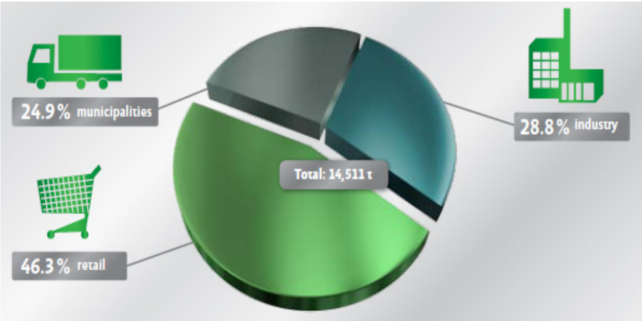

Figure 4: Volume of batteries collected, by origin
(Source: GRS Batterien – Annual Review Report, 2012 [8]))

Figure 4 shows the retail sector remains the most popular collection point for waste batteries and accumulators showing extended producer responsibility, including retailers, is a key.

Figure 5: Proportion of batteries recycled (from the collected 50 %)
(Source: GRS Batterien – Annual Review Report, 2012 [8])

Effective implementation of battery legislation together with improved sorting and recycling technologies could increase recycling rates to nearly 50 % within a decade (Figure 3 and 5). From the batteries collected in 2012, 97 % were recycled (Figure 5).

2.2 Country approach Japan

In Japan, the recycling of rechargeable batteries[5] and devices using compact rechargeable batteries is regulated by the April 2001 Law for the Promotion of Effective Utilization of Resources. The Law complemented by an Enforcement Order and by Ministerial Ordinance no 1 requires 10 specific Industries and 69 product lines to apply comprehensive 3R (reduction, reuse and recycling) measures. The law provides for measures to be taken by businesses, including 3R related measures in the product design and production stage, labelling to improve collection, and development of a system for collection and recycling by manufacturers.

In 2004 the Japan Battery Recycling Centre (JBRC) was established to address the collection and recycling of compact rechargeable batteries. The centre has been authorised as the Business Entity of Specified Resources – Recycling Product by the Ministry of Economy, Trade and Industry and the Ministry of Environment of Japan.

Figure 6 illustrates the process of collecting and recycling compact rechargeable batteries in Japan, as provided by the International Nickel Study Group [9].

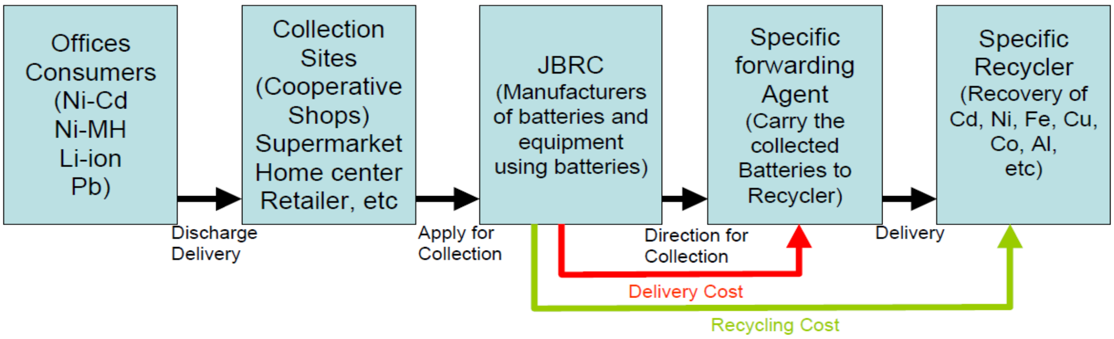

Figure 6: Process of collecting and recycling of compact rechargeable batteries in Japan (Source: Kunitomo 2006 [10])

JBRC has installed a total 8,000 collection sites for consumers and 60 sites for Local Government. The centre consists of manufacturers of both compact rechargeable batteries and of equipment that uses such batteries. The ministries set standards to facilitate separate collection with the widespread introduction of specific labelling for four types of small-sized secondary batteries as seen with the examples of recycling boxes:

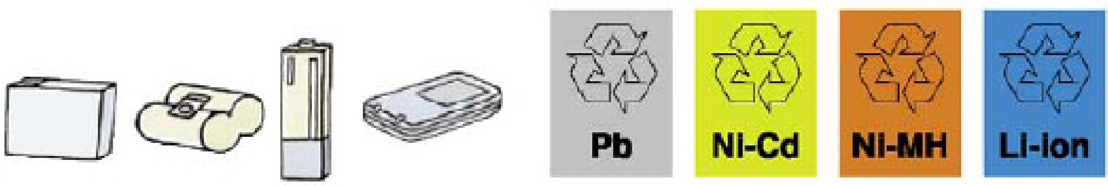

Figure 7: Specific Labels by types of batteries in Japan (Source: Kunitomo 2006 [10])

Publicity and educational measures were implemented continuously through various media. Promotion has been largely participatory including various events such as eco-products fairs. Additionally a range of education brochures have been produced to cover guidance for recycling.

Central to the Japanese approach is the use of extended producer responsibility (EPR) [11] in the form of producer "take-back" legislation. The dual objectives of EPR are to provide an incentive for producers to incorporate environmental considerations into product design, and to shift the responsibility for end-of-life products (physically or financially, or both) upstream to the producer and away from municipalities. Take-back legislation has been widely incorporated into Japanese environmental regulations over the past decade.

The success of Japanese EPR policy can be seen by comparing the statutory recycling targets set by the EPR laws. Targets have been set for recovery rates of home appliances, food waste, computers, rechargeable batteries, construction waste, and ELVs with timetables for achieving some targets (food waste, construction waste, and ELVs), but not with others (home appliances, computers, and batteries) which are subject to periodic review [11].

According to the information provided by the Japanese Ministry of Economy, Trade and Industry within the document "Disclosure of the Status of Collection and Recycling Conducted by Manufacturers and Marketers Based on the Law for Promotion of Effective Utilization of Resources" the results of collection and recycling of batteries at the level of 2004 are as set out in Table 1.

Batteries	Processed Volume (t)	Recycled Volume (t)	Recycling Rate (%)	Statutory Target (%)
Nickel-cadmium	878	647	73.7	60
Nickel-hydrogen	99	76	76.8	55
Lithium-ion	216	119	55.1	30
Small Lead Acid	3,938	1,970	50.0	50
Total	5,159	2,831		

Table 1: Results of batteries recycling in Japan (Source: Japanese Ministry of Economy, Trade and Industry 2005 [12])

2.3 Taiwan – a national approach to recycling [13]

Taiwan is an island with limited natural resources with most raw materials being imported. Since 1980 the municipal solid waste (MSW) in Taiwan has increased from 0.63 kg to 1.15 kg per person per day, resulting in increased waste management challenges. To address this issue and encourage a closed-loop economy that minimises resource loss, the Environmental Protection Administration of Taiwan (EPAT) actively promoted resource recovery and has subsequently developed standards for collection, treatment and recycling of waste [13].

In response to the Waste Disposal Act EPAT established the 4-in-1 Recycling Programme in 1997, which integrates manufacturers and importers of waste products into a complete system that also includes recyclers, municipal collection teams and community residents. The 4-in-1 Recycling Program (see Figure 8) established a fee-and-subsidy system, operated by EPAT's Recycling Fund Management Board (RFMB). EPAT determined the types of wastes that must be recycled under the 4-in-1 Recycling Programme. To date, this list includes 33 items divided into 13 categories, including waste batteries and waste lead-acid batteries [13].

The 4-in-1 Recycling Program aims to formalise waste recycling channels and reduce the environmental impacts of recycling. Under the programme, residents may send their waste to municipal collections, private collectors licensed by EPAT, or to the second-hand market [13].

Figure 8: 4-in-1 Recycling Programme Taiwan [13]

According to the Waste Disposal Act, waste collectors with facilities over 1,000 square metres and waste recyclers of all size are required to register with local Environmental Protection Bureaus (EPBs) and meet EPAT's environmental and safety standards in order to be eligible for subsidies under the 4-in-1 Recycling Programme. Waste collectors with facilities under 1,000 square metres, collectors and recyclers of non-waste are not required to register but must meet environmental and safety standards set by EPAT. Enterprises that are registered with local EPBs are considered "licensed", while enterprises that meet the additional standards required by the 4-in-1 Programme are considered "eligible for subsidy". Under the 4-in-1 Recycling Program, different waste items have different subsidies associated with them [13].

The Recycling Fund Management Board (RFMB) was created to manage the Recycling Fund that is used to subsidise the recycling and collection of waste. For each waste item, RFMB calculates a recycling fee rate based on the cost of recycling and collecting that item. The RFMB also determines the appropriate collection and recycling subsidy rates for each type of waste. The logic used to determine the fees to be paid is simple: manufacturers must pay the difference between the cost of collecting and recycling their product, and the revenues generated by selling any recovered resources. However, the actual calculations can be quite complex since they also take into account externalities and associated environmental clean-up costs [13].

RFMB regularly reports the status of the Recycling Fund to a Recycling Rate Review Committee (RRRC) and makes recommendations on whether the fee rate or the subsidy rate needs to be modified, and if so, how. The RRRC is responsible for final decisions on:

(a) the fee and subsidy rates based on waste component materials;

(b) the per unit weight or volume of waste;

(c) the annual cost of municipal waste collection;

(d) the value of recycled or reused waste products (based on a market survey);

(e) the cost of private collection, recycling and disposal (of non-recyclable components);

(f) the collection and recycling rates (verified through auditing);

(g) the auditing costs;

(h) the financial condition of the Recycling Fund, and other relevant factors.

The concept of green design also impacts the fee rates, serving as an incentive for manufacturers and importers to achieve sustainable production by designing products that can enhance resource reuse and reduce waste.

The RRRC is made up of representatives from multiple sectors, as recycling fee and subsidy rates have a direct impact on collectors' and recyclers' costs and competitiveness. The committee is composed of 21 members appointed by the Minister of EPAT incorporating representatives of governments (not exceeding 33 %), industry and trade associations, environmental protection NGOs, consumer protection NGOs and academia. The RRRC has three working groups where two of the sub-working groups deal with batteries [13] (Figure 9).

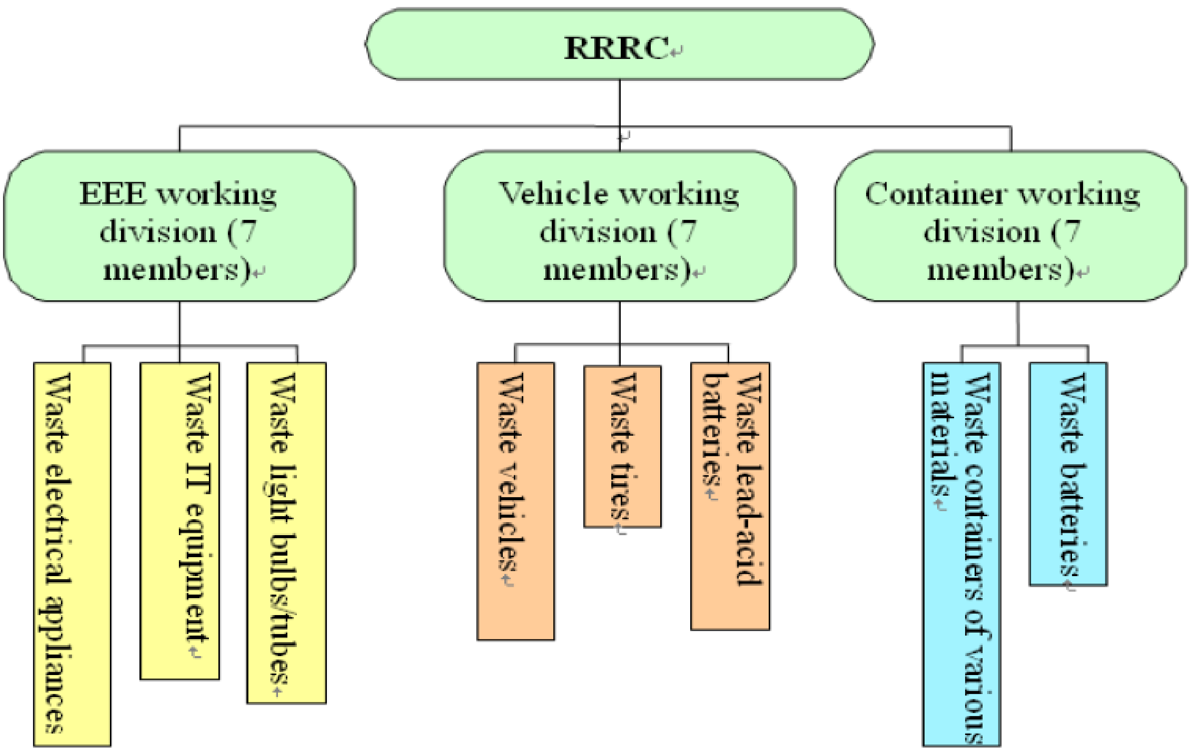

Figure 9: RRRC Working Divisions [13]

Figure 9 illustrates the structure of the RRRC Working Divisions. In addition to the RFMB and RRRC, EPAT established the Auditing and Certification Group (ACG) to verify the volumes of wastes that are collected and recycled by companies in the programme (see Figure 10 to see where the ACG groups sit within the programme structure). These volumes determine the amount of subsidy received by collectors and recyclers. The ACG is also responsible for auditing collectors and recyclers to ensure their compliance with EPAT's environmental and safety standards [13].

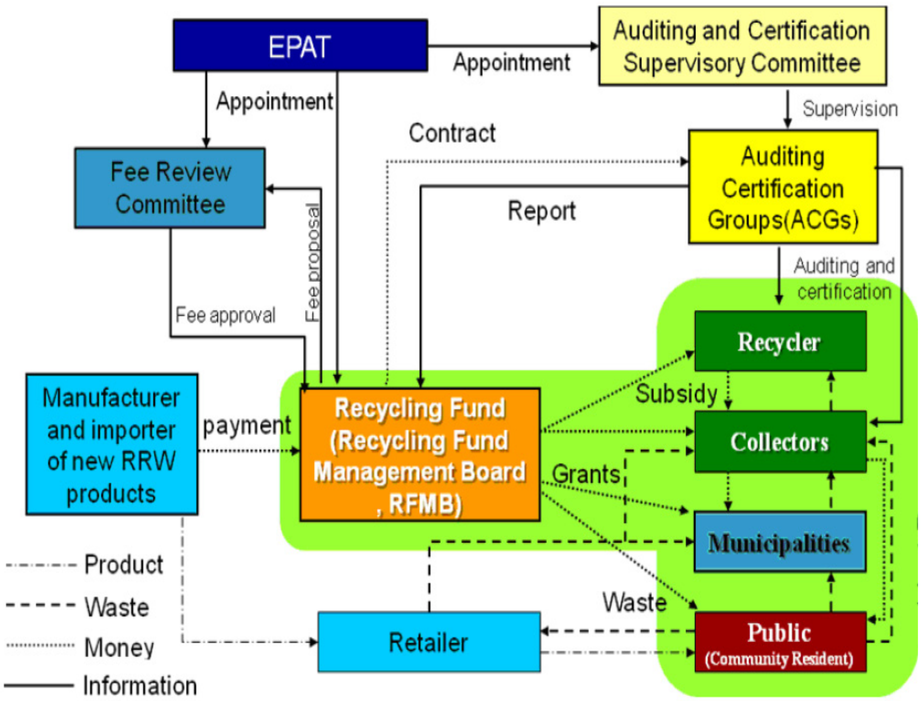

Figure 10:
Organisational Structure of the Taiwanese 4-in-1 Recycling Programme [13]

In this programme 20 % of the fee income goes to a "special income fund", while the remaining 80 % is distributed among eight trust funds, organised by waste category.

Taiwan's recycling fund is an example of Extended Producer Responsibility (EPR) in practice, because producers in Taiwan are responsible and accountable for the recyclability of their products. Producers also have an economic incentive for innovation, because if they "go green" they pay lower fees and can offer these products at a reduced price.

Due to the implementation of the 4-in-1 Recycling Programme, the Taiwan's battery recycling rate has been above 45 per cent since 2007. This represents one of the highest rates in the world, outpacing even the EU [13].

2.4 China – improving and controlling lead recycling

China has become the world's chemical and physical battery making power with more than 4,000 companies employing more than a million people [1]. In 2009 China's production of chemical batteries reached 33.5 billion units, which exceeded half of the world's production.

In recent years, due to frequent pollution incidents in China and relatively high lead levels in children [14] [15], the pollution problems from lead-acid battery and related industry has become a focus of remediation with the Chinese Ministry of Environmental Protection and five other ministries issuing a new policy outlining „views & norms on the promotion and the development of lead-acid batteries and secondary lead industry"[6]. The document stated that the government will take measures to speed up industrial restructuring and upgrading, increase the efforts to eliminate backward production capacity, control the industry access and production license management, and strengthen project management [16].

According to the statistics, before government intervention, there were more than 1,700 lead-acid battery enterprises registered by the Ministry of Environmental Protection. In order to reduce pollution, the Chinese government has issued improved environmental standards and has been active in monitoring the industry and factories. The standards have been established since February 2010 and specify that smelters using sintering machines must have at least a 50,000 metric-ton capacity; they further detail the amount of waste and sulphur dioxide the plants can discharge. The Chinese environmental ministry divide smelters into three categories for the discharge standards. The plants should discharge a maximum of 8 kilograms of sulphur dioxide and less than 5 kilograms of solid waste for each ton of crude lead produced. The policy is to eliminate pollution, strengthen lead pollution prevention and recycling of resources, and to promote the development of industry norms and a stricter control scheme [16].

China phased out 583 lead-acid battery producers, processors and recyclers in 2011. In 2012 a large number of lead-acid battery companies were still failing to meet national environmental requirements were also closed down [17]. As a result other suppliers increased production capacity and output to seize their market share. The recent nationwide activity covered 1,930 plants, of which 1,015 plants closed temporarily for maintenance or technical upgrades, resulting in a total 1,598 plants, or 82.8 per cent of the total, shutting down [18].

In the same year, Chinese lead-acid battery output was 175 million kVA – an increase of 23 % in 2011. Following the ever-growing market demand for electric bicycle batteries, automotive starter batteries, electric vehicle batteries and energy storage batteries, lead-acid battery output in 2015 is expected to reach 240 million kVA. These figures highlight the need for environmental control of this booming industry with it's high pollution potential. By 2015, the rate of waste lead-acid battery recycling and comprehensive utilisation should be over 90 % whilst the rate of lead recycling should be more than 50 % [17].

2.5 Senegal – mitigation of lead pollution from informal recycling [19]

Recovering lead from used lead acid batteries is a profitable livelihood activity for many people in developing countries and economies in transition. Unfortunately, the majority of small-scale battery recycling and smelting is conducted without pollution controls, releasing large amounts of lead into the environment. Because lead does not break down in the environment, it can continue to poison communities and children for generations unless it is cleaned up. The case of acute lead poisoning in the neighbourhood of Thiaroye Sur Mer in Dakar, Senegal is but one example of a problem faced in urban areas across low- and middle-income countries around the world.

In March 2008 eighteen children under the age of five died from lead poisoning in Thiaroye Sur Mer. The source was exposure to highly contaminated soil caused by unsafe recycling of used lead acid batteries, which was the main economic activity for local women at the time. Because this activity was conducted by the informal sector, without protection measures the surrounding population – particularly children – were affected by lead poisoning [19]. After the deaths the government shut down these battery-smelting operations. However, the legacy of many years of unregulated lead processing has rendered the entire community of 40,000 people exceedingly polluted.

In April 2008, the Ministry of Health in conjunction with the University of Dakar Toxicology Division conducted blood tests among 41 children of Thiaroye-Sur-Mer. All children tested had blood levels that exceeded WHO limits of 10 µg/dl, with the highest average being 158 µg/dl for the one-to-five year age group [19]. According to most international standards, lead levels above 70 µg/dL in children are considered medical emergencies.

In response to a request for emergency assistance from the Senegalese Ministry of Health, a consortium of international and Senegalese partners launched a project to mitigate the health risks from contaminated soil and homes, and eliminate the unsafe recycling practices. The first priority was to protect the health of the children immediately at risk through treatment, education and remediation of contaminated soil and homes. The University of Dakar's Toxicology Department worked with the Ministry of Health alongside local authorities to develop an education and outreach program to raise awareness about the dangers of lead exposure. The World Health Organization (WHO) conducted the emergency blood lead monitoring and environmental screening and later helped treat lead-poisoned children and adults.

The average levels of lead in the soil removed were 200,000 PPM. With funding from Green Cross Switzerland, Blacksmith Institute, Terra Graphics Environmental Engineering, Inc and Quality Environmental Solutions (QES), the local government were able to remediate the area. Approximately 3,000 cubic metres of lead-contaminated soil was removed to a lined landfill using local contractors and community labour, under the supervision of Blacksmith, Terra Graphics, QES experts and the Senegalese Ministry of the Environment. Soil was removed from more than 100 homes, where lead dust had accumulated to dangerous levels. The homes were scrubbed and soil was removed with heavy-duty vacuums. The remediation was completed in February 2013 achieving safe and permanent disposal of the lead-contaminated soil. Local residents were educated about the risks and trained in techniques to effectively protect themselves from re-contamination.

The second objective was to support the government to develop sustainable ULAB recycling program and policies to prevent future contamination. To this end, the International Lead Management Centre (ILMC), the International Lead/Zinc Management Study Group (ILZMC) and Blacksmith Institute assisted the Ministry of Environment, Health and Trade to develop national policies to regulate battery-recycling activities to prevent future informal economies from surfacing [20]. Policy changes are now in effect, targeting the elimination of informal ULAB recycling through improved battery collection regulation, transport, storage and recycling. Finally, the project is helping local residents identify alternative forms of economic activity to replace the lost income from battery recycling. A newly-constructed ULAB collection centre is now being used to manage batteries safely and the Senegalese Department of Women's Affairs, with support from the French Global Environment Facility, are working to support alternative livelihood projects for the women previously engaged in ULAB recycling in the area.

Soil levels in the area are now below 400 PPM. Additionally, children between the ages of one and five years old who previously had blood lead levels in excess of 150 µg/dl in early 2008 were retested in August 2013. The average blood lead level in that group is now 53.5 µg/dl – still considerably above the WHO limit of 10 µg/dl, however levels are predicted to continue to decrease. Similar decreases were seen across other age groups as well, – a massive achievement. Monitoring of children's blood levels will continue.

Figure 11a: Transfer of contaminated materials (Source: Blacksmith Institute 2009 [20])

Figure 11b: Local crew hired and trained to remove lead contaminated soil (Source: Blacksmith Institute 2009 [20])

3 Conclusions and Lesson learned

The heavy metal life cycle of batteries represent a major hazard to human health and the environment. Effective laws and regulations are urgently needed to reduce the current levels of harm. Without appropriate controls and technology the recycling of batteries often severely damages the health of recycling workers those living close by as well as polluting the land in the vicinity of recycling sites and smelters. Technical guidelines such as the Basel Technical Guidelines and/or the EU BAT Reference Documents should be used to improve the standards of smelters before permits are issued. Furthermore smelters must have the technical and financial capacity to implement improved technologies, and governments must be able to monitor and regulate smelters emissions effectively.

The problems associated with battery collection and management can be overcome by the introduction and application of mandatory policies and regulations together with restrictions on batteries being disposed in dumps/landfills or being incinerated. In addition, the economics, regulation, licensing and improvement/formalization of the informal sector need to be addressed in order to reduce or prevent flows of batteries into informal recycling.

The most effective way to reduce the flow of toxic heavy metals from batteries, however, is the imposition of restrictions on the substances used in batteries and accumulators including imposing concentration limits.

As a result of this study, it becomes evident that battery recycling should be supported by free-of-charge collection and recycling programmes based on Extended Producer Responsibility. This should be developed at a national level. Funding for recycling programs should ideally be provided by the manufacturers, importers and retailers.

The use of extended producer responsibility (EPR) shifts the responsibility for end-of-life products (physically or financially, or both) upstream to the producer and away from municipalities in line with producer “take-back” legislation. EPR should also incentivise producers to incorporate environmental considerations into product design and recyclers and collectors to improve recycling levels. To achieve such results a range of communication methods, incorporating awareness raising exercises, is essential.

The Swiss government set a battery recycling target of 80 % in response to concerns about the high levels of heavy-metal in household waste. Whilst progressive at the time this might be considered a minimum standard that is needed. Most national recycling levels are still below 50 %, however, and so the majority of batteries still end up in landfills or dumps with associated heavy-metal pollution. In addition to improving recycling levels, Extended Producer Responsibility Programmes which eliminated contamination at source by banning the use of the most hazardous materials and which internalise the high external costs of environmental pollution should be implemented. These EPR programs should encourage the production of more environmentally benign products which could play a vital role in a more sustainable production and consumption.

4 Links and Materials Available

Technical Guidance and BAT/BEP Guidance

Basel Convention (2003), Technical guidelines for the environmentally sound management of waste lead-acid batteries

European Commission (2013), Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metal Industries (Draft)

European Commission (2001), Reference Document on Best Available Techniques in the Non Ferrous Metals Industries

United States Department of Labor, Occupational Safety and Health Administration (2008), Guidance for the Identification and Control of Safety and Health Hazards in Metal Scrap Recycling, 2008

Selected Legislation

China (1989), Environmental Protection Law of the People‘s Republic of China

China (2000), Technical Policies for the Municipal Refuse Disposal and the Prevention and Control of Pollution

China (1995), Law of the People’s Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Waste

China (1991), Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, and the relevant laws and regulations

China (2009), Catalogue of Solid Wastes Forbidden to Import in China, as amended

China (2008), Catalogue of Restricted Import Solid Wastes that Can Be Used as Raw Materials in China

China (2008), Catalogue of Automatic-Licensing Import Solid Wastes that Can Be Used as Raw Materials in China

European Commission (2006) Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC

European Commission (2012), Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast)

European Commission (2000), Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles

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1 The EU has prohibited the sale of nickel-cadmium batteries since 2008 [6]. China (the major producer of nickel-cadmium batteries) decided in 2011 to restrict the production of nickel-cadmium batteries due to serious cadmium pollution on agricultural land and water. It also planned to gradually reduce the consumption of cadmium within battery industry [1].

2 According to the World Health Organization, the limits for lead in blood are 10 µg/dl. In most of the international standards, lead levels above 70 µg/dL in children are considered medical emergencies often exceeded around smelting operations.

3 With restrictions on the use of particularly hazardous materials such as lead and cadmium

4 GRS Batterien Foundation operates the common collection scheme for portable batteries as specified by the German Federal Ministry for the Environment under Section 6 of the German Batteries Act (BattG)

5 Including compact Pb-Batteries, Ni-Cd-Batteries, Ni-MH Batteries, Li-ion Batteries;

6 In China, the laws and regulations governing the management of batteries management by the Ministry of Environmental Protection include the Environmental Protection Law of the People's Republic of China, the Technical Policies for the Municipal Refuse Disposal and the Prevention and Control of Pollution, the Law of the People's Republic of China on Prevention and Control of Environmental Pollution Caused by Solid Waste", the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, together with the Catalogue of Solid Wastes Forbidden to Import in China, the Catalogue of Restricted Import Solid Wastes that Can Be Used as Raw Materials in China, the Catalogue of Automatic-Licensing Import Solid Wastes that Can Be Used as Raw Materials in China (http://english.mep.gov.cn/Policies_Regulations/).