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# A Study on the Environmental Policies of Waste Batteries in China

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*Wenwu Zhao*

## Abstract

Following rapid economic growth and industrialization in China, environmental problems from waste batteries are rising as a consequence. There is an urgent environmental demand to establish a waste battery management system in China. With the purpose to contribute to the development of waste battery policy in China, this study presents the environmental problems from waste batteries in China and evaluates the environmental policies of waste batteries using an analysis framework. The framework is divided into two levels: Principle of Environmental Policy and Performance Criteria of Environmental Policy.

According to the newly released the Technical Guide on Waste Battery Management, the future waste battery management system is described and analyzed, leading to the findings of its strength and weakness. Some possible policies are also discussed, including a common label, bar cod, collection approaches, environmental taxes/charges, deposit refund system, environmental education and public information.

Finally, the study arrives at the conclusion that the general status of waste battery management in China is not good. It must be a long-term task for China to set up an effective waste battery management system and drive battery industry toward sustainable development.

## Key Words

China, Collection, Environmental policy, Hazardous waste, Labeling, Prevention at source, Producer responsibility, Recycling Sorting, Waste battery management system,

# Executive Summary

Following economic growth and industrialization, the environmental problems from waste batteries are emerging rapidly in China. The environmental policy of waste batteries is lagging behind development of the battery industry.

The Chinese authorities and environmental researchers have recognized the environmental problems from waste batteries, and some policies relating to battery industry have been released. With the purpose to contribute to the development of waste battery policy in China, this study presents the environmental problems from waste batteries in China and evaluates the environmental policies of waste batteries.

Based on the research purpose, the study is to address the following research questions:

- What are the environmental problems of waste batteries in China?
- What do the existing polices look like?
- What policies could be adopted for the development of waste battery management?

In order to evaluate the environmental polices of waste batteries an analysis framework is developed. The framework is divided into two levels: Principle of Environmental Policy and Performance Criteria of Environmental Policy.

In order to understand the environmental policies, background information is introduced in chapter 2, 3 and 4. Through analyzing the data and information offered from these chapters, a number of findings are identified and can be summarized as follows.

- Until today, China has not established a waste battery management system. China is facing environmental risks from waste batteries. There is an urgent demand to set up an effective and efficient waste battery management system in China.
- The newly released Technical Guide on Waste Battery Management is the framework for a future waste battery management system. The technical guide introduces the extended producer responsibility (EPR) into the Chinese environmental policy system for the first time. The technical guide carries out strict requirements on the collection and recycling of waste batteries. But the technical guide focuses secondary batteries and button cells more than primary batteries.
- The implemented policies, especially the Regulation on the Limitation of Mercury Contained in Batteries, have obtained environmental effectiveness partially. They are successfully implemented by large battery manufacturers. But these policies did not get good result of implementation in small and medium sized plants.
- Although the Chinese authorities tried to regulate the battery industry toward sustainable development, some policies failed to reach the goal. Some problems happened in the processes of policy making, implementation and administrability.
- As a matter of fact, rural regions are suffering more serious environmental risks from waste batteries than urban regions.

According to the information and analysis in this study, some possible policies are discussed and suggested to the environmental authorities and policy-makers.

- A common label and code bar for batteries are suggested in order to provide the convenient information for collection and separation by manual or automatic devices.

- The municipal waste management system may take an important role in the collection of waste batteries. The producers may transfer responsibility of collection of waste batteries to municipal waste system. In order to improve collection rate, the multiple collection approaches discussed in this thesis could remedy each this.

- The economic instruments of environmental taxes/charges and a deposit refund system are discussed. The environmental taxes/charges can drive the battery industry to reduce environmental impacts and toward sustainable development. The deposit refund system may offer economic incentive for improvement of collection rate.

- In the end, environmental education, public information and public participation should be considered by authorities and NGOs.

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# 1. Introduction

## *1.1 Why Discuss Waste Batteries?*

China has been experiencing a high rate of economic growth since the end of 1970s. In the past two decades, China has achieved great industrial and social development, and China is becoming quickly the manufacturing center in the world.

Following economic growth and industrialization, serious problems of waste disposal are emerging rapidly. This is happening not only in urban areas, but also in the rural regions. Among the environmental problems in China, the problem of waste batteries is an urgent case. China has been the largest battery manufacturer in the world since 1982,[1] and the output of batteries is still quickly growing. In China, the battery consumption has reached around 7-8 billion units per year.[2]

Batteries, especially the batteries containing mercury, cadmium and lead, are potential pollutants for the environment. But the environmental management and policy of batteries are seriously lagging behind the industrial development in China.

In recent years, the environmental problems from waste batteries are getting attention by environmentalists, authorities and the general public. The first policy focusing on mercury batteries was released in 1997. Some more policies relating to batteries have been released since then. Concerned by the serious potential environmental risks from waste batteries, the Chinese authorities are designing a waste battery management system. It is expected that the waste battery management system could lead the battery industry toward sustainable development.

Sustainable development is a long-term goal of world development. The Chinese Government and public have recognized the importance of sustainable development of the battery industry and responsible waste battery management. The environmental policies of waste batteries could be a drive to lead the industry towards sustainable development.

## *1.2 Purpose and Research Questions*

The purpose of this study is to evaluate the existing policies of waste batteries, and discuss the possible policy approaches in order to contribute to the development of waste battery policy in China.

Based on the research purpose, the study is to address the following research questions:

- What are the environmental problems of waste batteries in China?
- How do the existing polices look like?
- What policies could be adopted for the development of waste battery management?

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[1] CBIA. (2000). *The 10th 5-year plan of battery industry*. [Online]. Available: http://www.chnbia.com/dchydsgwnjh.htm. (August 20, 2003). (Chinese)

[2] Fujian Daily. (2002). *Waste treatment: A rising industry*. [Online]. Available: http://www.fujian-window.com/Fujian_w/news/fjrb/gb/content/2002-10/28/content_312502.htm(July 12, 2003) (Chinese)

## *1.3 Scope of the Study and Limitations*

### 1.3.1 Subject Boundaries

In this study, only the policies at the national level relating to waste batteries are studied, excluding the policies at the provincial and municipal levels. Since the policies on hazardous substances in batteries are related closely to the issue of waste batteries, these policies are also included in the research scope. The researched policies are mainly found in the following legal documents:

- Law on Prevention of Environmental Pollution Caused by Solid Waste[3]
- Regulation on the Limitation of Mercury Contained in Batteries[4]
- The Technical Guide on Hazardous Waste Management[5]
- The Technical Guide on Waste Battery Management[6]

In this study, in order to analyze existing policies and discuss possible future policies, the scope of waste batteries only includes:

- Waste consumer batteries (including portable primary batteries, portable secondary batteries and button cells),
- Waste lead-acid batteries
- Waste special batteries groups and single batteries incorporated in electronic and electrical equipment

### 1.3.2 Geographical Boundary

In this study, the geographical boundary is defined as China Mainland. The general concept of China includes China Mainland, Hong Kong, Macao, and Taiwan. Under the Chinese legal system, the above policies are not valid in Hong Kong, Macao, and Taiwan. Hong Kong and Macao are Special Administrative Regions, and Taiwan is an un-unified region. In this study, all information and data are from China Mainland, and reflect the condition of China Mainland.

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[3] Standing Committee of the National People's Congress. (1995). The law of the people's republic of china on prevention of environmental pollution caused by solid waste. Issued on October 30, 1995, and enter in force on April 1, 1996. Article 24. (Chinese)

[4] Light Industry Association. (1997). Regulation on the limitation of mercury contained in batteries. Qinzonghangguan. (1997) 14. (Chinese)

[5] SEPA. (2001). The technical guide on hazardous waste management. [Online]. Available: http://www.sepa.gov.cn/650210499031465984/20021117/1035325.shtml.(November 22, 2003). (Chinese)

[6] SEPA. (2003). The technical guide on waste battery management. Huanfa (2003) 163. (Chinese)

### 1.3.3 Limitations

During this research, it was not feasible to go to China to collect some original information and interview people. So in this paper, all information is from secondary sources or obtained by interviews via telephone and e-mail.

Many information resources are from 1997 to 2001. Thus, in many cases they are quite outdated. For statistical data, the optimal would be data from 2002. Unfortunately, the newest data are generally not available from journals, Internet and literature.

There are some limitations to the quality of statistical data. Firstly, according to convention in China, the battery industry is divided into two segments: the light industry, including primary batteries and small portable secondary batteries; and storage batteries, including the lead acid storage batteries. Therefore, confusion may occur when dealing with statistical data on the Chinese battery industry if the segments are misinterpreted. Secondly, there are no systematic statistics of the batteries market and battery industry in China. Many articles report differing statistics about the same types of batteries. Hence, some statistical data may come to the reader along with defects.[7]

The study has been facing language challenges as all information and data are from sources written in Chinese or English. Because of the lack of written information in English, more than half of all information sources and materials used are in Chinese. Many articles, documents and other data sources are only available in Chinese, and they had to be translated to English. There is always a risk that translations used in the text will not fully convey the message in the original language.

## *1.4 Methodology*

### 1.4.1 Information Sources

This study is based on reviews of literature, legal and governmental documents, discussions with researchers in the area, and analysis of policies.

In this study, most materials relating to waste batteries were collected from journals, newspapers and websites. Most governmental documents were obtained from official government websites. The statistical data are mainly from annual reports of industries and government. In order to clarify some unclear questions, as well as information and data, discussions were conducted with Chinese researchers from various research institutes and educational institutions through telephone and e-mail. Internet BBS is also an information source in this study.

### 1.4.2 Research Method

Figure 1-1 displays the thesis structure, which shows that the study includes four phases. The Chapters 2-4 offer the basic information for analysis. Based on the basic information and analysis, the possible policies are discussed and the conclusion is carried out.

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[7] Business Communications. (1998). *China's Batteries Market*. [Online]. Available: http://www.buscom.com/energy/html/gb213.html. (August 15, 2003)

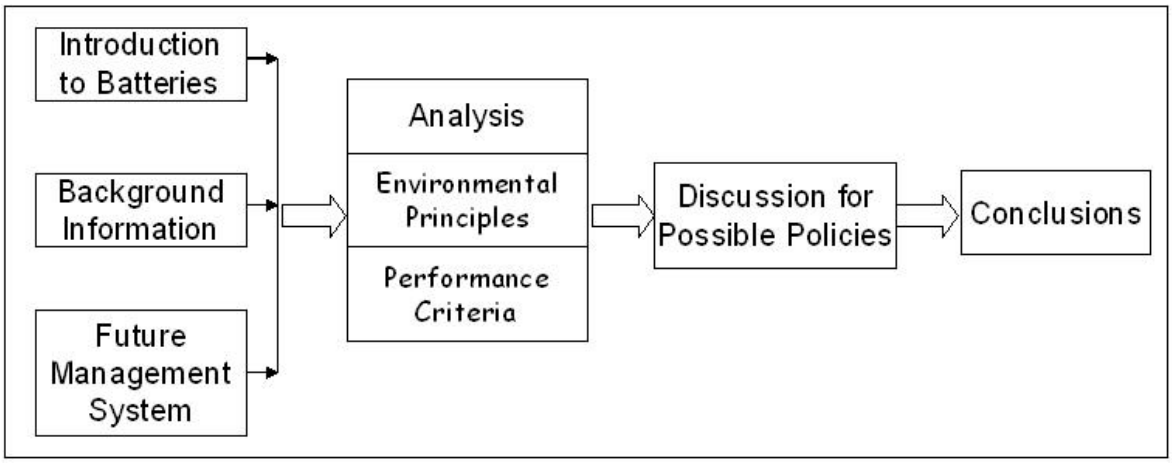


Figure 1-1: Thesis structure

In order to conduct the analysis of environmental polices of waste batteries an analysis framework is developed. The framework is divided into two levels: **Principle of Environmental Policy** and **Performance Criteria of Environmental Policy**. The policies of waste batteries in China will be examined according to the principles and performance criteria of sustainable environmental policies.

In this study, four principles are discussed. These are sustainable development, prevention at source, polluter pays principle and the 3Rs principle. Normally, the first three principles are applied in environmental law and economics. In this study, the author extends the scope to general environmental policy.

Performance criteria are usually applied for evaluation of environmental policies. In this study, the following five performance criteria are selected from OECD reports on EPR programs. The author extends the scope of these performance criteria into general environmental policy.

- Environmental effectiveness
- Economic efficiency
- Innovative advancement
- Political acceptability
- Administrability

### 1.4.3 Gap of Information

Some potentially useful information is not available, since China has not implemented a waste battery management system yet and is lacking statistical data. Under this condition, it is difficult to build the information basis for analysis of the environmental policies. In order to remedy the gap of information, the author tries to look for experiences in other countries and from programs managing other discarded products.

Foreign experiences and programs can supply valuable information. But the economic and social conditions are different from China as compared to foreign countries, especially the industrial countries. In order to decrease uncertainty, such information is selected and

analyzed carefully. In the analysis, the differences between China and referenced countries will be considered.

# 2. Introduction to Batteries

A battery is an electrochemical cell (or enclosed and protected material) that can be charged electrically to provide a static potential for power or released electrical charge when needed. A battery generally consists of an anode, a cathode, and an electrolyte.[8]

The first battery was demonstrated nearly 200 years ago. By 1866, Georges Leclanché, a French engineer, patented a new system, which is the zinc-carbon battery. Leclanché's zinc-carbon battery became the forerunner to the world's first widely used batteries.[9] At that time, the batteries were very simple, and were not used widely. During the more than one hundred years since then, the batteries have developed a lot. New battery types and significant improvements in the performance of existing batteries have spurred an increased use of batteries throughout today's society. Batteries are one of the most important objects in our everyday lives.

## *2.1 Types*

The chemical elements, sizes and functions of batteries are different from battery to battery. The batteries can be divided into groups by different approaches. This brief introduction to the various types of batteries aims to help the readers understand the basic knowledge of batteries, with the purpose to help readers understand the policies on waste batteries.

### 2.1.1 Primary and Secondary Batteries

Commonly, the batteries are divided into two categories: **primary** and **secondary** batteries.

Primary batteries are designed to deliver a single discharge[10], and they are not rechargeable. Consequently, in the cells of primary batteries, through chemical reactions the chemical energy converts into electric energy in an irreversible process. This leads to that the batteries have to be thrown away when the chemical energy is consumed.

Secondary batteries are capable of repeated charging and discharging[11]. Consequently, this type of batteries can be used many times. Secondary batteries are more expensive than primary batteries and need a re-charger to support their work. In the cells of secondary batteries, the chemical reactions are reversible. In the process of discharge, the chemical energy converts into electric energy; while during charging the electric energy converts into chemical energy.

Secondary batteries are commonly used in mobile phones, computers, home appliances, power tools, emergency lighting systems and back-up systems for professional users, as well as for many other applications. One secondary battery can substitute hundreds of primary

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8 Whatis. (2003). *Batteries.* [Online]. Available: http://whatis.techtarget.com/definition/0,,sid9_gci214364,00.html. (June 28, 2003)

9 About. (2003). *Batteries History.* [Online]. Available: http://inventors.about.com/library/inventors/blbatteries.htm. (June 29, 2003)

10 Dell, Ronald M. & Rand, David A. J. (2001). *Understanding batteries.* Cambridge, UK: The Royal Society of Chemistry. p. xxvi

11 Dell, Ronald M. & Rand, David A. J. (2001). *Understanding batteries.* Cambridge, UK: The Royal Society of Chemistry. p. xxvii

batteries. So, the secondary batteries have the potential to bring less environmental impacts than primary batteries.[12]

### 2.1.2 Categories Based on Chemical Composition

It is common to divide the batteries according to chemical composition. The chemical composition of batteries is given by the name of the batteries. Here is only a general description of the most common types of batteries.

#### 2.1.2.1 Zinc-Carbon Battery

The zinc-carbon battery (also named dry battery or zinc-manganese battery) is the technological foundation of today's growing battery industry. The zinc-carbon battery has a zinc anode, a manganese dioxide cathode, and an electrolyte of ammonium chloride or zinc chloride. The zinc-carbon battery usually provides 1.4 to 1.7 volts of direct current electric power, and the voltage gradually declines to 0.9 volts during use. With the purpose to improve the performance, zinc-carbon battery may contain mercury. The zinc may contain about 0.05% cadmium, as the cadmium refines the grain and makes the alloy harder and also more corrosion resistant, and may also contain 0.25% lead.[13]

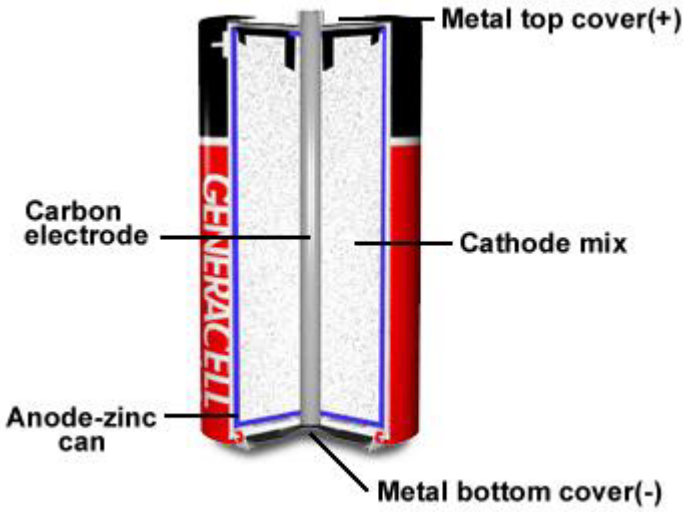


Figure 2-1: An example of zinc-carbon battery[14]

Mercury and cadmium are harmful substances to the enviornment. But, because of the low cost and simple production, many mercury-containing zinc-carbon batteries are still used in developing countries, including China.[15]

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[12] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. P.21.

[13] Davidson, Michael W. & Florida State University. (2003). *Zinc-carbon batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/zinccarbon.html (July 2, 2003)

[14] Davidson, Michael W. & Florida State University. (2003). *Zinc-carbon batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/zinccarbon.html (July 2, 2003)

### 2.1.2.2 Alkaline-Manganese Battery

The alkaline-manganese battery (also or named alkaline battery) contains manganese dioxide and aqueous alkaline electrolyte, as well as zinc metal as a powder.[16] Formerly, the alkaline-manganese battery contained around 1% of mercury by weight.[17] The voltage of an alkaline-manganese battery begins above 1.5 volts, which reduces gradually during use. A merit of alkaline-manganese batteries is that they can work well at temperatures up to 55 degrees Celsius.

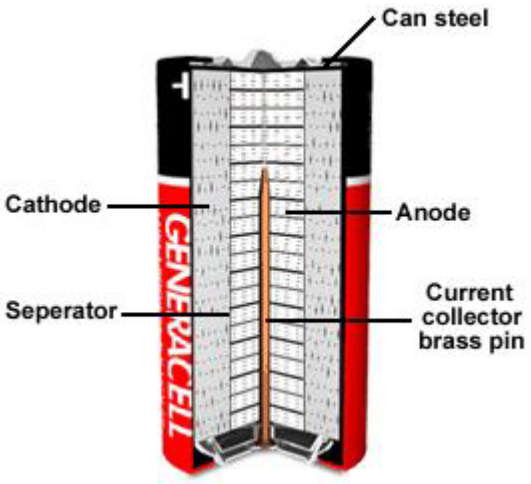


Figure 2-2: An example of alkaline-manganese battery[18]

The alkaline-manganese battery has a higher capacity than the zinc-carbon battery of same sizes. The alkaline-manganese battery was introduced in the early 1960's and keeps the strong position on the battery market today.

The disadvantage of alkaline-manganese battery is that they often contain mercury to improve performance. In the last decade, the mercury proportion decreased gradually with the technology development and following legal requirements. In many industrial countries, such as the member states of EU, and the United States, batteries containing mercury more than set legal standards are prohibited.[19]

### 2.1.2.3 Lithium Battery

Showing from Figure 2-3, the lithium battery has an anode of lithium foil and iron sulfide as the active material in a porous carbon cathode. A non-aqueous electrolyte such as an organic

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[15] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003). (Chinese)

[16] Davidson, Michael W. & Florida State University. (2003). *The alkaline-Manganese batteries.* [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/alkaline.html (July 2, 2003)

[17] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.22.

[18] Davidson, Michael W. & Florida State University. (2003). *The alkaline-Manganese batteries.* [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/alkaline.html (July 2, 2003)

[19] Cao, Guoqing, Shen, Yingwa & Jian Xiaodong. (2002). *Management of spent batteries and environment protection regulations.* Chinese batteries industry. 7, 6, p.323. (Chinese)

solvent blend is used, and the anode, cathode, and electrolyte combine for high current and low temperature performance.[20]

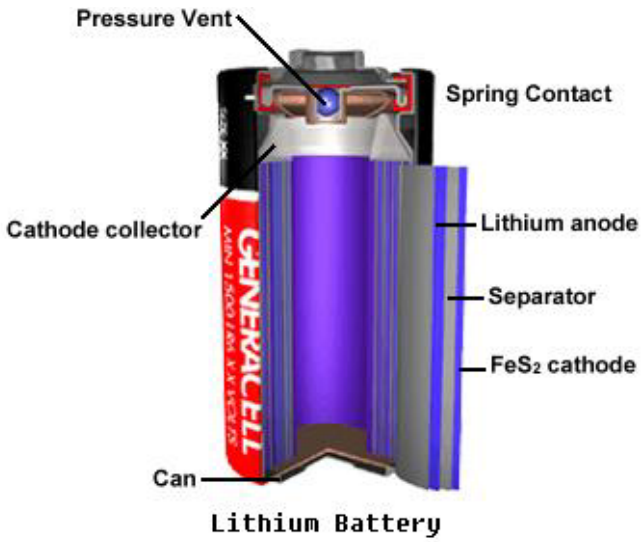


Figure 2-3: An example of lithium battery[21]

The advantages of a lithium battery include high voltage (up to 4 volts), high energy density, and operation over a wide temperature range, good shelf life, and excellent power density.[22] For these reasons, lithium batteries are widely used as primary and secondary batteries. Various button cells of lithium type are used for maintaining clocks in computers, watches, calculators, cameras, and toys. Advanced lithium batteries have many military and industrial applications.

#### 2.1.2.4 Nickel-Cadmium Battery

A nickel-cadmium battery can provide a high energy density in a short time. It is widely used as back-up power units for industry and for communications systems. Nickel-cadmium batteries contain cadmium, which is a hazardous element for the environment. Nickel-cadmium batteries are considered by US EPA to be the largest source of cadmium in municipal solid waste in the United States[23]. Considering the environmental impacts from nickel-cadmium batteries, some substitutes have been developed, like lithium-ion battery and nickel-metal hydride battery[24].

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[20] Davidson, Michael W. & Florida State University. (2003). *Lithium batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/lithium.html (July 2, 2003)

[21] Davidson, Michael W. & Florida State University. (2003). *Lithium batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/lithium.html (July 2, 2003)

[22] Davidson, Michael W. & Florida State University. (2003). *Lithium batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/lithium.html (July 2, 2003)

[23] Shapek, Raymond A. (1995). *Local government household batteries collection programs: costs and benefits*. Resources, Conservation and Recycling,15, pp. 1-19.

[24] CMP. (2003). *A battery of potential*. [Online]. Available: http://www.electronicstimes.com/story/OEG20010829S0013. (September 14, 2003)

Another disadvantage of nickel-cadmium batteries is the 'memory effect', which decreases the performance of the battery. However, this is solved gradually by technology improvements in recent years.[25]

#### 2.1.2.5 Nickel-Metal Hydride Battery

The nickel-metal hydride battery has become increasingly popular as a power source for computers, mobile phones, electric shavers and other products since it was commercialized in 1990.[26] Unlike the nickel-cadmium battery, the nickel-metal hydride battery contains no toxic metals such as cadmium, mercury, and lead. The composition of the nickel-metal hydride battery is not harmful to the environment. The nickel-metal hydride battery has been developed as an environmentally more benign alternative to the nickel-cadmium battery.[27]

The nickel-metal hydride battery has long cycle life, typically 500-1000 cycles at deep discharges. It also has the advantage of a greater energy density, 25-75% greater than that of nickel-cadmium battery, depending on their designs.[28]

#### 2.1.2.6 Lithium-ion Battery

The lithium-ion secondary battery has a high energy density, high voltage and lightness. The lithium-ion secondary battery also has superior performance in charge-discharge cycles.[29] The battery is also relatively safe, is reliable, works well in most environmental conditions, and contains capacity independent of load.[30] Therefore, the lithium-ion battery is one of the optimal alternatives for portable devices such as laptop computers, mobile phones and other equipment recharged often.

#### 2.1.2.7 Lead-Acid Battery

The lead-acid battery is the oldest secondary battery and it is mainly used for industrial and automotive purposes. The small sealed lead-acid battery is also employed for some portable devices. Figure 2-4 illustrates the typical lead-acid battery for a car. The advantages of lead-acid batteries include low cost, availability of raw materials, ease of manufacture, work within a large temperature range and good electrochemical characteristics.

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25 China Electronic Technology Information Net. (2001). *Nickel-cadmiun batteries & lithium ion batteries.* [Online]. Available: http://www.cetinet.com/t_power/list.asp?id=122 (July 2, 2003)

26 Besenhard, Jurgen O. (1999). *Handbook of battery materials*. Winheim: Wiley-VCH. 1999. p.30.

27 Levy, Samuel C. (1994). *Battery hazards and accident prevention*. New York: Plenum Press. p.165.

28 Levy, Samuel C. (1994). *Battery hazards and accident prevention*. New York: Plenum Press. p.165.

29 Matsushita Batteries Industrial Co. (2003). *Lithium ion batteries.* [Online]. Available: http://www.mbi.panasonic.co.jp/oembatteries/english/e_ion/out_eion/defeion.htm (July 2, 2003)

30 Davidson, Michael W. & Florida State University. (2003). *Lithium/iron sulfide batteries.* [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/ironsulfide.html(September 27, 2003)

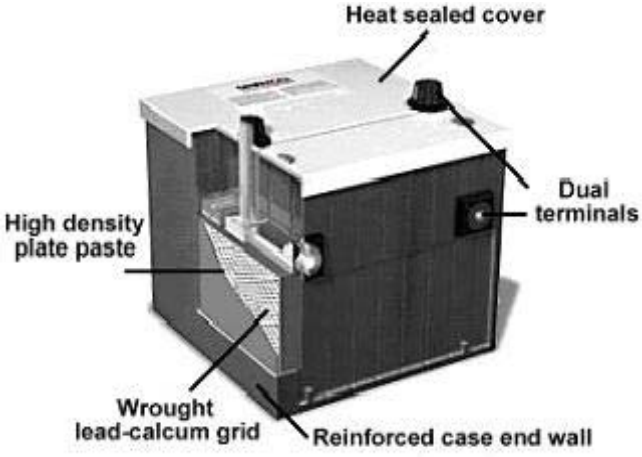


Figure 2-4: An example of lead-acid battery for car[31]

Lead is one of the major components in the lead-acid battery. Lead is a heavy metal, which can pose fatal result if entered into the human body. In the environment, lead does not degrade and may cause soil and water to become contaminated.[32] Another major component of the lead-acid battery is sulfuric acid, which is a corrosive liquid.

### 2.1.3 Categories Based on Function

Divided by size and functional similarities of the batteries, four categories are occurring: **button cells, portable, industrial and automotive batteries**. According to the Draft Proposal of a New EC Directive on Batteries and Accumulators, the batteries are divided into three categories: portable, industrial and automotive batteries.[33] The author thinks the size and use purpose of button cells are very different to general portable batteries, and this may have implications for the waste battery management. Hence, the button cell batteries are regarded as an independent category in this study.

#### 2.1.3.1 Button Cells

Button cells are specially designed for small electronic appliances such as hearing aids, watches, calculators and toys. They are small, round, of silver color, and have a shape of a button covered by metal.

Many button cells contain high levels of mercury, in particular, the mercury-oxide battery. The button cells often contain more mercury than general primary batteries, and the proportion of mercury may reach 10-30% in mercury-oxide batteries[34]. The button cells containing high mercury levels can bring serious environmental risks.

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[31] Davidson, Michael W. & Florida State University. (2003). *Lead-Acid Batteries*. [Online]. Available: http://micro.magnet.fsu.edu/electromag/electricity/batteries/leadacid.html (2003-07-03)

[32] Government of Yukon. (2003). *Used batteries*. [Online]. Available: http://www.environmentyukon.gov.yk.ca/epa/usedbat.shtml. (July 4, 2003)

[33] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. p.22.

[34] TemaNord. (1997). *Environmental impact of consumer goods: A guideline for specific assessments*. Copenhagen: Nordic Council of Ministers

### 2.1.3.2 Portable Batteries

Portable batteries (also named consumer batteries) are small and medium sized batteries, which are the sources to power the mobile appliances. The shapes of these batteries vary due to the variation of space within the appliances. Round cells are the standard shape, as shown in the examples in Figure 2-5.

Figure 2-5: Round cells[35]

All primary batteries are portable batteries, and part of the secondary batteries are portable batteries. The weight of a typical portable battery does not exceed 100 g.[36]

### 2.1.3.3 Industrial Batteries

Industrial batteries are normally of large size, and are usually used as backup systems for computers and telecommunications installations, photovoltaic power generation systems, emergency lighting and disaster-prevention equipment, and other systems for power stations and transformer stations. Most industrial batteries are lead-acid batteries.[37]

### 2.1.3.4 Automotive Batteries

Automotive batteries are mainly used by the cars ignition system for cranking the engine. The automotive batteries may also power the lights and other accessories. When the alternator does not work, the batteries might also need to support the automobile's entire electrical system for a short period of time[38]. A majority of automotive batteries are lead-acid batteries.[39]

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35 Tigerhead. (2002). [Online]. Available: http://www.555bf.com.cn/china/Product/index.htm. (August 20, 2003). (Chinese)

36 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. p.22

37 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. p.22

38 AutoBatteries. (2003). *Frequently asked questions*. [Online]. Available: http://www.autobatteries.com/faq/index.asp(July 14, 2003)

39 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. p.22.

### 2.1.4 Hazardous and Non-hazardous Waste Batteries

Some of the waste batteries are considered as hazardous waste because of their corrosivity, reactivity, or toxicity.[40] In this study, hazardous waste batteries and non-hazardous waste batteries both are important concepts. In most countries, the environmental policies on batteries are different for hazardous waste batteries and non-hazardous waste batteries.

According to the review of legislation and literature, the author thinks that the hazardous waste batteries could be defined as those batteries that contain a certain proportion of hazardous substances. Words of 'a certain proportion' and 'hazardous substances' must be decided by legislation, based on scientific knowledge and environmental ambitions.

There is no clear definition for hazardous waste batteries in the Chinese policy system for batteries. In the National Hazardous Waste List of 1998, only waste batteries containing mercury, cadmium and lead are considered as hazardous waste, but the proportion of hazardous substances is not defined.[41] In reality, the consumption of those batteries containing other hazardous substances is very small. Therefore, the hazardous waste batteries only include the batteries containing mercury, cadmium and lead in this study.

## *2.2 Batteries and Environment*

Although the hazardous substances are different from battery type to battery type, the main hazardous substances contained in batteries are heavy metals (mercury, cadmium, lead, silver), the sulfuric acid ($H_2SO_4$) in lead-acid batteries, potassium hydroxide (KOH) in alkaline-manganese batteries, and the $LiPF_6$ in lithium batteries.

All of these materials may bring environmental risks if they are handled in an improper way. The waste batteries can release corrosive fluids that can cause chemical burns and damage to a wide variety of materials. The heavy metals contained in batteries are toxic and bioaccumulate in plants and animals.[42] The solution of acid or alkaline in batteries may influence the pH of soil and water.[43] Figure 2-6 displays the ways waste batteries enter the environment, and come to affect human health.

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[40] University of Missoure-Rolla. (2003). *Hazardous battery waste.* [Online]. Available: http://campus.umr.edu/ehs/Hazardous_Waste_Mgmt/Waste_Minimization_Program/wmbattry.html. (September 26, 2003)

[41] SEPA. (1998). *National hazardous waste list.* Huanfa (1998) 089.

[42] Government of the Northwest Territories. (1998). *Guideline for the management of waste batteries.* www.gov.nt.ca/RWED/library/eps/batteriesguideline.pdf. (July 19, 2003)

[43] Wang, Jinliang & Wang Qi. (2003). *About the wasted batteries: Pollution, prevention and cure.* Chinese batteries industry. 8, 1, pp.37-40 (Chinese)

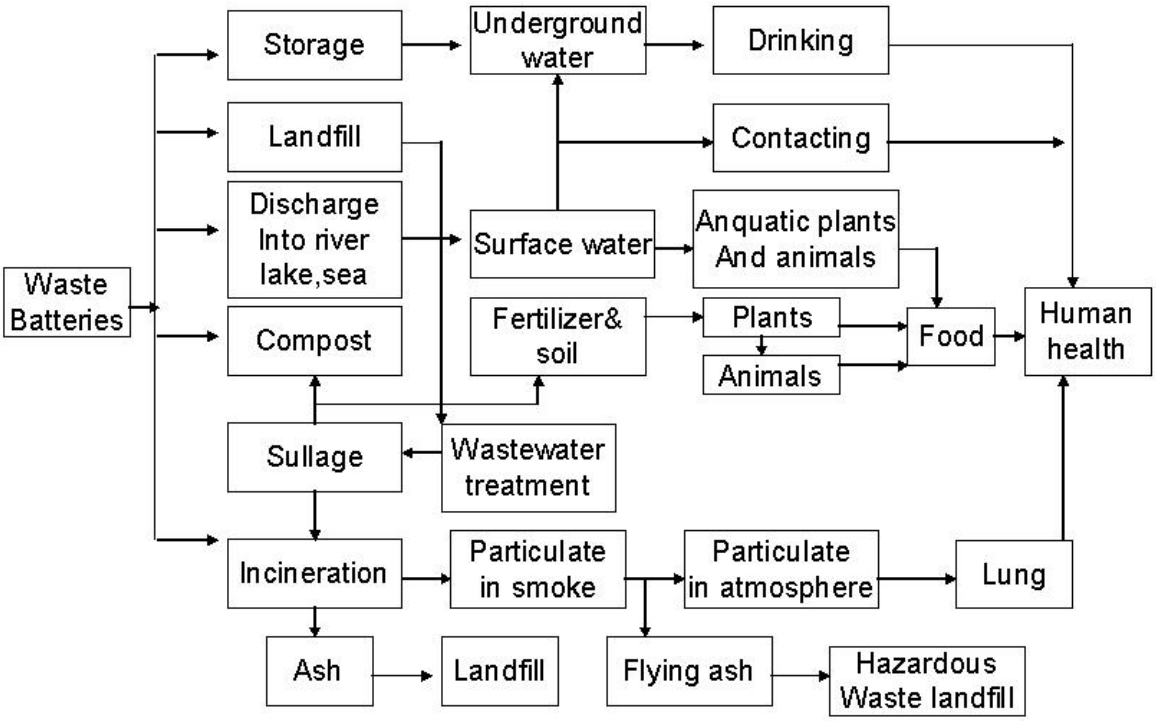


Figure 2-6: The ways that the chemical compounds in waste batteries damage environment and human health[44]

In China, most waste batteries are treated together with municipal solid waste.[45] Commonly, the hazardous substances contained in waste batteries enter the environment through **incineration**, **landfilling**, or **composting**, which are the major treatment approaches of municipal solid waste. In addition, the abandoned waste batteries that do not enter the municipal solid waste stream can also bring fatal environmental risks.

**Incineration**

In the process of incineration, hazardous heavy metals like mercury and cadmium, contained in batteries, are gasified or react with other elements. The gasified materials may enter the atmosphere, and move over distances following the wind. By lower temperature, they become condensates and fall down together with precipitation.[46] The gasified hazardous materials damage animal and human health through breathing and skin contacts. The hazardous condensates pollute the soil and water after falling down.

Chinese authorities and researchers have recognized the potential risks from incineration of waste batteries, and it is banned in the Technical Guide on Waste Battery Management. Without waste battery separation from the municipal waste, it is impossible to prevent the incineration of waste batteries.

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[44] Niu, Dongjie & Nie, Yongfeng. (2000). *Analysis on Pollution and Recycling Value of Waste batteries*. Shanghai Environmental Sciences. 10, p. 462. (Chinese)

[45] Niu, Dongjie & Nie, Yongfeng. (2000). *Analysis on Pollution and Recycling Value of Waste batteries*. Shanghai Environmental Sciences. 10, p. 462. (Chinese)

[46] Niu, Dongjie & Nie, Yongfeng. (2000). *Analysis on Pollution and Recycling Value of Waste batteries*. Shanghai Environmental Sciences. 10, p. 463. (Chinese)

**Landfill**

In China, about 98% of all municipal solid waste is treated by the approach of landfill.[47] Consequently, it must be regarded that landfilling is the major approach of waste battery treatment today.

In landfills, the speed at which hazardous materials contained in batteries enter soil and air is very slow.[48] If the landfill managers adopt suitable technology, the waste batteries do not bring serious environmental pollution in a short term. A survey on environmental impact of waste landfilling was conducted in 2001-2002 in China. The survey shows that almost no landfill has created mercury pollution. Among 288 landfills in the survey, only one landfill created mercury pollution in underground water.[49]

Based on the survey in China, some environmental researchers think it is secure to landfill waste batteries together with municipal solid waste in general landfill. But the author does not agree with this viewpoint. The potential pollution of waste batteries from landfills is always a big problem in the long term. Hazardous materials like mercury and cadmium do not disappear in the landfill processes. If the leachate moves into soil, the hazardous substances will seriously pollute the soil and underground water. Landfilling of waste batteries together with municipal solid waste means that it is not possible to recycle the metals and other materials contained in waste batteries. This approach will lead to consumption of more natural resources.

**Composting**

As Figure 2-6 shows, in composting of municipal solid waste, the hazardous components of batteries may enter soil and water. These hazardous substances accumulate in soil and enter the food chain, damaging the health of human and animals.

## 2.3 Waste Battery Management

The environmental risks from waste batteries are increasing in the world. Authorities in various countries have recognized the problems, and many countries have adopted policies to promote a waste battery management compatible with sustainable development. When reviewing the waste battery management in the world, there seem to be two main approaches to reach the goal of controlling the potential pollution: **prevention at source** and **waste battery treatment.**[50]

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47 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

48 Wang,Jinliang & Wang Qi. (2003). *About the wasted batteries*: Pollution, prevention and cure. Chinese batteries industry. 8, 1, p.39 (Chinese)

49 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

50 Wang,Jinliang & Wang Qi. (2003). *About the wasted batteries: Pollution, prevention and cure.* Chinese batteries industry. 8, 1, p.38 (Chinese)

### 2.3.1 Prevention at Source

Prevention at source is to reduce the hazardous substances contained in batteries in the production process. The author thinks this approach is more economical and effective approach than waste battery treatment.

Removing mercury from batteries is a usual method to reduce the potential environmental risks. Many industrial countries, such as the United States, Japan and member states of the EU, have since the 1990's made policies to limit the mercury content in batteries[51]. China has started the schedule of prohibiting mercury contained in batteries in 1997, with the aim of reaching a mercury-free level on the market of primary batteries. The manufacture and marketing of mercury-oxide battery is prohibited in China[52].

Reduction of cadmium content is more complex than mercury. In the EU, those primary batteries containing more than 0.025% of cadmium by weight are prohibited.[53] But there is no policy concerning the cadmium content in China.

### 2.3.2 Waste Battery Treatment

According to the toxicological experiments done by EPA, mercury free batteries are less of a potential environmental risk, and they are out of the hazardous waste list in the United States.[54] It is not necessary to collect and treat non-hazardous batteries in any special way. It is natural to collect and recycle the waste batteries with high economic value, like lead-acid batteries, which are collected and recycled in China.

It is absolutely necessary to collect hazardous waste batteries, and treat them in a secure way. Generally, there are three methods to treat the hazardous waste batteries: **deep-well disposal, temporary storage and recycling**.[55]

**Deep-well Disposal**

The method of deep-well disposal is commonly used for the liquid hazardous waste. The method is also introduced for treatment of hazardous waste batteries. The hazardous waste batteries are packaged in sealable boxes, and put down the deep-well. Sometimes the deep-well is an abandoned mine-well.[56]

This method is simple and at low cost. Since it is done underground, it is less visible pollution. It is convenient for future recycling or other forms of advanced secure treatment. But this method has special requirements on the geomorphic conditions.

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51 Cao, Guoqing, Shen, Yingwa & Jian, Xiaodong. (2002). *Management of spent batteries and environment protection regulations.* Chinese batteries industry. 7, 6, p.323. (Chinese)

52 SEPA. (2003). *The technical guide on waste batteries management.* Huanfa (2003) 163. (Chinese)

53 Commission Directive 98/101/EC of 22 December 1998 adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances. OJ L001, 05.01.99

54 Cao, Guoqing, Shen, Yingwa & Jian, Xiaodong. (2002). *Management of spent batteries and environment protection regulations.* Chinese batteries industry. 7, 6, p.322 (Chinese)

55 Zhang, Shengtao, Wang, Lin, Han, Lianyi, Zhang, Na & Tang Yanqiu. (2002). *Harm of wasted batteries and its recovery and reuse.* Chinese batteries industry. 7, 1, p.5 (Chinese)

56 Zhang, Shengtao, Wang, Lin, Han, Lianyi, Zhang, Na & Tang Yanqiu. (2002). *Harm of wasted batteries and its recovery and reuse.* Chinese batteries industry. 7, 1, p.5 (Chinese)

## Temporary Storage

The temporary storage of hazardous waste batteries is not regarded as a long-term solution. Temporary storage of waste batteries is only acceptable as an interim measure to avoid the hazardous waste batteries dispersal, while waiting for technology development and identification of suitable ways to treat them. For some types of batteries, the economic value is low or the present technology cannot treat them in a reasonable way. However, in the future, there is a possibility that suitable methods will be available.

## Recycling

Recycling is the optimal disposal method for waste batteries. Among components contained in waste batteries, the primary objective of recycling has been focused on metal recovery mainly lead, zinc, mercury, silver, and cadmium. A typical illustration is the recycling of waste lead-acid batteries. The lead is of high economic value. Because of economic motivation, the collection rate of waste lead-acid battery and recycling rate of waste lead-acid battery and recycle rate of lead are very high. In Japan, the recycling rate of lead is 90%-95%, and it is 80% in China.[57]

Waste batteries with less economic value are facing some problems in recycling in China. The major reason is financial. If the economic value from recycled materials cannot cover the cost of the recycling business, the treatment plants of waste batteries cannot make profit. Without financial aid from government or producers, it is impossible that the recycling plants stay in operation.

[57] Zhang, Shengtao, Wang, Lin, Han, Lianyi, Zhang, Na & Tang Yanqiu. (2002). *Harm of wasted batteries and its recovery and reuse.* Chinese batteries industry. 7, 1, p.5 (Chinese)

# 3. Background Information

This chapter presents the background information relating to the waste batteries in China. The chapter mainly focuses on general information of the Chinese battery industry, today's waste battery management, stakeholders of waste battery management and the problems of waste batteries. Additionally, the solid waste management is introduced briefly.

## *3.1 General Statistical Information*

China has been the largest battery manufacturer in the world since 1982.[58] According to statistics, China manufactured 18.22 billion batteries in 2001, which is more than a 1/3 of world output.[59] Among these batteries, 13.8 billion batteries contain mercury, 0.4 billion batteries contain cadmium, and 25 million batteries contain lead.[60]

Since there are no systematic statistics of the batteries market and battery industry in China, it is difficult to calculate the annual consumption of batteries. According to reports, Chinese battery manufacturers exported 14.446 billion batteries in 2001.[61] It is estimated that the domestic consumption of batteries is around 7-8 billion units per year.[62] If calculation based on the principle of 'discharged waste batteries = battery consumption', it is estimated that more than 7 billion unit waste batteries enter the waste stream each year.

## *3.2 Today's Waste Battery management*

China started to adopt policies to prevent the environmental risks from waste batteries in the end of 1990s. The Regulation on the Limitation of Mercury Contained in Batteries was released in 1997, which is the first policy that focuses on the battery pollution in China. According to the regulation, **High Mercury Batteries** are defined as the batteries containing more than 0.025% mercury by weight; **Low Mercury Batteries** are defined as the batteries containing less than 0.025% mercury by weight; **Mercury Free Batteries** are defined as the batteries containing less than 0.0001% mercury by weight[63]. The regulation issued the mandatory schedule for producers to reduce the mercury content contained in batteries:

- **January 1, 2001** Prohibition to manufacture all types of batteries containing more than 0.025% mercury by weight; mandatory requirement to put the label of 'low mercury' or 'mercury free' on the individual battery, and prohibition to sell any batteries without label.

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58 CBIA. (2000). *The 10th 5-year plan of batteries industry.* [Online]. Available: http://www.chnbia.com/dchydsgwnjh.htm. (August 20, 2003). (Chinese)

59 Eastday. (2002). *The industry chain of waste batteries.* [Online]. Available: http://www.sqhgz.cz.jsinfo.net/h2o/news/cell.htm.(September 16, 2003)

60 Xinhuanet. (2002). *The killer of hazardous waste.* [Online]. Available: http://www.people.com.cn/GB/huanbao/56/20020215/669044.html. (July 12, 2003) (Chinese)

61 CBIA. (2002). *CBIA Annual Report 2001.* [Online]. Available: http://www.ica.gov.cn/new/zxdt/zxdt2002/zxdt0204/1702.htm. (July 12, 2003) (Chinese)

62 Fujian Daily. (2002). *Waste treatment: A rising industry.* [Online]. Available: http://www.fujian-window.com/Fujian_w/news/fjrb/gb/content/2002-10/28/content_312502.htm(July 12, 2003) (Chinese)

63 Light Industry Association. (1997). *Regulation on the limitation of mercury contained in batteries.* Qinzonghangguan. (1997) 14.

- **January 1, 2002** Prohibition to market of the batteries containing more than 0.025% mercury by weight.

- **January 1, 2005** Prohibition to manufacture alkaline-manganese batteries containing more than 0.0001% mercury.

- **January 1, 2006** Prohibition of the marketing of alkaline-manganese batteries containing more than 0.0001% mercury.

The requirements of environmental performance of batteries in the regulation are similar with European Commission Directive 98/101/EC, 91/157/EEC and 93/86/EEC. But the requirement to reach mercury free batteries is almost 7 years postponed as compared to the EU. The cadmium contained in batteries is considered in a EU directive, but this has not happened in the Chinese regulation.

In the regulation, there is no mandatory requirement of mercury elimination for zinc-carbon batteries, which is a major product on the Chinese primary battery market. The policy-makers think that alkaline-manganese batteries are replacing this type of battery. They believe that the zinc-carbon battery will disappear from the Chinese market in some years.[64]

According the National Hazardous Waste List and the Technical Guide on Hazardous Waste Management, the waste batteries containing mercury, cadmium and lead, belong to hazardous waste. These waste batteries are required to be collected and treated in a special way. Limited by the lack of collection system, the policy has not been implemented.

China does not have a waste battery collection system except for lead-acid batteries, and the producers do not have the legal responsibility to collect the waste batteries. Few of the waste batteries are collected by voluntary action, and most of them enter the municipal waste steam, see Figure 3-1. According to an interview with an environmental authority, waste batteries are commonly landfilled as municipal solid waste, including hazardous waste batteries.[65]

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[64] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

[65] Xinhuanet. (2002). *The killer of hazardous waste.* [Online]. Available: http://www.people.com.cn/GB/huanbao/56/20020215/669044.html. (July 12, 2003) (Chinese)

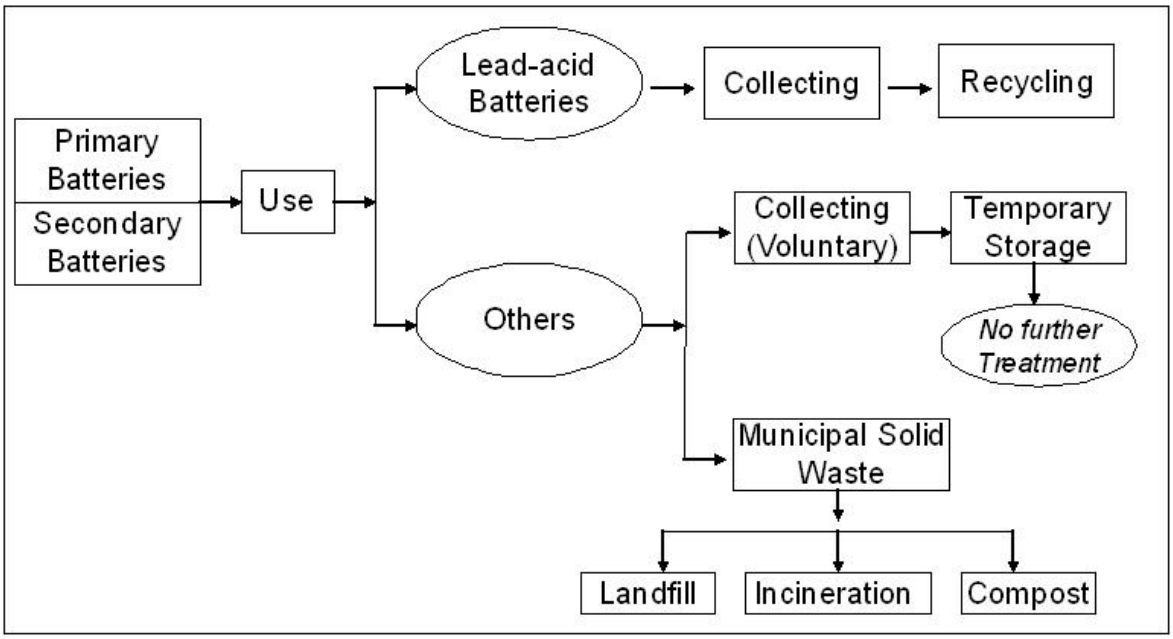


Figure 3-1: The waste battery flow in China today

The collection rate is very low in China. Only 2% of waste batteries are collected in China.[66] These waste batteries are mainly collected by voluntary action. Beijing started a voluntary collection action of waste batteries in 1998. Many shops, communities, schools, colleges and restaurants have joined this voluntary collection action, and more than 1,000 collection points have set up over the city. The amount of waste batteries is about 6,000 tons per year in Beijing, but only 7% of the waste batteries are collected.[67] According to a telephone interview with Lu, Jianguo, from Beijing Recycling Center for Useful Waste, all types of collected waste batteries are mixed, without being sorted. The center has accepted more than 450 tons of waste batteries from voluntary collection, but these waste batteries are only stored, without any further treatment.[68]

The voluntary collection has also been carried out in some other big cities in China, like Shenzhen, Chengdu, and Shanghai, but the effectiveness of the voluntary collection is not good. For instance, Shanghai, a big city in Eastern China, started a voluntary collection in 1998, but only 175 tons of waste batteries were collected. Compared with the 3200 tons of waste batteries generated every year in Shanghai, the collected waste batteries are a small proportion. These collected waste batteries are stored temporarily in sealed containers in Shanghai. According to the interview with Tang, Jiafu, from Shanghai environmental authority, these waste batteries will be landfilled in the future.[69]

China started research on recycling of waste batteries in the 1980s, and successful recycling technology has been developed. But no recycling plants for waste batteries are in operation

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66 Xinhuanet. (2002). *The collection rate of waste batteries.* [Online]. Available: http: //www.qzwb.com/gb/content/2002-07/08/content_538648.htm.(October 18, 2003). (Chinese)

67 CENEWS. (2003). *Beijing studies to cope with waste batteries.* [Online]. Available: http://www.china.org.cn/english/environment/62148.htm.(September 28, 2003). (Chinese)

68 Lu, Jianguo. Beijing Recycle Center for Useful Waste. Topic: the collection of waste batteries in Beijing. (September 24, 2003). Telephone interview. +86(0)1087500818

69 Xinhuanet. (2002). *Shanghai: Voluntary collection of waste batteries.* [Online]. Available: http://www.chinagate.com.cn/chinese/MATERIAL/3289.htm.(October 18, 2003). (Chinese)

today. Donghua Xinxin is the first recycling plant for waste batteries, and it was built in 2001. After establishment, the recycling plant has never been in operation.[70] The recycling business is facing many difficulties. The first reason is the financial problems. Under current policies, the Government and battery producers do not provide financial aid to the recycling plant. It is difficult to make profit from recycling. The second reason is the supply of waste batteries. Since there is no collection system of waste batteries in China, the voluntary collection cannot reach high collection rate. In order to stay in operation, the recycling plant demands the supply of 3000 tons of waste batteries per year.[71] It is clear that the current collection rate cannot support the operation of the recycling plant. The third reason is that the local authority is strongly against the recycling plant. They think, the recycling plant of waste batteries may bring potential risks to local environment.[72]

Another possibility is that the waste batteries could be recycled at a hazardous waste treatment plant. Tianjin[73] Hazardous Waste Treatment Center is the first professional hazardous waste treatment plant in China. It started operation in August 2003.[74] Tianjin Government is planning recycling/final disposal of waste batteries at this plant.[75]

A recent news item is that a new storage center for waste batteries was set up in June 2003 in the Heilongjing province in the Northeast of China. It is the first professional storage center for waste batteries in the country. The center is used for temporary storage of waste batteries, and it has a capacity of accepting 1000 tons of waste batteries. A hazardous waste treatment plant is in preparation in the province. After the establishment of the treatment plant for hazardous waste, the waste batteries will be moved there.[76]

## *3.3 Stakeholders of Waste Battery management*

In the waste battery management, the main stakeholders include: producers, consumers/public, environmental authorities, environmental groups/NGOs and environmental researchers. In this section, the situation and attitude of these stakeholders are discussed.

### 3.3.1 Producers

According to the polluter pays principle, the producers should take the responsibility for collection and final disposal of their products. In today's policies in China, the producers do not have the legal responsibility to collect and dispose their waste products.

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70 BEC Group. (2001). *Recycling waste batteries.* [Online]. Available: http://www.aibj.cn/hszx/hszx.asp.(September 28, 2003). (Chinese)

71 China Business. (2002). *The status of investment in the business of recycle waste batteries.* [Online]. Available: http://www.ezhon.net/news/03/36.htm.(September 28, 2003).(Chinese)

72 Lu, Jianguo. Beijing Recycle Center for Useful Waste, China. (September 24, 2003). Topic: the collection of waste batteries in Beijing. Telephone interview. +86(0)1087500818

73 Tianjin is a big city in Northern China, close to Beijing.

74 Greatwall Online. (2003). *The first hazardous waste treatment centre start operation.* [Online]. Available: http://www.hebei.com.cn/node2/node4/node6/userobject1ai142376.html.(October 19, 2003).(Chinese)

75 Sunsky. (2002). *Tianjin EPA released the plan for waste batteries.* [Online]. Available: http://dalian.runsky.com/homepage/dalian/navigation/citycoach/userobject1ai230559.html.(October 19, 2003). (Chinese)

76 Yang, Jun. (2003). *Starting storage center for waste batteries.* [Online]. Available: http://www.hljdaily.com.cn/gb/content/2003-06/12/content_115606.htm.(September 28, 2003). (Chinese)

Some big producers have carried out voluntary action concerning waste batteries. Baoding Huazhong Industry Co. is a battery manufacturer, who carried a voluntary program to collect the waste batteries in Baoding city.[77] Desay is one of the biggest battery manufacturers in China. The company contributed 1 million RMB (121,000 US$) to policy research on waste batteries.[78] Desay includes an environmental guidebook in their product package, in order to provide more environmental knowledge to consumers. Additionally, the company promised to contribute 0.01 RMB (0.12 US cents) to China Environmental Protection Foundation per battery.[79]

Motorola (China) has initiated a responsible care program named Green China Program (GCP) to collect Motorola's mobile phones, and their batteries and accessories from consumers at the end of their useful lives. Motorola collects the used batteries through its network in big cities, and ships the waste batteries to Korea for recycling, since there is no qualified recycling plant in China.[80]

The voluntary action of a few producers could promote the collection of waste batteries and enhance environmental protection. But it is impossible for the collection rate to reach a high level by voluntary action. Voluntary action is only initiated to a few big producers, and most of the small and medium producers do not join these voluntary actions.

### 3.3.2 Consumers/Public

Batteries are a daily product, and everyone can be the consumer of a battery. The consumers/the general public plays an important role in the collection of waste batteries. There is no available survey on a national level to examine the public knowledge and concerning waste batteries. An available survey was conducted in Jiangmen, which is a medium sized city with a population of 530 thousand in the Southeast of China.[81] From Table 3-1, the survey displays the level of public knowledge and concern of waste batteries.

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77 Zhang, Xiaohui. (2001). *Collection of waste batteries.* [Online]. Available: http://unn.people.com.cn/GB/channel19/49/117/200106/11/70298.html.(September 29, 2003). (Chinese)

78 Jia, Quanxin. (2002). *The foundation of research on waste batteries.* [Online]. Available: http://www.sm.gov.cn/rmht1/0438.htm.(September 29, 2003). (Chinese)

79 Desay. (2002). *Desay's action of environmental star.* [Online]. Available: http://www.desaypower.com.cn/News/2002/08/0802.asp.(October 18, 2003). (Chinese)

80 Motorola. (2003). *Green China programme.* [Online]. Available: http://www.motorola.com.cn/about/greenchina/english.asp.(October 18, 2003). (Chinese)

81 Jiangmen Government. (2002). *The human resource and region development in Jiangmen.* [Online]. Available: http://www.jiangmen.gov.cn/gov/jmtjj/tjfx/fx11.htm. (August 21, 2003). (Chinese)

Table 3-1: Survey of public knowledge on waste batteries[82]

| Questions in Survey | Result | |
|---|---|---|
| | **Yes** | **No** |
| Do you know that the waste batteries pollute the environment? | 13% | 87% |
| Do you know the waste batteries recycle? | 9% | 91% |
| Do you know the substances contained in batteries? | 22% | 78% |
| Do you throw waste batteries as general waste after use? | 94% | 6% |
| Do you use rechargeable batteries? | 27% | 73% |

In the survey, 160 persons were interviewed, from 8 years old to 59 years old, including students, teachers and people from industry. The result of the survey shows that the public has low knowledge and concern regarding waste batteries.

According to a telephone interview with Miss Liu, from one of the biggest mobile phone retailers in Beijing, few consumers pay attention to the environmental performances of batteries when they purchase mobile phones.[83]

The environmental knowledge and regarding waste batteries is varying from region to region. In some big cities, the public has more environmental knowledge and concern of waste batteries than in small and medium sized cities and rural regions. Jiangmen is in the developed economic region in China, where the levels of education and economy should be higher than in other regions. Hence, it is expected that the public knowledge and concern of waste batteries are lower in other regions. The author thinks that the national average level of environmental knowledge and concern of waste batteries is very low.

### 3.3.3 Environmental Authorities

The environmental authorities include the State Environmental Protection Administration (SEPA) and its regional branches. The environmental authorities have paid concern to waste batteries for some years, and they are trying to adapt a systemic solution for waste batteries. The environmental authorities take the responsibility of monitoring the mercury batteries, with the aim to prohibit the marketing of batteries containing high mercury levels. SEPA also appointed an environmental expert team to design a waste battery management system in 2002.

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82 Ying, Shongjian. (2003). *The serious battery pollution in China.* [Online]. Available: http://www.jmyz.com/yjxxx/55/diaochashuju.htm. (July 29, 2003) (Chinese)

83 Miss Liu. Zoomflight Telecommunication Equipment Co., Ltd. (October 17, 2003). Topic: the consumption behavior of on green mobile batteries. Telephone interview. +86 (0) 10-65916591.

The authorities support the voluntary collection of waste batteries. The environmental authority in Beijing provides collection boxes for waste batteries to tailors, shops, restaurants, schools and colleges. Beijing Recycling Center for Useful Waste accepts most waste batteries from the voluntary collection in Beijing, which is financed by Beijing environmental authority. The new storage center for waste batteries in Heilongjiang is also financed and managed by Heilongjiang environmental authority.

The environmental authorities are in an embarrassing situation. They should support the voluntary collection of waste batteries. But there are no facilities/plants to treat the collected waste batteries at present. If they do not support the voluntary collection, the public may regard them not being responsible. This situation leads to that most of collected waste batteries are only stored, without any further treatment.[84]

### 3.3.4 Environmental Groups/NGOs

Due to the particular social and political structure in China, NGOs and environmental NGOs do not have a long tradition. Compared with the NGOs in the EU and US, the status of NGOs in China is very different. There are two types of NGOs in China. The first type is the NGOs associated closely with the government, like industry associations. Commonly, they obtained independence from government departments a few years ago. The industry associations are usually regarded as 'quasi-government organizations' in China, which often participate in making and implementing industry policies. They often take the role of an administrative department rather than NGO.

The second type of NGOs is the real NGO without governmental background. To sustain an environmental NGO in China is difficult. The first reason is that limited financial funding is available for environmental NGOs. The second reason is that being an environmental activist is still not regarded as a proper profession, and few people would like to be full-time environmental activists. [85] Shandong Association of Battery Pollution Prevention and Treatment was established in 2001, which is the first environmental NGO concerned with waste batteries. In the beginning, the association planned to sponsor research for the production of environment-friendly batteries and promote the collection of waste batteries.[86] Limited by financing, the association has not carried out significant action since its establishment.

Some environmental groups are also concerned with the waste battery question. These groups have carried out educational programs and voluntary collection of waste batteries. Greener Beijing is a volunteer group concerned with environmental issues and is mainly financed by volunteers.[87] According to a telephone interview with Mr. Song Xinzhou, the director of Greener Beijing, Greener Beijing mainly focuses on environmental education and to

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[84] Lu, Jianguo. Beijing Recycle Center for Useful Waste, China. (September 24, 2003). Topic: the collection of waste batteries in Beijing. Telephone interview. +86(0) 10 8750 0818

[85] Fung, Shuk-wai Freda. (1999). *Handling the municipal solid waste in China: A case study of policies for 'white pollution' in Beijing.* IIIEE Master's thesis 1999: 8. Lund, Sweden: IIIEE. P.28

[86] Peopledaily. (2001). *Association established to combat battery pollution.* [Online]. Available: http://fpeng.peopledaily.com.cn/200105/02/eng20010502_69135.html.(September 29, 2003). (Chinese)

[87] Greener Beijing. (2002). *Greener Beijing.* [Online]. Available: http://gbj.grchina.net/greenerbeijing.htm.(September 29, 2003).

encourage environmentally friendly products. Further, the Greener Beijing is supporting the development of a greener battery with new environmental technology.[88]

School students and college students play an important role in the voluntary action of waste batteries. These students are working on environmental education and collection of waste batteries.[89]

### 3.3.5 Environmental Researchers

Chinese environmental researchers have paid attention to waste batteries for many years. There are two typical opinions among the environmental researchers.

The first opinion is that all waste batteries should be collected and recycled, including the mercury free batteries. These researchers think that the waste batteries contain many valuable metals, which are one-off natural resources in the earth. Although the mercury free batteries cause less environmental risks, it does not mean that there are no any potential environmental risks.

Professor Zeng, Pingrong, from the University of Science and Technology Beijing, is the typical representative of this opinion. Professor Zeng thinks that it is difficult to make profit from the recycling, but it can save natural resources and contribute to sustainable development. From the viewpoint of social benefit, it is necessary to collect and recycle all types of waste batteries. Professor Zeng spent more than 20 years on the research of waste batteries and obtained a patent of recycling waste batteries. Donghua Xinxin, the first recycling plant of waste batteries in China, adopted his patent to recycle waste batteries.[90] Unfortunately, the recycling plant failed, as was described Section 3.2.

The second opinion is that only the hazardous waste batteries should be collected and treated in a special way. The researchers of this opinion think that non-hazardous waste batteries are of less environmental risk, and it is not necessary to spend high costs to collect them. Professor Nie, Yongfeng, from Tsinghua University, is the typical representative of this opinion.

The two opinions meet concerning the need to collect hazardous waste batteries. The focus of debate is if it is necessary to collect and recycle non-hazardous waste batteries. The debate obviously influences the authorities and the general public. The second opinion is criticized strongly by environmentalists. From the discussions on BBS, many environmentalists criticized that the second opinion does not accord to the sustainable development principle.[91] The argument also influenced the media. The TVs, newspapers and environmental websites have joined the discussions. But in the process of debate, the environmental authorities kept silent.

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[88] Song, Xinzhou. Greener Beijing. (October 17, 2003). Topic: environmental NGOs in China. Telephone interview. +86(0)10 8482 0742

[89] WWFChina. (2003). *Environmental education at school.* [Online]. Available: http://www.wwfchina.org/zhiyuanzhe/huodong/12-08d/home.htm. (September 29, 2003).(Chinese)

[90] CCTV. (2002). *The way of recycling waste batteries.* [Online]. Available: http://www.cctv.com/lm/257/91/40094.html.(October 18, 2003). (Chinese)

[91] FonBBS. (2003). *The bomb: waste batteries should not be collected.* [Online]. Available: http://www.fon.org.cn/forum/showthread.php?s=7143726d563d6974dea0b7632e047281&threadid=1966&perpage=15&pagenumber=1.(October 28, 2003). (Chinese)

According to the newly released Technical Guide on Waste Battery Management, it is clear that the environmental authorities support the second opinion. In the technical guide, only waste secondary batteries and button cells are required to be collected, and the waste mercury free primary batteries and low mercury primary batteries are not encouraged to be collected.

In the last year, SETC was planning to make the regulation on collection of waste primary batteries.[92] Because of the debate on the necessity of collecting waste primary batteries, it is less likely that the regulation is adopted in the near future.[93]

## 3.4 Solid Waste Management in China

In order to help the readers to understand the current status of waste battery management, it is necessary to introduce briefly the solid waste management in China. This section only presents the household waste management system in urban regions. It should be noted that the management of industrial solid waste is more complex. Commonly, they are treated in special plants. Further, there is no existing household waste management system in rural regions. In most rural regions, the household waste is stacked in fields, on riversides and lakesides, including the hazardous waste batteries.

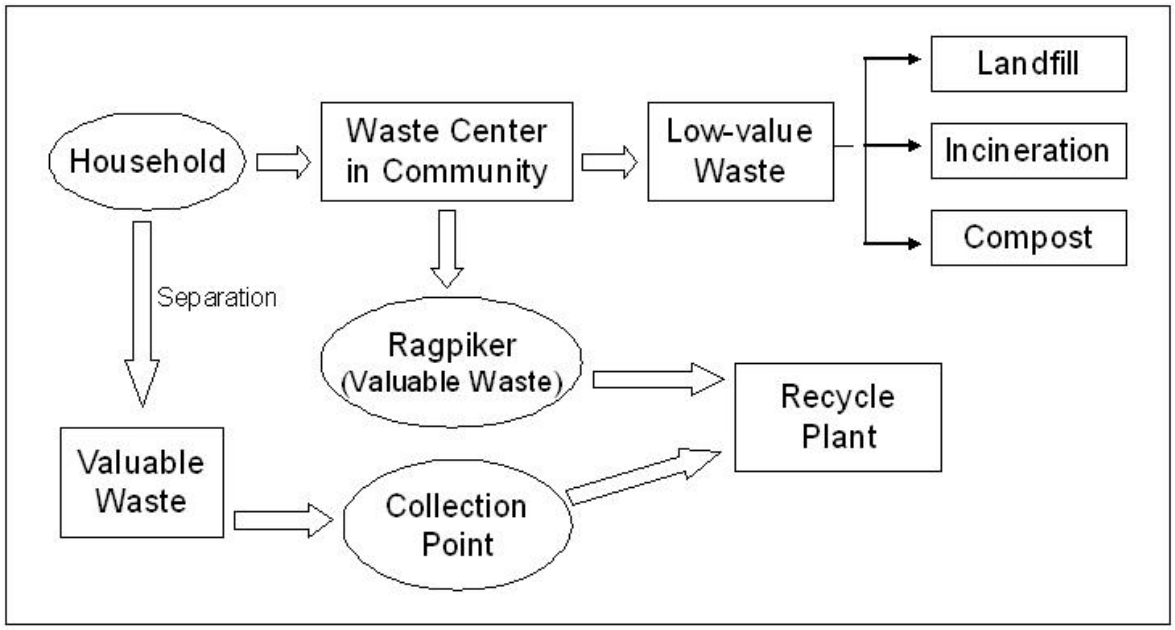


Figure 3-2: The household waste management system in urban region in China

The Figure 3-2 displays the general household waste management system in urban region in China. The current separation of waste is only limited to the valuable waste, like metals, drinking bottles and paper, which is based on the economic incentive. The household separates the valuable waste from the other household waste, and sells it to the collection points. The collection points could be dealers or a waste buyer-person.[94] The ragpickers play

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92 SETC. (2002). *SETC is making the regulation on collection of waste primary batteries.* [Online]. Available: http://www.setc.gov.cn/zyjyyhjbh/200208060220.htm.(October 28, 2003).(Chinese)

93 Jiang, Hao. State Economic & Trade Commission, China. (June 23, 2003). Topic: the environmental policies on waste batteries. E-mail communication. E-mail: jhjnzx@sina.com. Telephone: +86 (0) 10 68391399

94 Waste buyer-person is a new term in this study. These persons buy valuable waste from household, and sell them to recycling plants. They make money from the business.

an important role in the management system. They collect the valuable waste that is abandoned by households from the waste centers in communities and the garbage boxes on streets. The low-value household waste from urban areas is mainly treated by landfilling, incineration and composting. 98% of household waste is treated by the approach of landfilling in China.[95]

The waste sorting system is not established in most cities in China. Only 8 big cities had started to establish a waste sorting system in 2000.[96] The author believes that the waste sorting system should be the basis of the waste battery separating management. Without the success in separating household waste, it is impossible to establish the separation system for waste batteries.

## 3.5 What Are the Problems?

Based on the description and introduction in previous sections, the main environmental problems of waste battery management could be found. They are briefly presented as following.

The batteries containing hazardous substances pose potential environmental risks. Although the batteries containing more than 0.0001% mercury will be prohibited in 2006, they are having a considerable market share today and will do in the near future. Unfortunately, these batteries containing hazardous substances are not collected and treated in an environmentally acceptable way in the past and today. They enter the municipal solid waste stream, and most of them are landfilled as general solid waste. This will cause big environmental risk in the future.

The waste batteries collected by voluntary action are only stored, without further treatment, since China has no any recycling plant for waste batteries. If the batteries are stored longer, the leachate from the hazardous waste batteries could create serious environmental risk.

Lead-acid batteries are the only group collected and recycled today. The collection rate and recycling rate of lead are not high. Especially, some small sized recycling plants only capture the valuable lead, and care less of other pollutants. For example, some plants discharge the waste acid from the lead-acid batteries into rivers.

Another problem is that the general public has less knowledge and concern on waste batteries. The status of public environmental knowledge and concern could be a barrier for collecting waste batteries. Generally, public participation is important factor for improvement of collection rate.

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[95] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

[96] Ministry of Construction. (2000). *The notice for establishment of waste sorting management.* [Online]. Available: http://www.cin.gov.cn/city/other/2000062305.htm. (September 10, 2003). (Chinese)

# 4. Future Waste Battery Management System

Both government and researchers have recognized that there is an urgent environmental demand to establish a waste battery management system. The discussion of setting up the management system of waste batteries has lasted for some years. In 2002, the Chinese Government started to design a waste battery management system, and an expert team was appointed to work on the design of a waste battery management system. The expert team developed the Technical Guide on Waste Battery Management, which was released in October 2003.

The technical guide is the framework document for the future waste battery management system in China. It is expected that the detailed policies of waste battery management will be developed following the technical guide.

The technical guide covers the whole process of waste battery management, including production, sorting, collecting, transport, recycling, storage and final disposal. Figure 4-1 displays the future waste battery management system.

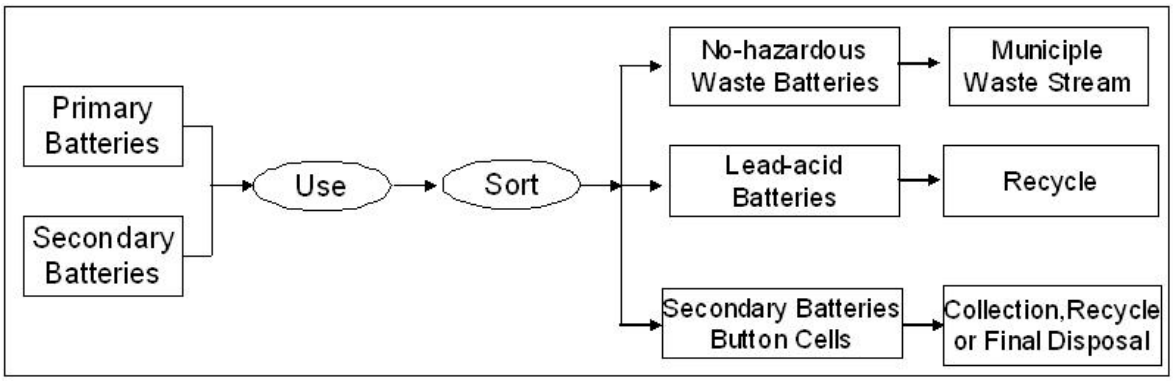


Figure 4-1: The future waste battery management system

## *4.1 Labeling*

Battery labeling of mercury content has required in the regulation on the limitation of mercury contained in batteries. In the newly released Technical Guide on Waste Battery Management, the label is regulated more strictly than in the regulation on the limitation of mercury contained in batteries. The producers and importers have to put the following information on the batteries bodies:

- Information if the batteries need to be collected after use
- The categories of waste batteries
- The content of hazardous substances

In the new technical guide, all batteries sold in China must be with the above information, including the special battery groups and single batteries built into electronic and electrical equipment. But the technical guide does not suggest a common label for the batteries. A common label would be easier to remember for consumers. If the manufacturers put different

labels on battery bodies, it could bring confusion to consumers.[97] More discussion of common labels can be found in Section 6.1.

## 4.2 Collection

In the newly released technical guide, a waste battery collection system is suggested. The technical guide requires that the collection should be mainly focused on secondary batteries and button cells, which include nickel-cadmium, nickel-metal hydride, lithium-ion, lead-acid, mercury-oxide and silver-oxide batteries.

It is not encouraged to collect mercury free and low mercury primary batteries in the technical guide. The emphasis of preventing pollution from primary batteries is to reduce the hazardous substances in the production process.

### 4.2.1 Extended Producer Responsibility

The technical guide introduces the instrument of 'Extended Producer Responsibility' into the waste battery management system. It is the first time that the principle of extended producer responsibility is introduced into the Chinese environmental policy system. In the future waste battery management system, the responsibility of collecting waste batteries is set on the producers. According to the technical guide, the producers only have the mandatory responsibility to collect waste batteries, but the responsibilities to recycle and final disposal are not set on the producers.

In the technical guide, the following battery producers have the responsibility for collection of waste batteries[98]:

- The manufacturers of secondary batteries and button cells
- The importers of secondary batteries and button cells
- The manufacturers of electronic and electrical equipment which use secondary batteries and button cells
- The brand owners of secondary batteries and button cells

### 4.2.2 Collection Rate

Chinese authorities and research institutions do not set the target for the collection rate of waste batteries based on their research and survey in China. The target for collection rate is set by following the Japanese target for collection rate of waste batteries. Chinese authorities and researchers think that the status of waste battery management in China is five years later than the Japanese. Therefore, the target of average collection of waste secondary batteries is to reach 40% in 2004, and reach 50.5% in 2010.[99] But the target of collection of waste button

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97 Wang, Jinliang. (2001). *Quicken the step of non-mercurialized of batteries*. Batteries bimonthly. 31, 2, p.64. (Chinese)

98 SEPA. (2003). *The technical guide on waste batteries management*. Article 3.3. (Chinese)

99 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

cells is not found in the technical guide and relevant documents. More discussion about collection rate is found in Section 5.3.1.2.

Table 4-1: The target of collection of waste secondary batteries in Japan[100]

| | **Status of 1999** | | **Target of 2005** | |
|---|---|---|---|---|
| | Collection Weight (ton) | Collection Rate (%) | Collection Weight (ton) | Collection Rate (%) |
| Nickel-cadmium | 1183 | 45.0 | 1320 | 78.0 |
| Nickel-metal hydride | 72 | 20.0 | 250 | 35.0 |
| Lithium-ion | 195 | 20.0 | 620 | 40.0 |
| Small sealed lead-acid | 157 | 55.1 | 152 | 80.0 |
| Total | 1607 | 40.0 | 2092 | 50.5 |

## *4.3 Movement*

In order to avoid the potential environmental risks, both of the Technical Guide on Hazardous Waste Management and the Technical Guide on Waste Battery Management give strict rules on transport of waste batteries.

The movement of hazardous waste batteries should follow the rules of hazardous waste. The mixture of hazardous waste batteries and non-hazardous waste batteries are also managed as hazardous waste in movement. The containers for waste batteries are required to have a special design, in order to prevent leakage and potential pollution. The containers must be marked with a label to show what category the waste batteries belong to. These measures make sure the security of waste batteries in terms of movement.

Another highlight is the system of 'United Reporting Rule of Hazardous Waste Movement', which was released in 1999. The domestic movement of hazardous waste must follow the United Reporting Rule.[101] According to the rule, the transporters of hazardous waste batteries must get permission from local environmental authorities before movement of hazardous waste. After the hazardous waste batteries arrive in destination, the transporters must report to the environmental authority at the destination. The reporting rule secures the information of hazardous waste to the environmental authority, which could be helpful for preventing the potential environmental risks. In reality, the rule has seldom been followed in the past and today. Since most hazardous waste batteries are not collected, it is impossible to meet the problem of movement.

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[100] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

[101] SEPA. (1999). *The united reporting rule of hazardous waste movement*. SEPA order (1999) 5. (Chinese)

The transboundary movements of hazardous waste batteries should follow the Basel Convention.[102] Exporting hazardous waste batteries to China is prohibited by Chinese legislation.[103] Since the transboundary movements of hazardous waste batteries are out of the scope of this study, it is not discussed in detail in the study.

## 4.4 Recycling

Recycling should be considered as the prior choice for waste battery disposal. But China doesn't have any waste battery recycling plants today, except the lead-acid battery recycling plants. With the establishment of a waste battery collection system, it is expected that the recycling plants of waste batteries will be built in the future.[104] The technical guide suggests that the recycling plants should focus on secondary batteries and button cells. At the same time, the recycling plants for waste primary batteries are not encouraged to be built.[105]

The recycling plants for waste batteries must obtain a certificate from the environmental authority. In order to absolutely prevent the secondary pollution from the recycling process, the recycling plants must meet strict environmental requirements. The recycling rate of hazardous substances, such as mercury and cadmium should be more than 95% of the total. The emission, water discharge, solid waste and work environment have to meet the national environmental standard.[106]

## 4.5 Final Disposal

According to the information offered in Section 2.2, incineration of waste batteries is more dangerous. Therefore, the approach of incineration of waste batteries is forbidden in the technical guide.[107] The technical guide also suggests separating waste batteries from municipal waste at the incineration points and composting points.

The non-hazardous waste primary batteries may be landfilled together with municipal solid waste. But the hazardous waste batteries are prohibited to be landfilled together with municipal solid waste. These waste batteries should be treated as hazardous waste and landfilled into a special area within suitable facilities.

## 4.6 Waste Lead-Acid Batteries Management

The status of waste lead-acid batteries is different to other types of waste batteries. Waste lead-acid batteries are the only group of batteries collected and recycled in China nowadays. The collection and recycling of waste lead-acid batteries is run by market economy mechanisms,

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[102] The official name of Basel Convention is Convention on the Transboundary Movements of Hazardous Wastes and their Disposal. Enter into force on 5 May 1992

[103] Standing Committee of the National People's Congress. (1995). *The law of the people's republic of china on prevention of environmental pollution caused by solid waste.* Article 24. (Chinese)

[104] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003)

[105] SEPA. (2003). *The technical guide on waste batteries management.* Huanfa (2003) 63. Article 6.1. (Chinese)

[106] SEPA. (2003). *The technical guide on waste batteries management.* Huanfa (2003) 63. Article 6.5. (Chinese)

[107] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

since the waste lead-acid battery is of high economic value. Therefore, the technical guide gives special rules for management of waste lead-acid batteries.

The targets of waste lead-acid battery management are to improve the collection rate and recycling rate of lead, and to promote the recycling efficiency and environmental performance. The collection rate of waste lead-acid batteries has reached 90% today in China. But it is almost 100% in industrial countries. The introduction to the technical guide on waste battery management suggests the target of collection is to reach 100% in 2005.[108]

The lead contained in waste lead-acid batteries is the major recyclable and valuable material. The recycling rate of lead is only 80% in China nowadays. That means the rest 20% of the lead is not recovered and it could bring potential environmental risks. In the technical guide, the standard of recycling of lead is set as 95%. Those recycling plants that cannot meet the standard will be shut down by mandatory order. But the technical guide does not give out the schedule of implementation of the standard.

Another principle is 'centralized recycling'. There are more than 300 recycling plants of waste lead-acid batteries in China at present. Among them, only three plants have the ability to recycle more than 10 thousand tons of lead per year. Many small and medium sized plants have less environmental technology and facilities, and cannot ensure that the lead-acid battery is recycled in a secure and environmental way.[109] Considering the potential environmental risks from small and medium sized recycling plants, the technical guide carries out a standard of lead output, with the purpose of eliminating small and medium sized recycling plants. If the output of recycled lead is less than 5 thousand tons per year, the plants should be shut down. A newly established recycling plant must have the capacity of 10 thousand tons of recycled lead per year.[110]

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[108] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

[109] Ma, Yonggang. (2003). *Lead-acid batteries and recycling lead: Status, problems and solutions.* [Online]. Available: http://www.ctiin.com.cn/hydt/js/js0207/js0718-2.htm.(July 26, 2003).(Chinese)

[110] SEPA. (2003). *The technical guide on waste batteries management.* Huanfa (2003) 63. Article 8.8 (Chinese)

# 5. Analysis

Based on the information offered in previous chapters, this chapter presents the analysis of the policies of waste batteries in China. In the scope of this study, the technical guide on waste battery management was just released in October 2003. Lacking data and relevant information on the implementation of the newly released policy, it is difficult to evaluate the policy by performance criteria. In order to remedy the information gap, the author tries to look for some useful information from the experience in other countries and programs of other waste products.

## *5.1 Framework for Policies Analysis*

In this study, a framework is developed for policy analysis of waste battery management in China. The framework is divided into two levels: **Principle of Environmental Policy** and **Performance Criteria for Environmental Policy**. The framework is applied to evaluate the policies and examine if these policies are in accordance with the principles and performance criteria of sustainable environmental policies.

### 5.1.1 Principles of Environmental Policies

A series of principles have been developed for sustainable environmental policy in the recent decades. Originally, these principles have been formulated in legalization. But these principles are also applied in making and evaluating environmental policy. Commonly, these principles are considered as general policy guidelines, guiding the behavior of authorities in environmental policy decision.[111] Hence, they are regarded as the basis of developing environmental policies.

According to Faure (2001), the following principles should be considered for environmental law and environmental economics:[112]

- Sustainable development
- Prevention at source
- Proximity principle
- Precautionary principle
- Polluter pays principle
- Integration principle (IPPC)
- Environment and human rights
- Subsidiary principle

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111 Faure, Michael. (2001). *Environmental law and economics*. Maastricht: Maastricht Univerity. p.193. (Un-published)

112 Faure, Michael. (2001). *Environmental law and economics*. Maastricht: Maastricht Univerity. pp.193-214. (Un-published)

In Faure's book, these principles are discussed for environmental law and environmental economics. In this study, the author extends the applied scope of these principles to all types of environmental policies. Based on lacking of data and information, relevant for the above principles, only sustainable principle, prevention at source, and polluter pays principle are discussed in this study. Additionally, the **3Rs principle** is also discussed as an import principle in this study. 3Rs principle means reduction, re-use and recovery.

### 5.1.2 Performance Criteria of Environmental Policies

In evaluating the effectiveness and appropriateness of a policy for addressing a given problem in environmental pollution control, it is important to have clearly in mind a set of policy evaluation criteria.[113] Performance measures are the key issues in environmental policy analysis. Five core performance measures have been developed and applied to analysis of environmental policy programs by OECD. The five core performance measures are:[114]

- Environmental effectiveness
- Economic efficiency
- Innovative advancement
- Political acceptability
- Administrability

In OECD's report, these measures are designed for EPR programs. The advantage of the proposed criteria is that they do not only facilitate more consistent performance assessment, but they can also be more broadly used as central policy considerations for the mid-stream adjustment of existing EPR programs, as well as for the strategic planning of future EPR programs.[115] In Field (2001), similar performance criteria are discussed. According to Field (2001), the applied scope of these measures is more than EPR programs; they are also suggested to be applied to other environmental policies.[116]

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113 Field, Barry.C. (2001). *Environmental Economics: An Introduction*. 3 ed. USA: McGraw-Hill. p.183.

114 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report*. p.43 [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

115 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report*. p.43. [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

116 Field, Barry C. (2001). *Environmental Economics: An Introduction*. 3 ed. USA: McGraw-Hill. Pp.183-193.

## 5.2 Principles of Environmental Policy

### 5.2.1 Sustainable Development

> **Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs**[117]**.**
>
> *Brundtland Commission*

The concept of 'sustainable development' was presented by the Brundtland Commission in 1987. It has become a basic principle for making environmental policy, social policy and economic policy. In the principle of sustainable development, three main dimensions of sustainable development can be identified: **Environmental Dimensions**, **Economic Dimensions** and **Social dimensions**.[118] The goal of policy should be to promote the progress of environment, economy and society, which should be balanced and sustainable.[119]

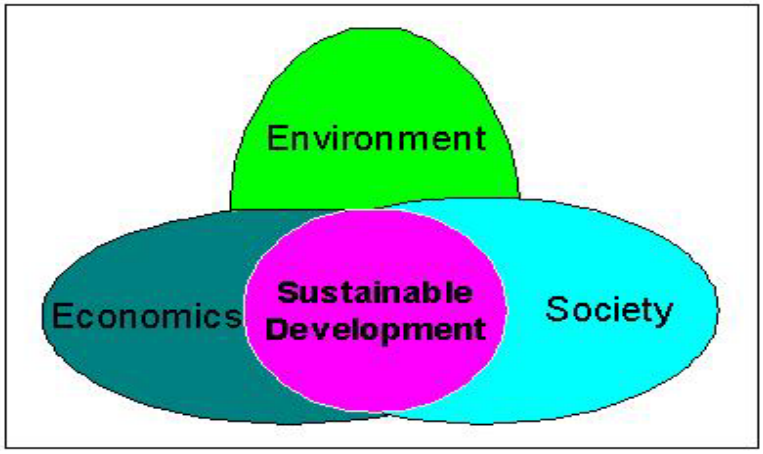


Figure 5-1: Three dimensions of sustainable development

Although the policy of waste batteries in China started later than in industrial countries, sustainable development in China has been recognized by authorities and the general public. According to the review of governmental and legal documents, the principle of sustainable development has been introduced into the Chinese environmental policy system, and it has been applied into Chinese policies of waste batteries.

Among the policies relating to waste batteries, the principle of sustainable development is found in the text of the Technical Guide on Hazardous Waste Management and the Technical Guide on Waste battery Management. In both technical guides, sustainable development is regarded as the basic principle and long-term goal.

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117 SDinfo. (2003). *What is sustainable development.* [Online]. Available: http://www.sdinfo.gc.ca/what_is_sd/index_e.cfm.(September 30, 2003)

118 UNIDO. (2001). *The Three Dimensions: Defining sustainable development.* [Online]. Available: http://www.unesco.org/education/esd/english/sustainable/notion.shtml.(August 1, 2003)

119 Faure, Michael. (2001). *Environmental law and economics.* Maastricht: Maastricht University. p.194. (Un-published)

The Technical Guide on Hazardous Waste Management requires that the hazardous waste batteries must be separated from municipal solid waste. But the policy is not implemented at all. The reason is that there is no waste battery management system to support the policy, and no hazardous waste batteries are separated from municipal waste today. Therefore, the implementation of these policies is not in accordance with the principle of sustainable development.

### 5.2.2 Prevention at Source

Prevention at source is the principle that preventive action should be taken and that environmental damage should be rectified at source.[120] Source reduction means reduction of the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and reduction of the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.[121]

Considering the potential environmental risks from hazardous substances contained in batteries, China has implemented the schedule of reducing mercury in batteries. This policy is to reduce gradually the mercury content contained in batteries, with the aim of removing mercury batteries from market. According to the survey and inspection of battery quality, it is recognized that large manufacturers implement the policy efficiently, and their products have met the requirement of being mercury free earlier than the schedule.[122] According to statistics, all 14 large manufacturers have reached the requirement of mercury free alkaline-manganese batteries, which corresponds to more than half the output of alkaline-manganese batteries in China.[123]

The policy implementation is unsatisfactory from the side of small and medium sized manufacturers. Consequently, on today's market in China, the mercury batteries are mainly from small and medium sized manufacturers.[124] These small and medium sized battery manufacturers have less capacity to improve the environmental performance and production technique. The implementation of environmental policy in small and medium sized plants is discussed in Section 5.3.1.

Cadmium and lead are also considered in the Technical Guide on Waste Battery Management. The technical guide suggests removing nickel-cadmium batteries from the civil battery market and encourages developing lithium batteries and nickel-metal hydride batteries to substitute nickel-cadmium batteries. There is no policy to limit the lead content contained in batteries, and it is difficult to find a substitute-battery for the lead-acid battery today. The emphasis on reducing the environmental risks from lead-acid batteries is to collect and recycle.

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120 Faure, Michael. (2001). *Environmental law and economics.* Maastricht: Maastricht Univerity. P.197. (Un-published).

121 EPA. (2002). *Definitions of pollution prevention and source reduction.* [Online]. Available: http://www.epa.gov/oppt/p2home/p2policy/definitions.htm.(August 2, 2003)

122 Resource and Environment. (2001). *The free mercury alkaline-manganese of 14 manufacturers in China.* [Online]. Available: http://www.myearth.com.cn/kply/lsjy/lsjy3-5.htm. (August 27, 2003). (Chinese)

123 Resource and Environment. (2001). *The mercury free alkaline-manganese of 14 manufacturers in China.* [Online]. Available: http://www.myearth.com.cn/kply/lsjy/lsjy3-5.htm. (August 27, 2003). (Chinese)

124 CINIC. (2002). *Batteries qualification rate of 3rd quarter is 78.3%.* [Online]. Available: http://chanye.sina.net/qg/2002-11-26/107281.shtml. (August 2, 2003). (Chinese)

The following discussion is about reduction of cadmium contained in batteries. According to Commission Directive 98/101/EC, primary batteries containing more than 0.025% of cadmium by weight is prohibited on the EU market.[125] But there is no policy to limit the cadmium content contained in batteries in China.

The European Commission is planning to revise its Battery Directive and is seeking comments from interested parties on how legislation on batteries recycling and disposal should be set out. In the Consultation on the Revision Batteries Directive, a ban on the use of cadmium in batteries and accumulators placed on the community market is suggested.[126] Since the EU is one of the major markets for Chinese battery manufacturers, The Chinese battery industry actively responds to the consultation. The suggestions of The Chinese battery industry do not support the ban of batteries containing cadmium on the EU market, and they suggest to encourage consumers purchasing the substitutes of nickel-cadmium batteries and to collect the waste batteries containing cadmium.[127]

In line with the suggestions of The Chinese battery industry, the author thinks that it is impossible to ban the batteries containing cadmium on the Chinese battery market in the near future. In the suggestions to the EU battery directive, the Chinese battery industry also supports that less than 0.025% of cadmium content in primary batteries is acceptable.[128] Therefore, it is possible that China will take 0.025% as the limitation of cadmium content contained in primary batteries in the future policy.

It is acknowledged that the cadmium contained in batteries is a hazardous substance to environment. The focus of argument is what level of cadmium contained in batteries is acceptable to the environment. The author thinks, this should be decided by scientific experiments.

### 5.2.3 Polluter pay principle

Polluter pay is a principle which states that those who cause industrial pollution should offset its effects by compensating for the damage incurred, or by taking precautionary measures to avoid creating pollution.[129] This means that polluters should be required to pay for environmental damage, environmental controls, and the administration of environmental agencies. The principle sets the legal responsibility of pollution on the polluters, and it is also an economic instrument with the aim to reduce potential environmental risks and use the money from polluters for prevention, abatement, treatment of pollution, and information.

The polluter pays principle has been introduced into Chinese environmental policies, and it also has also been introduced into the environmental policy on waste batteries. In the Technical Guide on Waste Battery Management, the polluter pays principle is introduced.

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125 Commission Directive 98/101/EC of 22 December 1998 adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances. OJ L001, 05.01.99

126 European Commission. (n.d.). *Consultation on the revision batteries directive.* [Online]. Available: http://europa.eu.int/comm/environment/waste/batteries/consultation.pdf. (September 7, 2003)

127 CBIA. (2003). *The suggestions of Chinese batteries industry on EU consultation on the revision batteries directive.* (Draft). [Online]. Available: http://www.chnbia.com/0013. (September 7, 2003)

128 CBIA. (2003). *The suggestions of Chinese batteries industry on EU consultation on the revision batteries directive.* (Draft). [Online]. Available: http://www.chnbia.com/0013. (September 7, 2003)

129 Center for Sustainable Development in the Americas. (2003). *An annotated glossary of commonly used climate change terms.* [Online]. Available: http://www.csdanet.org/glossary.html(August 3, 2003)

Figure 5-2 displays the material flow of batteries. Manufacturers, distributors and consumers are the main actors in the process. But, who are the polluters? The author thinks that the manufacturers and consumers should be regarded as polluters, since their actions directly lead to potential environmental risks. They should take the joint responsibility to pay for environmental problems from batteries.

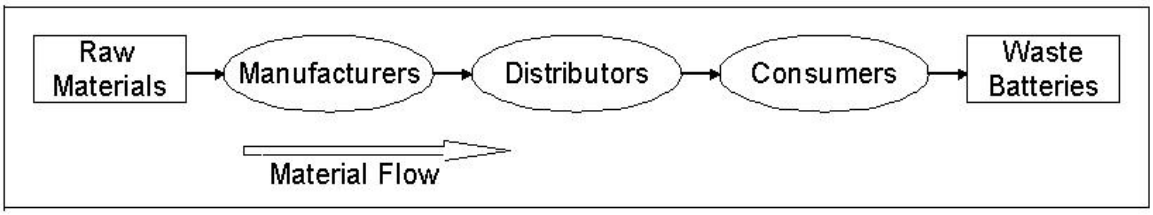


Figure 5-2: The material flow of batteries

In the Technical Guide on Waste Battery Management, the producers have the legal responsibility to collect waste secondary batteries and button cells, but the responsibilities of recycling and final disposal are not given to the battery producers. Taking the responsibility, the producers have to spend money on waste battery collection, which will add extra cost to the price of batteries. The producers will want transfer the extra cost of collecting waste batteries to the consumers. And consequently, the consumers will pay for purchasing batteries than before. In the end, the consumers pay for the environmental problems from batteries.

In the Technical Guide on Waste Battery Management, only the responsibility of collecting waste batteries is given to producers. It is not clear who will pay for recycling and final disposal of the waste batteries, if the plants cannot balance the costs and incomes from the business of recycling and final disposal. Therefore, it is reasonable to say that the polluters only pay for the environmental impacts partially.

Environmental taxes/charges are another economic instrument to meet the polluter pays principle. But there is no existing environmental/charge on batteries in China today. Environmental groups have suggested the environmental taxes/charges on batteries. But no available information shows that the authorities will adopt the environmental tax/charge on batteries in the near future. More discussion of environmental taxes/charges is found in Section 6.3.1.

### 5.2.4 3Rs Principle

The 3Rs principle is known as **reduction**, **re-use** and **recycle**. The 3Rs principle has been very widely adopted and achieved official recognition from the governments, as well as it has been applied in environmental policy. The 3Rs principle has also been applied in the environmental policy of waste batteries in China.

The **reduction** principle could be recognized at three levels in this study. The first level is to reduce the hazardous substances contained in batteries, which is similar with the principle of prevention at source. It is clear that the Chinese environmental policy is implementing the policy to reduce the mercury content contained in batteries. The second level is that the policy is to encourage the manufacturers to improve battery performance and extend the batteries lifetime through technological and managerial innovation. It is understood that the consumption could be decreased if the performance is improved and the battery lifetime is extended. The third level could be understood that the policy is to reduce the consumption of batteries containing hazardous substances, and encourage consumers to purchase

environmentally friendly batteries. For example, the battery policy in China is encouraging consumers to purchase nickel-metal hydride and lithium-ion batteries instead of nickel-cadmium batteries, which contained hazardous substances.

It is impossible to reuse the primary batteries. But the **re-use** principle could be understood as a policy to encourage the consumption of secondary batteries rather than primary batteries, since secondary batteries are preferable provided you have high return rates and recycling. Unfortunately, this principle is not found in the Chinese policy system.

The **recycling** principle could be recognized as the policy requires and encourages recovering of the waste materials so that they may be used again, either for their original purpose or for some other purpose. After reduction and re-use, recycling should be considered as the prior choice, preferable to other alternatives of waste treatment.

The recycling principle has been introduced into the implementation of waste lead-acid management. It is not yet implemented in waste management of other types of batteries today. In the Technical Guide on Waste Battery Management, the recycling principle is applied into the recycling of waste secondary batteries and button cells. It is stated that the recycling rate of hazardous substances must reach 95% by the mandatory requirement in the technical guide.[130]

It is a fact that there are some barriers for recycling of all types of hazardous waste batteries. According to the interview with an engineer from a battery manufacturer, the technical barriers have been removed, and mature recycling technology and methods are available. The most difficult problem is the financial aspect. It is impossible to make a profit from the business of recycling batteries today, without government aid or other financial support.[131]

According to the above analysis and the information in previous chapters, it is recognized that the policies of waste batteries in China partially meet the 3Rs principle. The reduction principle was introduced into the policy system and it has been already implemented. The author thinks the re-use principle could play an important role in the policy system, but unfortunately, this principle is not found. The recycling principle was introduced into the policy system and has been applied in waste lead-acid battery management. There are some barriers for applying the recycling principle into other type of waste battery management. The major problem is financial.

## *5.3 Performances Criteria of Environmental Policy*

### 5.3.1 Environmental Effectiveness

The performance measure of environmental effectiveness deals with the extent to which the program has achieved environmental objectives and/or the extent to which environmental improvements occur from year to year. Components of environmental effectiveness include changes in environmental quality, health risk reduction, and resource efficiency.[132]

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130 SEPA. (2003). The technical guide on waste batteries management. (Chinese)

131 Zhang, Dongcao. (2000). *The way of recycling waste batteries.* [Online]. Available: http://www.cyol.com/cydgn/gb/cydgn/2001-07/17/content_260552.htm. (August 28, 2003). (Chinese)

132 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report.* p.43.[Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

A policy is said to be effective if it achieves the goals set in the policy.[133] The desired major environmental goal of the policy of batteries should be to prevent or mitigate the potential environmental risks associated with batteries. Here, the goals of the policy of waste battery management include: a) reduction of hazardous substances contained in batteries; b) collection rate of waste batteries; c) recycling/final disposal without secondary pollution. In this study, recycling/final disposal is excluded in the discussion, since data and information are lacking.

#### 5.3.1.1 Reduction of Hazardous Substances

Reduction of hazardous substances contained in batteries is the crucial phase in waste battery management. After the regulation on the limitation of mercury contained in batteries entered in force, many battery manufacturers have taken action to prevent waste battery pollution, by reducing hazardous substances, improving lifetime of batteries through technological innovation. In 2001, more than half of alkaline-manganese batteries have reached a mercury free level. All of the 14 large manufacturers have finished the transition from traditional mercury alkaline-manganese batteries to mercury free batteries.[134] Concerning the development of mercury free alkaline-manganese batteries, the goal of the regulation on the limitation of mercury in batteries must be reached in 2005.[135] It could be said that the policy of reducing hazardous substances contained in batteries has been effective. It is expected that those small and medium sized manufacturers who cannot meet the mercury free standard will be shut down by mandatory order.

#### 5.3.1.2 Collection

As mentioned in Section 4.2.3, the Chinese authorities and researchers assume that the status of waste battery collection is five years behind the Japanese. The target setting of collection rate is based on this assumption. The target of an average collection rate of waste secondary batteries of 40% is to be reached in 2004, and 50.5% in 2010.[136]

The author does not agree with the method of setting targets for the collection rate. The economic and social conditions are different from country to country, and it is not reasonable set targets based on the target of another country. The setting of collection target should consider the situation of the waste management system, public environmental knowledge and economic conditions.

The author thinks that it is difficult to meet the target of collection of waste secondary batteries in 2004, and it is difficult to expect what will happen with the target in 2010. Talking about the target for collection rate, the following factors should be considered.

The Technical Guide on Waste Battery Management has just been released in October 2003, and it is the framework document for future waste battery management. Following the

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133 Narayan,Priya. (2002).*Analysing Plastic Waste Management in India: Case study of Polybags and PET bottles*. Lund: IIIEE. p.56

134 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

135 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

136 Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management*. [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

technical guide, some detailed policies should be presented later. The process of making detailed policies may take considerable time. Even if the collection system is initiated very soon, it is impossible to establish a reasonable and effective collection system of waste batteries in one year and reach the desired collection rate.

Some experience from other countries could be worthwhile remembering when considering the collection rate. Japan started to collect waste batteries in 1993. After 6 years, the collection rate of waste secondary batteries reached 40% in 1999.[137] Switzerland adopted legislation concerning batteries in 1986, called Ordinance relating to Environmentally Hazardous Substances. The ordinance requires setup of the collection system of waste batteries. The collection rate of waste consumer batteries reached 54% in 1995.[138] It took 9 years from the establishment of the collection system to the collection rate of 54%. According to the collection experience in Japan and Switzerland, it will be impossible for the collection rate in China to reach 40% in 2004.

Another key factor is that there is no professional recycling plant for waste secondary batteries in China today, except for the recycling plants for waste lead-acid battery. If the collection rate reaches 40%, the collected waste batteries could constitute a huge amount. How to deal with the collected waste batteries is a big problem, since it is impossible to build recycling plants in a short time.

In order to reach a high collection rate, the key issues are to set up a reasonable collection system in the near future and ensure it operates effectively and efficiently. The recommendations for collection of waste batteries will be discussed in Chapter 6.

Another problem in the Technical Guide on Waste Battery Management is that the separation rate of waste batteries is not regulated. A specified separation rate of waste batteries should be an important goal in the waste battery management system.

Evidently, the calculation method can influence the statistics significantly. When the calculation method is different, it is difficult to compare the collection results from country to country. The following presents the calculation methods in the Netherlands and Switzerland. The calculation method in Switzerland is the most common approach for the calculation of collection rate. But the calculation method of collection rate has not been considered in the Technical Guide on Waste Battery Management. It is not clear which calculation method should be adopted in China.

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137 Cao, Guoqing, Shen, Yingwa & Jian, Xiaodong. (2002). *Management of spent batteries and environment protection regulations.* Chinese batteries industry. 7, 6, p.323. (Chinese)

138 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.42. P.45

**The Netherlands:**

CR%[139] = Weigh of batteries collected / Weight of batteries discarded[140]

**Switzerland:**

CR% = Weigh of batteries collected year t / Weight of batteries sold year t[141]

In the policies, only the target for collection rate at national level is considered. To establish a collection target for individual producers is not considered. The author thinks it is necessary to set a collection target for a producer.

Another problem is the quality of statistical data from the battery industry in China. As mentioned in Section 1.3.3, there are no systematic statistics of the batteries market and battery industry in China. Under this condition, it is difficult to calculate the amount of sold batteries and discarded batteries.

In the newly released Technical Guide on Waste Battery Management, the management of waste hazardous primary batteries is a blind spot. These batteries are not required to be collected. According to the information in previous chapters, both the low mercury and high mercury batteries will be on the market for some years. Without collection, these batteries continue to bring environmental risks.

Waste mercury free batteries and low mercury batteries are not encouraged to be collected and recycled in the newly released technical guide. It is clear that the authorities adopted the 'second' opinion as outlined in Section 3.3.5. The author thinks that the policy fails to encourage saving of natural resources and fails to contribute to sustainable development. In the fact, China is facing a shortage of natural resources for the battery industry, especially zinc and mercury.

### 5.3.2 Economic Efficiency

The performance measure of economic efficiency is the extent to which the policy has operated with minimum cost to society and obtained the benefit. Components of economic efficiency may include various domestic impacts (prices, employment, profitability and competitiveness, growth), as well as trade and international competitiveness.[142]

Costs associated with a policy should be discussed quantitatively, and a cost-benefit analysis should be conducted, which could present the economic efficiency accurately.[143] Due to unavailability of data, it is often the case that costs to society cannot be measured accurately.[144]

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139 CR = collection rate

140 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.61

141 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.61.

142 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report.* p.43 [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

143 Field, Barry.C. (2001). *Environmental Economics: An Introduction.* 3 ed. USA: McGraw-Hill. p.184.

144 Field, Barry.C. (2001). *Environmental Economics: An Introduction.* 3 ed. USA: McGraw-Hill. p.184.

Because the collection and recycling systems have not been setup in China today, it is impossible to conduct the quantitative cost-benefit analysis on the policies of waste batteries. Hence, this aspect has been discussed only qualitatively in this study.

From the viewpoint of private business, it is impossible to make a profit from the collection and recycling of waste batteries, except for lead-acid batteries. From the viewpoint of social cost-benefit, the collection and recycling of waste batteries can bring benefits to society and future development. But it is difficult to evaluate the total costs (cost of collection, recycling, final disposal, and information) and total benefits (reducing the environmental risks at present and in the future). Therefore, when we talk about the economic efficiency, both private cost-benefit and social cost-benefit should be considered.

In the Technical Guide on Waste Battery Management, collection and recycling of waste primary batteries are not required. The emphasis is to reduce the hazardous substances contained in primary batteries, with the aim to reach non-hazardous levels. The non-hazardous batteries have low environmental risks, and they could be treated as general municipal waste. It is regarded that the cost is very high to collect and recycle waste primary batteries. When recycling zinc from waste primary batteries, the energy consumption is three times that of smelting zinc from ore.[145] On other hand, if you do not collect and recycle these waste batteries, it leads to a loss of natural resources.

Another benefit is that the environmental policies on batteries strengthen the competitive advantages of Chinese manufacturers in the international market. According to the information in Section 3.1, 80% of the Chinese batteries are exported. The mercury free alkaline-manganese batteries are mainly exported to industrial countries.[146] The industrial countries have strict requirements on environmental performance of batteries. The mercury free alkaline-manganese batteries could get a bigger market share in the industrial countries.

### 5.3.3 Innovative Advancement

The performance measure of innovative advancement deals with the extent to which the policy has stimulated technological and managerial innovation. This 'dynamic efficiency' is essential to increasing economic efficiency and environmental effectiveness.[147]

Since the regulation on limitation of mercury contained in batteries entered into force, the large manufacturers have changed the production technique and improved technology. According to inspection of the battery industry conducted by the National Inspection Center of Batteries, many manufacturers have obtained achievement in innovative and managerial innovation, and the performance of batteries has been improved. For example, the electric capacity has been improved 10% since 1998.[148] The manufacturers also pay more attention to the improvement of facilities, especially the production devices. The information shows that

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145 CBIA. (2003). *The suggestions of Chinese batteries industry on EU consultation on the revision batteries directive* (Draft). [Online]. Available: http://www.chnbia.com/0013. (September 7, 2003)

146 China Batteries Industry Association. (2002). *CBIA Annual Report 2001*. [Online]. Available: http://www.ica.gov.cn/new/zxdt/zxdt2002/zxdt0204/1702.htm. (July 12, 2003) (Chinese)

147 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report*. p.45. [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

148 Resource and Environment. (2001). *The free mercury alkaline-manganese of 14 manufacturers in China*. [Online]. Available: http://www.myearth.com.cn/kply/lsjy/lsjy3-5.htm. (August 27, 2003). (Chinese)

the regulation also has offered incentives to Chinese battery equipment manufacturers to design and manufacture new production devices for environmentally friendly batteries.

In the Technical Guide on Waste Battery Management, the highlight of innovative advancement is that the policy requires elimination of the un-advanced production technologies and small-scale waste batteries recycling plants. It also provides the requirements for the recycling rate of hazardous substances contained in waste batteries. According to the experience gained in the implementation of the regulation on limitation of mercury in batteries, the author thinks that these policies will stimulate technological and managerial innovation.

But it is difficult to say how much incentive for the technological innovation emanates from the policy force and how much incentive is from market forces. For the technological and managerial innovation, also the market is a strong driver, especially for the large manufacturers with export business. They are facing strong competition on the international market, and the market will be another driver for the technological and managerial innovation. From this viewpoint, the policies offer more incentive for technological and managerial innovation to small and medium sized battery manufacturers than the large battery manufacturers.

In this study, the author thinks that the policies have successfully offered the incentives for reducing the mercury content in batteries, and have accelerated the transition from mercury batteries to mercury free batteries. It is expected that the newly released Technical Guide on Waste Battery Management could offer active incentives to industry and waste battery management in the future.

### 5.3.4 Political Acceptability

The performance measure of political acceptability is the extent to which the policy has enjoyed political acceptability. Components of this consideration may include public participation, transparency, social equity and conformity with international agreements.[149]

The fact that waste batteries pose potential environmental risks has been realized by the general public in big cities. Hence, the policies of waste batteries have found acceptance at most of levels in the big cities. Lacking education and environmental knowledge, the public in most of small and medium sized cities and rural region does not have much environmental knowledge and concern of waste batteries.[150] In all, the education and environmental knowledge are the weakness for public support and participation.

The response from large battery manufacturers, trader and user is positive for the policy of limiting the hazardous substances contained in batteries and the technical guide on waste battery management. Desay and Motorola (China), the battery manufacturers, have also shown the support for collection and recycling waste batteries.[151]

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149 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report.* p.46. [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

150 Ying, Shongjian. (2003). *The serious batteries pollution in China.* [Online]. Available: http://www.jmyz.com/yjxxx/55/diaochashuju.htm. (July 29, 2003) (Chinese)

151 Zhen, Xi. (2002). *Where are the waste batteries.* [Online]. Available: http://rockard.myrice.com/slaves/xiuxian/hf45.htm. (September 9, 2003). (Chinese)

The newly released policy of collecting waste secondary batteries and button cells is strongly supported by the general public. In some urban regions, many inhabitants, school students, and producers have for some years been involved in the voluntary collection of waste batteries.[152] Environmental knowledge of waste batteries has been introduced into the textbooks at primary schools in Beijing. Some collection boxes for waste batteries have been set up in some communities, schools, colleges, shops and restaurants.

These policies have also been found favor with the authorities since it promotes sustainable development in China and enhances the competitive advantage on the international battery market. With the enhancement of the competitive advantage in the international market, the Chinese battery manufactures could contribute more to the economic growth and generate tax incomes.

But small and medium sized battery manufacturers do not like some of the policies, since they have less capacity to improve their technology and equipments to meet the requirement. These manufacturers focus mainly on the domestic market for low-price batteries. If they follow the policy to reduce the mercury content contained in batteries, they have to pay money for the improvement of technology and equipment, and the cost of the products will be rising. According to statistics, the cost of mercury free alkaline-manganese batteries is 0.11-0.16 RMB[153] per unit higher than high mercury batteries in China.[154] The small and medium sized battery manufacturers are against this policy with the aim of keeping their competitive advantage of low price on the market.[155]

The small and medium sized battery manufacturers and recycling plants of lead-acid waste batteries complain that the policy is not fair to them, since they do not have enough capacity to improve technology and equipment to meet the policy, and the authorities do not offer any aid. They request lower environmental standards for batteries and for recycling of waste batteries. The author does not agree with their viewpoint. The environment and human health are public rights, and it is unreasonable to give up public rights to meet the demand of a few private businesses. But many workers could loose their jobs if these small and medium sized plants are shut down. The authorities could consider aiding them in technology improvement and with financial support.

### 5.3.5 Administrability

The performance measure of administrability is the extent to which the policy has been feasible to carry out. Components of administrability may include smooth integration with policies for other sectors, simplicity and flexibility of operation, effectiveness/compliance, and costs associated with monitoring, licensing, and enforcement. Cost impacts and attributes of effectiveness should be considered both for governmental and private-sector entities.[156]

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152 China Youth Daily. (2000). *The way of recycling waste batteries.* [Online]. Available: http://abfall.myrice.com/html/news/9939.html. (September 7, 2003). (Chinese)

153 Equal to 1.3-2 US cents

154 Wang, Jinliang. (2001). *Quicken the step of non-mercurialized of batteries.* Batteries bimonthly. 31, 2, p.64. (Chinese)

155 Jieyang.gd.cn. (2002). *The new policy on waste batteries management.* [Online]. Available: http://www.jieyang.gd.cn/cyxx/422/422-1.htm. (September 9, 2003). (Chinese)

156 OECD. (1998). *Extended and Shared Producer Responsibility. Phase 2. Framework Report.* p.43 [Online]. Available: http://www.olis.oecd.org/olis/1997doc.nsf/43bb6130e5e86e5fc12569fa005d004c/c125692700623b95c12569b9006ad6e5/$FILE/00043837.PDF. (August 1, 2003)

Experience of the regulation on the limitation of mercury contained in batteries (1997) provides substantial information on the administrability of the policy. After the regulation entered in force, the authorities of government like SEPA and CQI (China Quality Inspection) inspect the batteries on the market from time to time. Those battery manufacturers whose products failed to meet the environmental standards will be warned or punished.

Similar to other developing countries, poor enforcement has been one of the obstacles in the implementation of environmental policies in China. Some problems have been found in the experience of the implementation of the regulation on the limitation of mercury contained in batteries. Some small and medium sized battery manufacturers without satisfactory environmental performance have not been shut down, and some unqualified batteries with high mercury can be found on the market.[157] The strange thing is that some high mercury batteries with the label of 'mercury free' can also be found on the market.

Regarding the problems, some reasons could be defined. There are many unregistered battery workshops in China, which are small in size and have low technical capacity. They could put other producers' trademark on their batteries in an illegal way, or mark the label of 'mercury free' on their battery bodies.[158] It is really difficult for the authorities to find these workshops and monitor their production and product quality.

Another reason is called '**local protectionism**' in China. The local protectionism is regarded as a serious problem in the Chinese political system, not only in environmental policies. That means that the local authority may know the environmental problems in a local battery plant, but they do not like to take any measure to limit production or punish these plants, in order to charge tax from these plants and promote local economic development. Further, the local authority tries to protect these polluters from the monitoring and punishment from the national environmental authority.[159] The local government is also strongly against building recycling plants for waste batteries in their area. The recycling plant of waste batteries cannot create much of a tax income flow for the local government, but they could bring environmental risks. Local protectionism is one of the reasons why the first recycling plant of waste batteries failed. In a similar way, some years ago, the Beijing environmental authority prevented building a recycling plant for waste batteries in the region.[160]

Also other problems have happened with the voluntary collection of waste batteries. As will be elaborated in Section 6.3.2, Ms. Tian, Guirong, a volunteer of waste battery collection, collected and stored a significant amount of waste batteries. According to the legislation, the mixed batteries are considered hazardous waste. Without the permit from the environmental authority, nobody is permitted to store hazardous waste. Hence, the authority required that Ms. Tian could not store waste batteries. No recycling plant is able to accept the waste batteries, creating problems for volunteer problems.[161]

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157 Wang, Jinliang. (2001). *Quicken the step of non-mercurialized of batteries.* Batteries bimonthly. 31, 2, p.64. (Chinese)

158 Wang, Jinliang. (2001). *Quicken the step of non-mercurialized of batteries.* Batteries bimonthly. 31, 2, p.64. (Chinese)

159 Xinhuanet. (2002). *SEPA: Local protectionism and environmental pollution.* [Online]. Available: http://news.xinhuanet.com/zhengfu/2002-09/26/content_575365.htm. (September 9, 2003). (Chinese)

160 Lu, Jianguo. Beijing Recycle Center for Useful Waste, China. (September 24, 2003). Topic: the collection of waste batteries in Beijing. Telephone interview. +86(0)1087500818

161 CCTV. (2002). *The way of recycling waste batteries.* [Online]. Available: http://www.cctv.com/lm/257/91/40094.html.(October 18, 2003). (Chinese)

Without the permit from an environmental authority, collection, storage, and transport of hazardous waste are prohibited by legislation. That means the voluntary action of waste batteries is limited, since it is impossible for the volunteers to apply for a permit for waste batteries. The author thinks it is a big problem in the administrability of the policy.

# 6. Discussion of Possible Policies

Following the purpose of this study, this chapter discusses some possible policies, contributing to the development of an environmental policy on waste batteries in China. It should be noted that these possible policies are suggested individually, and it is impossible that some policies should be co-existing.

## *6.1 Labeling*

The label is the basic symbol for separating waste batteries by manual or automatic devices. According to the regulation in China, the batteries should be marked with a label to show the mercury content. But a common label is not required. Consequently, there are several different battery labels in Chinese and in English for mercury free batteries, like 'Mercury Free', '0% Mercury' and 'No Mercury Added'.[162] The situation is confusing for consumers, since the consumers do not have enough environmental knowledge of batteries, and most Chinese consumers do not know English. The confusion with such labels could be a barrier for effective sorting.

In this study, a common label for batteries is suggested. That means the batteries sold in China, as well as the imported batteries, must be marked with a common label. The label should present environmental information, which can easily be recognized and understood by consumers.

Bar code on the battery bodies is also suggested, with the purpose to sort batteries by through automatic separation devices. The bar code should include the necessary information for sorting batteries by such automatic devices. It is only a low cost to put the bar code on the batteries bodies.

## *6.2 Collection*

The newly released technical guide on waste batteries only suggests that the producers could set up a collection system based on their sales network or commission the collection business to other organizations. In this section, the author presents two suggestions for the waste batteries collection.

In Sweden, some big retailers like ICA, Matex, Konsum, have branches in most regions in the country. The status of retailer networks in Sweden is a strength for the establishment of a waste battery collection system over the country. The situation in the retail sector in China is different, and there is no retailer network that covers the whole country. The retailer network is based on various levels in China, such as first level wholesalers, second level wholesalers and retailers. In this situation, of sale network, it is impossible that the collection system work efficiently and achieve a high collection rate through the retailer network. Further, this network does not have technology and facilities to manage the waste batteries, especially the hazardous waste batteries. Another problem is that the retailers would have to obtain a permit for hazardous waste batteries from the environmental authority, if they would conduct the collection of waste batteries.

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[162] Wang, Jinliang. (2001). *Quicken the step of non-mercurialized of batteries.* Batteries bimonthly. 31, 2, p.64. (Chinese)

The author thinks it is possible that the municipal waste management system could play the major role in the waste battery collection in urban regions in China. The tradition of the municipal waste management system is long and the organization has been settled. And the consumers will remember the municipal waste collection system the first time when they throw away their waste batteries. The municipal waste management system has established a well-working collection system, using the professional equipment for waste collection, which will be helpful for improving efficiency and reduce total collection cost. The producers could transfer the responsibility of collection of waste batteries to the municipal waste management system by paying to the municipal waste management system. Or said differently, the producers take the financial responsibility for the collection of waste batteries, and the municipal waste management system takes the physical responsibility. The municipal waste management system has another crucial advantage. In that all municipal waste management systems in China are run by the government, and there is good communication and cooperation among the municipal waste management systems in various cities. The producers could commission the battery industry association to negotiate the question of waste battery collection with the association of municipal waste management systems. This will decrease the cost of negotiation.

If the municipal waste management system takes the collection responsibility of collecting waste batteries, some disadvantages should be considered:

- The municipal waste management system might tend to be stuck to old management solutions, not responding to new conditions for battery collection (e.g. collection depots that are open only during regular working hours).[163]

- Waste batteries might easily loose priority in the municipal waste collection system where all waste is collected.[164]

- Since the waste batteries share the collection costs with others waste, it is difficult to clarify if the municipal waste management systems spend enough money on the collection of waste batteries.

Some experience of collecting waste batteries from the Netherlands could be mentioned. In the Netherlands, producers play a role of collection guarantors. In the case that the desired collection target is not met through the municipal waste collection system, producers have to take measures in order to improve the collection results.[165]

Another proposal is to setup multiple channels for collection of waste batteries. Any single collection approach has both advantages and disadvantages. The multiple collection approaches could remedy these. The situation is different from region to region and from urban to rural regions. Different approaches for collection could be suggested in the various regions. Drop-off at retails stores, community collection programs, curbside collection and voluntary collection programs could be suggested.

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[163] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. P.67

[164] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. P.67

[165] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden*. Lund, Sweden: IIIEE. P.67

According to the Technical Guide on Waste Battery Management, the producers should pay money for the waste batteries collection. It is necessary to establish the legal system to force producers to finance the multiple channels of collection actions.

## 6.3 Economic Instruments

Today's prices of batteries are low, since the price only includes the private cost, without calculation of the social costs. If the social costs are calculated into the costs, the price of batteries must rise. According to environmental economics, the social costs could be transferred into private costs through economic instruments like environmental taxes and charges.

### 6.3.1 Environmental Taxes/Charges

In this study, environmental taxes/charges on hazardous batteries are suggested. There are certain differences between a tax and a charge, but the differentiation is not considered in this study. The environmental tax/charge on waste batteries is in accordance with the 'polluter pays principle'. As shows from Figure 6-1, the functions of an environmental tax/charge could be:

- Internalization of the social costs into private costs
- Increase the price of the product and decrease the demand

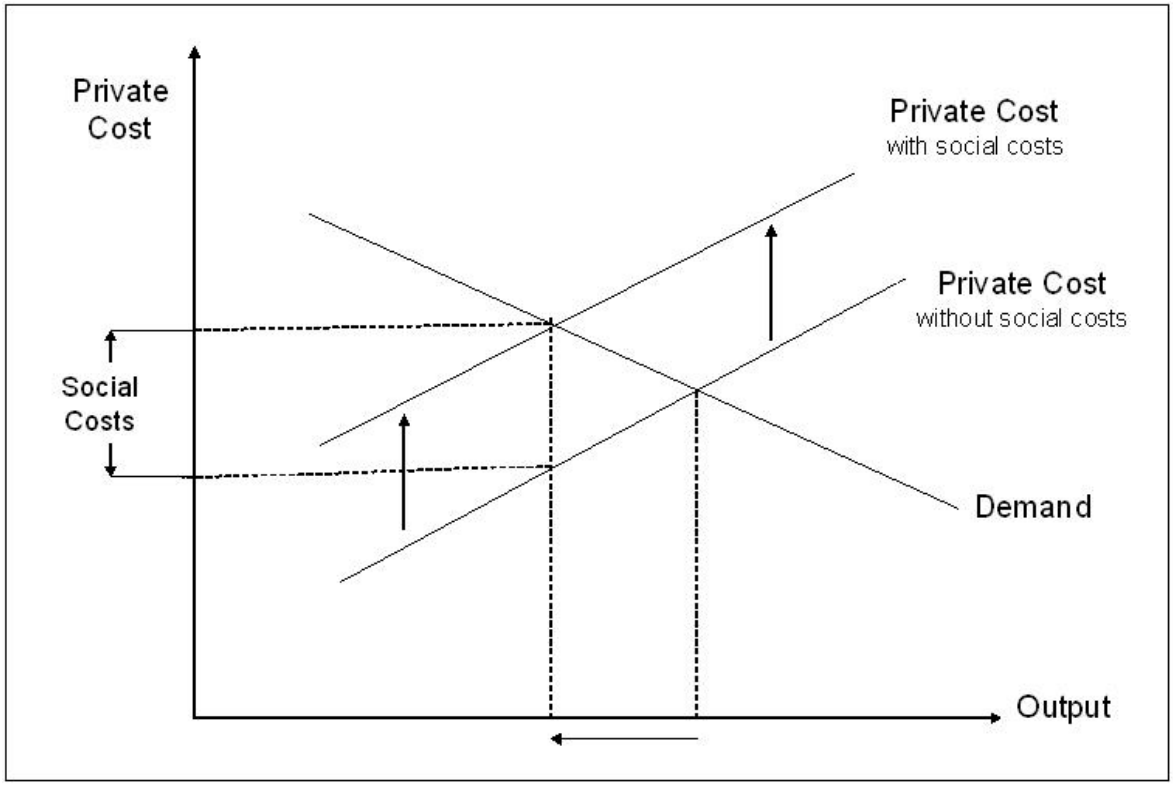


Figure 6-1: Internalization of environmental costs

The tax/charge rate can be different from battery to battery, based on the environmental performance of the batteries. If batteries containing more hazardous substances are charged at a high tax/charge rate, they will loose price advantages in the competition. In order to obtain a

competitive advantage, the battery manufacturers have to improve production technique and environmental performance of their products. If not, these batteries will be eliminated on the market. Therefore, the environmental tax/charge will be a driver to force the battery industry towards to sustainable development.

According to the interviews with manufacturers, many manufacturers like Motorola (China) would like to support an environmental tax/charge on waste batteries.[166] The environmental tax/charge is also strongly supported by the environmental NGOs and environmental researchers.[167]

The experience from the environmental charge in Sweden could be considered. The advance disposal fee was introduced in Sweden in 1987, and the current Swedish Ordinance concerning batteries came into force in 1997. The advance disposal fee is a payment, which is made at the time batteries are introduced on the market.[168] The fee is paid by the producers in advance, and the revenues from the charges are used to cover the costs of collection, transportation and recycling of batteries, the costs of information campaigns and some administration costs.[169]

The Swedish producers pay only for hazardous batteries, payment for non-hazardous batteries is not required. Below a certain threshold of mercury or cadmium batteries are not liable for the charge. The charge rate is different from battery to battery. The charges are SEK 500 (65 US$) per kg for hazardous alkaline-manganese batteries and SEK 300 (39 US$) per kg for nickel-cadmium[170].

The collection rate of nickel-cadmium batteries has not reach 30%.[171] But the advance disposal fee successfully forced the producers to substitute nickel-cadmium batteries. The higher charge on nickel-cadmium batteries is probably the reason why the consumption of nickel-cadmium batteries is in decline in Sweden. Producers have found that the nickel-metal hydride batteries could be a substitute for nickel-cadmium batteries. Compared to nickel-cadmium batteries, nickel-metal hydride batteries are less of an environmental risk and are not liable for the charge.[172]

According to the above experience of environmental charge in Sweden, it could be said that the environmental charge works well in Sweden. It is difficult to say what will happen if an environmental tax/charge is introduced in China. In all, the policy of environmental taxes/charges is only a suggestion to Chinese policy-makers for consideration.

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166 China Youth Daily. (2000). *The way of recycling waste batteries.* [Online]. Available: http://abfall.myrice.com/html/news/9939.html. (September 7, 2003). (Chinese)

167 GreenChina. (2002). *How to treat waste batteries.* [Online]. Available: http://www.grchina.net/NonCGI/Forum2/HTML/000125.html. (September 9, 2003). (Chinese)

168 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.70

169 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

170 Ordinance concerning batteries of July 15, 1997 (SFS 1997: 645)

171 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.49

172 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

### 6.3.2 Deposit Refund System

In a deposit refund system, a payment (the deposit) is made when the product is purchased and it is fully or partially refunded when the product is returned to a dealer or specialized treatment facility.[173] The deposit refund policy could offer the financial initiative to consumers to hand in their waste batteries.

According to Langrová (2002), all the three countries of Switzerland, Sweden and Netherlands have considered the introduction of a deposit refund system, but none of them put it into practice. The Netherlands and Switzerland even tried to use a deposit refund system as a threat in order to make the industry achieve high collection targets. But the actors do not like the deposit refund system. They think that the system would bring high financial burden and administration and handling problems to retailers and it could be jeopardized by import of used batteries from neighboring countries.[174] Hence, the deposit refund system has not been introduced in reality in these countries.

For conducting the deposit refund system, another factor should be considered. The duty of paying deposit fee is imposed on the producers of batteries incorporated in electronic and electrical devices. In reality, it is difficult to charge the fee from the producers, especially in the import business. Commonly, the importers do not know the type and weight of batteries incorporated in the electronic and electrical appliances. Sometimes they are not even aware of the fact that equipment contains a battery or not. In this case, it is necessary to require the manufacturers to put a label on the device to show that batteries are included.[175] Because some batteries built into devices, it is often not easy to find them. There is the possibility that some importers get free from the payment of their batteries because of this.

However, the experience from other sectors (for instance, beverage containers) shows that the deposit refund system works well, and offers financial incentives to consumers, and, consequently, the return rates increase significantly. Under a deposit refund system, the percentage for plastic bottles within the OECD is over 60%, and beer and soft drink return percentages range from 90-100%.[176] Such incentives are very important, especially for product groups, where problems with the collection occur. Collection of consumer batteries is one of these cases[177].

According above, the deposit refund system met some problems and failed to implement in Switzerland, Sweden and Netherlands. But, the author thinks China is a developing country, and the income of people is very low. Under these economic conditions, the consumer's behavior is sensitive for financial stimulation. Therefore, deposit refund system can be a choice for waste battery collection. The following case from China could illustrate the relations between financial incentives and collection of waste batteries.

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173 OECD. (2001). *Extended producer responsibility: A guidance manual for governments.* [Online]. Available: http://www1.oecd.org/publications/e-book/9701041e.pdf. (September 9, 2003). p.42.

174 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

175 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

176 OECD. (2001). *Extended producer responsibility: A guidance manual for governments.* [Online]. Available: http://www1.oecd.org/publications/e-book/9701041e.pdf. (September 9, 2003). p.42.

177 Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

> Ms. Tian Guirong lives in a medium sized city in China. She has recognized the potential environmental risks of waste batteries, and organized a voluntary program of waste battery collection in the local area. She bought the waste batteries from consumers at the price of RMB 2 cent (less than 0.2 US cents) per unit. The program has collected more than 60 tons of waste batteries within 3 years.[178]

According to telephone interview with Mr. Song Xinzhou, the director of Greener Beijing, a test of a deposit refund system of batteries has been conducted in China.[179] A college student invented a new style of environmentally friendly batteries. The sale and collection of the new battery were based on a deposit refund system at the college campus. The price was 0.5 RMB/battery (US cents 6), which is equal to the normal price of a zinc-carbon battery, and equal to half the price of a mercury free alkaline-manganese battery. The deposit fee was 10 RMB (US$ 1.3), which was really high. The collection rate was almost 100%, which was a good result. The high refund is a key factor for successful collection. This trial was limited and performed in the narrow scope of the campus, which is a non-complex environment and the consumers have comparatively good environmental knowledge. If the deposit refund system is operated in real society, more factors should be considered.

Based on above discussion and experiences, the author thinks that the deposit refund policy could be effective for collecting waste batteries in China, especially for the consumer batteries. The deposit can only be set on the hazardous batteries, which is similar with the experience in Sweden. It is believed that the refund can offer economic incentive to consumers to return the waste batteries. Figure 6-2 shows that the rag pickers can also play an important role in this collection.

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178 Li, Junde & Gui, Juan. (2002). *Who could help the environmentalist*. [Online]. Available: http://www.people.com.cn/GB/huanbao/55/20021223/893445.html. (September 9, 2003)

179 Song, Xinzhou. Greener Beijing. (October 17, 2003). Topic: environmental NGOs in China. Telephone interview. +86(0)10 8482 0742

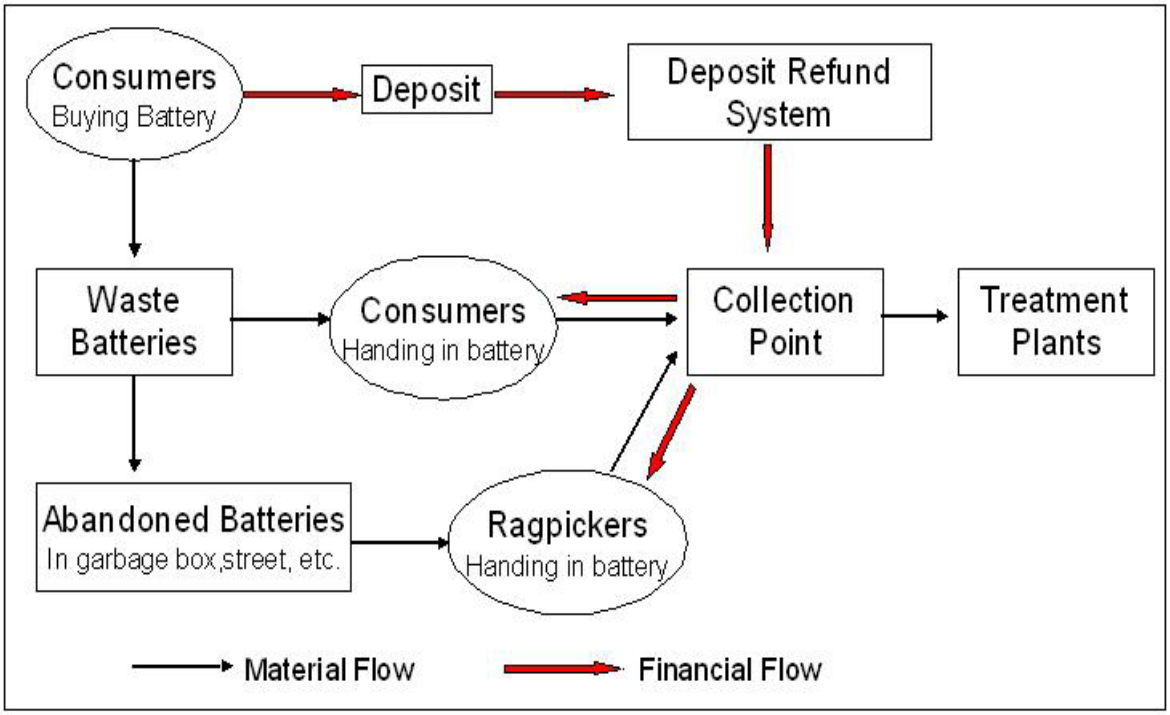


Figure 6-2: Deposit refund system

In the EU countries, there is a worry that the deposit refund system could be jeopardized by import of used batteries from neighboring countries, since the goods can move freely in the common market in EU.[180] China does not face this problem, since China does not involve in any free trade zone or common market. The import of waste batteries can be prevented by the customs. If there is a bar code put on the battery bodies, the problem of cheating free riders may be avoided.

## 6.4 Information and Public Participation

According to the survey presented in Section 3.3.2, the public commonly has less knowledge and concern of waste batteries. Lacking information is regarded as a barrier for collection of waste batteries. **Environmental education**, **public information** and **public participation** should be considered by the authorities and NGOs. The government, producers and NGOs could try to bring environmental information concerning batteries to the general public.

Changing the consumption behavior could be a special emphasis of environmental education. Evidently, the environmental education can influence the consumers to choose environmentally friendly batteries, or 'green batteries'.

In fact, some stakeholders have carried out activities for environmental education. As mentioned in Section 3.3.1, Desay, the big battery manufacturer, includes an environmental guidebook in their product package, in order to provide more environmental knowledge. Another case is that the environmental knowledge of waste batteries is introduced in the textbook at primary schools in Beijing, and many pupils join in the voluntary collection of waste batteries.

[180] Langrová, Veronika. (2002). *Comparative analysis of EPR programmes for small consumer batteries: Case study of the Netherlands, Switzerland and Sweden.* Lund, Sweden: IIIEE. P.71

# 7. Conclusions

This chapter highlights the main findings of this study. Finally, suggestions for future research are presented.

## *7.1 Main Findings*

In this study, the current status of the Chinese battery sector is analyzed, and the existing policies as well as the Technical Guide on Waste Battery Management are discussed. Based on the analysis of the policies on waste batteries, some additional policies are suggested, with the purpose to contribute to the policy development.

### 7.1.1 Rising Environmental Problems of Waste Batteries

The environmental problems from waste batteries have undoubtedly been rising in China. It is difficult to estimate the amount of discarded hazardous waste batteries in the past years. These hazardous waste batteries have been treated as municipal solid waste in the past and are still so today, which could result in environmental risks in the future. In fact, there are no available practical approaches to eliminate the potential environmental risks from hazardous waste batteries discarded in the past.

China is the largest battery manufacturer and a major battery exporter. The output and consumption of batteries are rising rapidly. On the other hand, environmental policy and management are lagging behind the development of the production of the battery industry. China has not established a management system for waste batteries. Most waste batteries are going to landfill and incineration together with municipal solid waste. With the large annual consumption, the potential environmental risks from waste batteries are accelerating year by year.

The problem has aroused concern of both the government and the general public because of its close tie with the living environment. In some big cities, the public has started voluntary collection of waste batteries, and the environmental authorities show support for the voluntary activities. But there is no available approach to deal with the collected waste batteries. The urgent demand of China is to develop an effective and efficient waste battery management system. Chinese authorities have recognized that environmental problems from waste batteries will be a barrier for sustainable development.

### 7.1.2 Findings from Policies

The environmental policies of waste batteries in China have achieved their goals partially, and they obtained good results from large battery manufacturers. The policy implementation in small and medium sized plants is not satisfactory. The policy-makers and authorities should pay more attention to the environmental problems in small and medium sized plants.

Although the Technical Guide on Waste Battery Management, which is the framework for the future waste battery management system, has just been released, some highlights of future waste battery management system could be found. The technical guide pays more attention to the collection, recycling, and final disposal of waste batteries and it pays special attention to the management of waste lead-acid batteries.

China has for the first time set the collection responsibility of waste collection on producers. It is regarded as an important step that China incorporates the successful experience in environmental management and policy from industrial countries into its policies. In the technical guide, much environmental experience from industrial countries is considered, especially the experience from Japan and member states of EU.

The technical guide introduces strict requirements for the future waste battery management system. It is believed that the strict requirements could be drivers to force the battery industry towards sustainable development.

According to the analysis in previous chapters, the policy implementation met many problems, like local protectionism, and unregistered plants. It is expected that the new released technical guide could meet similar problems in the process of implementation.

### 7.1.3 Long Term for Sustainable Development

It should be recognized that the general status of waste battery management in China is not good, especially for the environmental performance of small and medium sized plants. The current rapid growth of the battery industry in China is based on the low efficiency of consumption of natural resources and environmental pollution. China is facing the problems of shortage of zinc mines and mercury mines. On the other hand, the waste batteries contain metals that are posing potential environmental risks.

Establishment of a waste battery management system is in urgent demand in China. Although the environmental authority has released the Technical Guide on Waste Battery Management, it is facing a series of problems. Financing is the first problem. The producers take the responsibility of collecting waste secondary batteries and button cells, but it is not clear who will finance the recycling and final disposal. The second problem is the 'hen and egg question'. Without collection system, the recycling plants cannot stay in operation; without recycling plants, there is no suitable approach to deal with the collected waste batteries. The third problem is that the public has low environmental knowledge and concern for waste batteries. These problems are the barriers for battery industry to advance towards sustainable development.

Based on the information and analysis in this study, the author thinks it must be a long-term task for China to set up an effective waste battery management system. The waste battery management system is a necessary precondition for the sustainable development of the battery industry.

## *7.2 Suggestions for Future Research*

In this study, some interesting and valuable questions have not been analyzed deeply. The author presents these questions and hope that they could be considered for future research.

In this study, the discussion mainly focuses on the status in urban areas. It is a fact that urban regions are only a small part of China. The rural regions should not be forgotten when we discuss any question in China, since more than 0.87 billion people live in rural regions in China (the total population is 1.264 billion in 2000).[181] The author recognized that the

[181] China Population. (2001). *The statistics of world population in 2000*. [Online]. Available: http://www.chinapop.gov.cn/population/population_detail.asp?populationID=640. (August 13, 2003). (Chinese)

potential environmental risks of waste batteries in rural areas are more serious than in urban areas.

In most rural regions, there is no waste management system. Commonly, the household waste is stacked in fields, at riversides and lakesides, including the hazardous waste batteries. Since the rural people have lower purchasing power, they mainly use the high mercury containing primary batteries like the high mercury zinc-carbon battery[182], which is cheaper than mercury free battery and a secondary battery. The stacked waste batteries could release hazardous substances into the environment, bringing potential risks to human health through water, air, and the food chain. Unfortunately, Chinese authorities have no plan to establish a waste management system in rural regions in the near future. The author strongly suggests that policy-makers and environmental researchers should consider the waste battery management in rural regions.

[182] Wang, Qi, Dong, Lu, Nie, Yongfeng, Li, Jinhui, Wang, Jinliang, Li, Xia & Wu, Shaoping. (2002). *The Introduction to the technical guide on waste batteries management.* [Online]. Available: http://www.crra.com.cn/zcyj-fdc.htm. (July 4, 2003).(Chinese)

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## Personal Communication

**Telephone Interview**

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# Abbreviations

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| BBS | Bulletin Board System |
| CBIA | China Battery Industry Association |
| EPA | Environmental Protection Agency (United States) |
| EPBA | European Portable Batteries Association |
| EPR | Extended Producer Responsibility |
| IIIEE | The International Institute for Industrial Environmental Economics |
| NGO | Non-Government Organization |
| OECD | Organization for Economic Co-operation and Development |
| SEPA | State Environmental Prevention Administration (China) |
| SETC | State Economic & Trade Commission |
| UNIDO | United Nations Industrial Development Organization |