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E-WASTE MANAGEMENT IN DEVELOPING COUNTRIES THROUGH LEGISLATION AND REGULATIONS:
A CASE STUDY OF CHINA

By

Jing Ye, BSc (Eng), MSc (Eng)

A Doctoral Thesis Submitted in Partial Fulfillment of the Requirements for the Award of Doctor of Philosophy of Loughborough University

May 2008

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Dedication

This thesis is dedicated to my mother and father, whose patience and precious love have supported me in completing this research. Dedicated to my brother and sister-in-law, who help me both spiritually and financially during the period of this research. Dedicated to my lovely nephew who brings all the happiness to our whole family. I would also like to dedicate this thesis to my uncle, Ye Yongding, who passed away during the period of this research. Hope he would be proud of me.
Acknowledgements

I would like to express my gratitude to all those who gave me help and support to complete this research work and thesis both at Loughborough University and in China. I am deeply indebted to Dr. Mansoor Ali for his guidance, advice and useful comments for the first two and half years of the research process. Dr. Ali’s suggestions helped me to complete the whole research design and the fieldworks for data collection. His kindness made it easy to discuss issues relating to the research as and when they arose. I would also like to thank my supervisors, Mr. Ian Smout and Dr. Sam Kayaga, who helped me to finish my research work and made extremely useful comments on the drafts of this thesis. Special thanks go to the staff at the Water, Engineering and Development Centre (WEDC) and colleagues in Civil and Building Department of Loughborough University, particularly Mrs. Tricia Jackson for helping me immensely both in identifying the relevant literature in the Resources Centre and in proof reading the thesis.

I would also like to thank Mr. Zhou Yugang from Guohuan Environmental Engineering Design and Research Institution of Tsinghua University, Beijing, for helping to collect all Chinese journal papers and updating the information.

A number of people in China helped me during the data collection phase. I am particularly thankful to all the interviewees who took part in the research as informants. I would like to thank Mrs. Bai Yuehua, Mr. Xing Shaowen and Mr. Wei Wen who helped me to contact most of the interviewees in Shanghai; Mr. Xuyi, Mrs. Xu Lijie, Miss Zhang Yan, Mrs. Huang Manhong, and Mrs. Huang Yi, who helped me to contact the informants in universities and relevant institutions. In particular, I would like to thank Mr. Wu Weibo who was always willing to discuss this research with me and provided useful information.
Abstract

E-waste is an emerging issue driven by the rapidly increasing quantities, the hazards involved and the valuable materials in it. Due to a lack of environmentally sound technologies or equipment and the imperfect e-waste management system, the poor quality e-waste recycling and disposal methods commonly practiced in developing countries now have serious and hazardous effects on the environment and the workers'/residents' health. Additionally, industrialized countries are exporting increasing quantities of e-waste to developing countries, complicating the situation further. The environmental and health issues caused by e-waste in developing countries have resulted in the search for solutions to address this problem before it becomes worse.

The main purpose of this research is to find how legislation and regulations be used to improve management of e-waste in developing countries especially studying a case in China on e-waste management, which is a very helpful example to other developing countries which are also facing the same e-waste issue. A case study methodology was used in this research. To collect data, semi-structured interviews with officers or experts from key relevant government departments/institutions involved in e-waste management/regulation, from electronic appliance producers, from customers at different levels of the value chain, as well as direct and non-participant observations were carried out in six cities of China. For another perspective, the review of relevant departmental documents/publications was also carried out to multiply the source of data. In this case study the analysis relies largely on qualitative data and interpretive methods, applied to what was found in interviews/observations and what is written down in documents/ literatures.

The research found that lack of systematic and enforceable law and regulations has become the most serious obstacle in the e-waste management system and limited the
effective control of e-waste in developing countries. Developing subsidiary regulations and standards could support the enforcement of the main national law and regulations on e-waste management and it could further urge the development of local regulations to improve the enforceability of the national law and regulations. Identifying the principal administrative department and coordinating the cooperation of various departments could avoid the duplication of administrative functions among government departments. It is important to construct monitoring systems to supervise the enforcement of the regulations and construct the standards and registration system to qualify the e-waste recycling and disposal enterprises, the secondhand market of electronic products and the regenerative resources market of reusable materials in e-waste. The economic differences made it possible to formulate special regulations for economically backward areas compared to the more advanced areas even within one country. Improving the existing e-waste recovery system and regulating the payment system according to the local economic conditions for e-waste recycling and disposal could improve the integrated management of e-waste. Producers as well as government and even consumers should be responsible for e-waste together. The government needs to continuously strengthen regulatory systems to ensure that the huge economic benefits from the e-waste recycling industry are not overshadowed by the negative impact on the workers’/residents’ welfare and overall environmental sustainability.

Key Words: e-waste, e-waste management, e-waste recycling and disposal, legislation system, laws and regulations, administrative institutions, environment, and China
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Acronyms

APME  Association of Plastics Manufacturers in Europe
AQSIQ  General Administration of Quality Supervision, Inspection and Quarantine of the P.R China
BAN  Basel Action Network
BCRC  Basel Convention Regional Centre in China
BFRs  Brominated flame retardants
CCIA  China Computer Industry Association
CCICED  China Council for International Cooperation on Environment and Development
CCP  Chinese Communist Party
CCTV  China Central Television (the national television network of the P.R China)
CFC  Chlorofluorocarbon
CGA  General Administration of Customs of the P.R China
CIC  China Inspection Company Limited
CPUs  Central processing units
CRTs  Cathode ray tubes
DRCs  Development and Reform Commission
EEA  European Environment Agency
EHS  Environment, Health and Safety
EIA  Energy Information Administration, Official Energy Statistics from the US Government
Empa  Swiss Federal Laboratories for Materials Testing and Research
ENVICO  Korea Environment and Resources Corporation
EPA  Environmental Protection Agency
EPBs  Environmental Protection Bureaux
EPR  Extended Producer Responsibility
EPS Canada  Electronics Product Stewardship Canada
ERP  European Recycling Platform
ETC/RWM  European Topic Centre on Resource and Waste Management
EU  European Union
GOV  Central People's Government of the P.R China
HCFC  Hydro chlorofluorocarbon
HFC  Hydro fluorocarbon
HKPC  Hong Kong Productivity Council
ICSG  International Copper Study Group
ISWM  Integrated Solid Waste Management
LCDs  Liquid crystal displays
MII  Ministry of Information Industry of the P.R China
MoEF  Ministry of Environment and Forest, Govt. of India
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<td>MOFCOM</td>
<td>Ministry of Commerce of the P.R China</td>
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<td>MST</td>
<td>Ministry of Science and Technology of the P.R China</td>
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<td>MSW</td>
<td>Municipal Solid Waste</td>
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<td>NDRC</td>
<td>National Development and Reform Commission of the P.R China</td>
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<td>NEPSI</td>
<td>National Electronics Product Stewardship Initiative in the USA</td>
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<td>NGOs</td>
<td>Non-governmental Organizations</td>
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<td>OECD</td>
<td>Organization of Economic Cooperation and Development</td>
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<td>OEMs</td>
<td>Original Equipment Manufacturers</td>
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<tr>
<td>PAHs</td>
<td>Polycyclic aromatic hydrocarbons</td>
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<td>PBBs</td>
<td>Polybrominated biphenyls</td>
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<tr>
<td>PBDDs</td>
<td>Polybrominated dioxins</td>
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<td>PBDEs</td>
<td>Polybrominated diphenyl ethers</td>
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<tr>
<td>PCB</td>
<td>Polychlorinated biphenyl</td>
</tr>
<tr>
<td>PDAs</td>
<td>Personal digital assistants</td>
</tr>
<tr>
<td>PIC</td>
<td>Prior Informed Consent</td>
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<tr>
<td>POPs</td>
<td>Persistent Organic Pollutants</td>
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<td>PRCEE</td>
<td>Policy Research Centre for Environment and Economic in SEPA</td>
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<td>PVC</td>
<td>Polyvinyl chloride</td>
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<tr>
<td>RMB</td>
<td>Renminbi (Chinese Yuan)</td>
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<tr>
<td>RoHS</td>
<td>Restriction on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment</td>
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<td>SAFEL</td>
<td>Swiss Agency for the Environment, Forests, and Landscapes</td>
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<td>SAIC</td>
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<td>SECO</td>
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<td>WCED</td>
<td>World Commission on Environment and Development</td>
</tr>
<tr>
<td>WEDC</td>
<td>Water, Engineering and Development Centre, Loughborough University, UK</td>
</tr>
<tr>
<td>WEEE</td>
<td>Waste from Electrical and Electronic Equipment</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WRI</td>
<td>World Resources Institute</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
</tr>
<tr>
<td>ZETC</td>
<td>Zhejiang Provincial Economic and Trade Commission (P.R China)</td>
</tr>
</tbody>
</table>
Chapter 1 Introduction

1.1 General

Sustainable development has been a major international concern especially since the Earth Summit held in Rio de Janeiro, Brazil, 1992. As one of its main achievements, Agenda 21 addressed the pressing problems of the day and also aimed at preparing the world for the challenges of the future. It reflected a global consensus and political commitment at the highest level on development and environment cooperation (UN, 1992).

'Sustainable development implies a broad view of human welfare, a long term perspective about the consequences of today's activities and the full involvement of civil society to reach viable solutions (OECD, 2001a)'. How to deal with the relationship between socio-economic development and environmental protection has become an urgent issue both in industrialized countries and in developing countries. Sustainable development takes into account the economy, society and environment in an integrated way and involves meeting the present needs of humans without endangering the welfare of future generations.

Environmental sustainability is an important component of sustainable development. The implementation of environmental sustainability is to minimize environmental pollution and to protect human health. Many of the world's industrialized countries in the early stages of development have caused serious environmental pollution, which has happened in developing countries as well. With the rapid development of their economies, all the countries are confronted with shortages of natural resources and energy, environmental degradation, lack of infrastructure construction, unemployment...
and risks to human health (UNCHS, 2001). One of the serious consequences of economic and social development is the continuous growth of waste especially the solid waste.

The problem of solid waste is faced by both the industrialized and developing countries. The continued increasing quantities of solid waste, the more complex composition and its negative impact on the environment and human health have resulted in searches for solutions to control this problem. The proper management of solid waste needs appropriate technologies and should also be socially accepted and environmentally sound. Agenda 21 addressed the issue of environmentally sound management of solid waste and emphasized the four major waste-related programme areas, which are: (a) minimizing wastes; (b) maximizing environmentally sound waste reuse and recycling; (c) promoting environmentally sound waste disposal and treatment; and (d) extending waste service coverage to all urban and rural areas. With special regard to hazardous waste, the Agenda focused on: (a) promoting the prevention and minimization of hazardous waste; (b) strengthening institutional capacities in hazardous waste management; (c) promoting and strengthening international cooperation in the management of transboundary movements of hazardous wastes; and (d) preventing illegal international traffic in hazardous wastes (UN, 1992).

Although the universal Agenda was targeted to all countries, both industrialized and developing, the solid waste management problems in developing countries are quite different from those in industrialized countries, generally because of the social, economic and institutional situations (UNEP, 2000). In industrialized countries since the society is much more aware of the importance of environmentally sound management of solid waste, there are comprehensive legislation systems and enforceable regulations to control solid waste. The solid waste collection and disposal systems have been constructed and the concept of waste reducing, reusing and recycling is well understood and accepted. The challenge on solid waste management
in industrialized countries involves identifying more efficient and economic waste collection programmes, establishing new partnerships with communities and the private sector, and developing new economic policy instruments, such as recycling credits, landfill disposal tax and product charges (WRI, 1997). But in developing countries the solid waste collection and disposal systems are still largely uncontrolled and the environmentally sound management of solid waste is often given low priority in the socio-economic development process (Kassim, 2006). Rapid population growth, fast urbanization, shortage of public infrastructure and services, limited financial support, lack of technologies and equipment, inefficient or inappropriate use of available equipment and lack of public awareness are some of the reasons for inadequate solid waste management in developing countries (Pfammatter and Schertenleib, 1996 and Zerbock, 2003). Weak and outdated institutional patterns as well as ineffective legislation systems have also caused the failure of environmentally sound solid waste management in developing countries (Jindal et al., 1997 and van Beukering et. al., 1999). All of these lead to the search for environmentally sound management of solid waste in developing countries from a different perspective to the industrialized ones and on the basis of the conditions on the ground.

Over the last two decades technological advances in electronic data management and communications have spurred economic growth and improved people's lives in countless ways both in industrialized and developing countries. However, the rapid growth of the electronics industry and the growing dependence on electronic products both at home and in the work place have given rise to a new environmental challenge: electronic waste (e-waste). E-waste has affected the solid waste stream in a noticeable manner through the successive addition of new kinds of waste and informal e-waste recycling has further complicated the problems associated with solid waste management. Besides the fastest growing quantity, another issue of concern is that e-waste contains many hazardous substances. Due to the hazards involved, disposing and recycling e-waste has serious health, environmental and legal implications. If disposed improperly, e-waste will result in serious environmental pollution.
Additionally, there are also many valuable materials in e-waste which have a high economic value and could be recycled by proper technologies. Therefore environmentally sound recycling and disposal of e-waste has the potential to get high economic returns.

In industrialized countries governments have recognized the seriousness and urgency of the e-waste issue and have been building a meaningful response to this crisis. Many countries have enacted national e-waste legislation to regulate the manufacturers’ and importers’ responsibility for the collecting and recycling end-of-life electrical and electronic products. In developing countries informal recycling and disposal of e-waste has caused serious environmental pollution and affected the workers’ and residents’ health. Irresponsible exporting of e-waste by industrialized countries, as well as the increasing domestic quantity, has made e-waste management in the developing countries more complicated. The imperfect e-waste management system in developing countries has limited the effective control of e-waste. This research aims to find how the legislation and regulation can be used to improve e-waste management in developing countries through a case study of China. In particular, this research has identified the deficiencies in the legislation framework for e-waste management and the existing problems during the enacting and implementing process of legislation and regulations. The implications from the findings of this research could be valid in other developing countries which meet similar e-waste problems.

1.2 Background of the topic

The electronics industry is one of the largest and fastest growing manufacturing industries globally and, as a consequence of this growth, combined with rapid product obsolescence, e-waste has become the fastest growing waste stream. This waste stream covers a broad and growing range of obsolete electrical and electronic equipment, from household appliances, such as obsolete televisions, refrigerators and
Chapter 1 Introduction

air conditioners, to small entertainment electronics, such as video cassette recorders (VCRs), MP3 players and personal digital assistants (PDAs). It also includes the most popular used computers, mobile phones and other electronic components and accessories after they have been discarded. Considering only PCs, in 1994 it was estimated that approximately 20 million PCs became obsolete throughout the world. By 2004, this figure was to increase to over 100 million PCs, which means that about 500 million PCs reached the end of their lives in the period from 1994 and 2003 (Widmer et al., 2005). Obsolete PCs are only a fraction of all e-waste. The growing quantity of e-waste is beginning to reach disastrous proportions and all the industrialized countries are beginning to deal with the problem. Many countries have enacted national e-waste legislation to regulate the producers who collect and recycle e-waste, and to phase out the hazardous materials used in electronic products. Some multinational companies in the electronics industry have already instituted take-back programmes in some areas to recover their obsolete products (European Recycling Platform, 2005). The European Union (EU) Parliament issued two directives in February 2003, WEEE (Waste from Electrical and Electronic Equipment) and RoHS (Restriction on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) which set a standard for global e-waste management and have had an immediate global impact on the electronics industry.

At the same time, although compared with industrialized countries the volume of e-waste is not very huge and little reliable data are available, this problem cannot be ignored. Firstly, e-waste has now become the fastest growing waste stream in some developing countries as well. In India alone, it was estimated that until 2002 about 1.38 million PCs per year were discarded from the business sector and individual households, while 1,050 tons of e-waste was produced by manufacturers and assemblers annually (Toxic Link, 2003). Secondly, due to inadequate professional capacity and lack of environmentally sound technologies to dispose and recycle e-waste, the processes utilized in developing countries such as China, India and Pakistan are relatively primitive and extremely polluting. In some small-scale e-waste
dismantling factories and household work-sheds, workers use simple and even primitive methods to dispose of e-waste, such as open burning of circuit boards and plastic waste, exposure to toxic solder, acid operations in enclosed premises with inadequate ventilation, river dumping of acids and widespread general dumping; all of these processes are extremely polluting and harmful to workers’ and residents’ health (Basel Action Network and Silicon-Valley Toxics Coalition, 2002).

Good solid waste management practice often leads to economic benefits. Although e-waste is hazardous, if recycled properly some or all of its components may be used as replacement for raw materials and components required in the growing electronics industry and other manufacturing industries. Since most developing countries are resource-poor countries, e-waste recycling and disposal can play a role in the comprehensive utilization of resources. Presently, the unregulated recycling and disposal process of e-waste utilises backward technologies, and can only recover the most precious and easily extracted materials such as gold plating, copper wiring and lead solder. Other valuable materials, such as platinum, cadmium, and barium are discarded, which is not only wasteful, but also extremely polluting to the environment.

On the other hand, industrialized countries export e-waste to the developing countries, in the name of donations, reuse or recycling. Such ‘exports’ have aggravated the e-waste problem in developing countries. Besides handling their own rapidly growing e-waste, developing countries now also have to manage the e-waste being dumped within their national boundaries by industrialized countries, to the extent that e-waste management is becoming a critical issue in developing countries.

Unlike the sophisticated collection, transportation, sorting, dismantling, recycling, disposal and legislation systems in industrialized countries, the e-waste management system in developing countries is still in the early stage of development. The existing legislation and regulation system could not support the effective control of e-waste in developing countries. The e-waste management system is self-organized and market-
driven simultaneously (Desrochers, 2004), which has caused serious environmental pollution and health hazards. To address the issue of e-waste and to comply with the regulations of industrialized countries, some developing countries have formulated and drafted several laws and regulations to manage e-waste while their enforcement remains questionable (Sinha-Khetriwal et al., 2005).

The main drivers for improving e-waste management in China are adverse publicity, awareness of pollution and health problems, and requirement for competing in the domestic and international market. In China the national government and the general public paid more attention to the effective e-waste management after the environmentally unsound activities in Guiyu and Taizhou two areas were reported in 2002 by media. From then on several national level legislations which were built on and strengthened the earlier regulations had been drafted or came into force in response to the perceived problems caused by e-waste in China, such as the serious environmental pollution and health damage. To compete in the domestic markets for electrical and electronic products as well as the international ones, producers in electronics industry also showed supportive attitudes to effective e-waste management although the increasing cost for improving product design, phasing out hazardous materials and recycling or disposal of e-waste will have to be given priority consideration.

However, the stakeholders of the existing private small-scale dismantling factories or family work-sheds for recycling e-waste showed negative attitudes to e-waste management because they care more about economic profits than environmental or health protection. Local governments under the provincial (autonomous regional and municipal) level became the barriers to the effective e-waste management reflected by the lack of practical activities to implement relevant regulations. Economic development is considered the main priority by most local governments.
1.3 Justification for the research

E-waste is becoming a serious issue in developing countries, driven by the rapidly increasing quantities, as well as its toxic nature and the economic value of the recycled substances. In the long term the accelerated development of the electronics industry in developing countries, together with the associated high accumulation of e-waste will become a heavy burden on the solid waste management system in these countries. Since the materials in e-waste actually have a high economic value and many countries face a shortage of resources, it is important to carry out proper recycling plans and formulate relevant regulations to effectively manage e-waste, from both the national economic and sustainable development perspectives.

The regulations on e-waste management in industrialized countries have affected the whole electronics industry. To compete and survive in the international market for electrical and electronic products, the producers in developing countries have to comply with the standards of industrialized countries. The recycle rates for e-waste in industrialized countries have not gone unnoticed by the governments in developing countries.

Additionally, limited by the economic development and the unbalanced situation between urban and rural areas in developing countries, there is a broad secondhand market for the used electronic products and components. If the secondhand market is well regulated, electronic products which have been discarded by higher-income consumers can satisfy the needs of the low-income households at affordable prices, and contribute to the national economy. The policies of the government could also affect the awareness of the public and guide them towards participation in an environmentally sound e-waste recycling system.

Considerable research has already been undertaken by research institutions in developing countries on dismantling, sorting, reusing and recycling technologies, such
as how to effectively dismantle the printed circuit boards to get precious metals. But not much work has been done in developing countries on the study of legislation and regulations of e-waste management. From the literature review (section 2.4.4 and section 2.6), lack of regulations and lax enforcement have obstructed the effective management of e-waste in developing countries. On the other hand, there are other kinds of solid wastes in developing countries such as packaging waste, waste tyres and plastic waste which have similar characteristics to e-waste, both containing hazardous materials and economically valuable recycled substances. All the above reasons have made it necessary to understand more closely about how the legislation and regulations can be used in developing countries to improve the management of e-waste. The findings and implications of this research will have practical significance for improving the e-waste management system in developing countries as well as providing references to other solid waste management areas.

1.4 Purpose of the research and research questions

1.4.1 Purpose of the research

The main purpose of this research is to find how legislation and regulations can be used to improve management of e-waste in developing countries and especially in the case of China. In order to achieve this aim, this research focuses on the legislation framework of e-waste management and the implementation of legislation, as well as the links between these and the administrative institutions.

1.4.2. Primary research question

How can legislation and regulations be used to improve the management of e-waste?
1.4.3 Specific research questions:

After undertaking the literature review (chapter 2), the following specific research questions were identified:

- What deficiencies exist in the legislation for effective e-waste management in China?
- How are regulations on e-waste in China enforced and monitored?
- What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?
- What effects do the regulations have on e-waste management?

Sections 3.2 and 3.3 in chapter 3 give the detailed explanation of objectives and specific research questions guiding the thesis.

1.5 Scope of the research

This research limits itself to the legislation and regulations on e-waste management in developing countries, highlighting the deficiencies in the legislation framework for e-waste management and the existing problems during the enacting and implementing process of legislation and regulations, as well as the links between these and the administrative institutions. Legislation and regulations are an important instrument for improving e-waste management in developing countries, in setting standards and in overcoming barriers such as the reluctance of both producers and local governments to spend money on environmental protection. Other important instruments are financial measures, education and media publicity. These are not the focuses of this thesis, but some examples of these were identified during the research and included in the thesis.

E-waste in this research refers to all wastes of electrical and electronic equipment as a single category, unless the special definition in relevant regulations. The research also
Chapter I Introduction

acknowledges that there are other influences on e-waste legislation that can limit or support the effective management of e-waste, and here are restricted to the following main factors which were identified during the interviews:

- The industrialized countries' legislation or policies
- The recycling system for e-waste including: the recovery system of e-waste; the secondhand market; the regenerative resources market for reusable materials in e-waste; and the registration of recycling and disposing enterprises
- The pilot projects on e-waste recycling and disposal
- Public attitudes (producers' and consumers') on e-waste legislation

This research is based on a case study of China and therefore has the accompanying limitations associated with generalizing from the findings. The implications from the findings of this research are specific to the case study area - China, but could also be valid in other developing countries which meet similar e-waste problems and are at the same early stage of e-waste management.

1.6 General background of China

The People's Republic of China is a one-party state with the Chinese Communist Party (CCP) having been in power since 1949. Due to China's large population and area, the political divisions of China have consisted of several levels. The country is administered through 34 province-level regions, including 23 provinces, 5 autonomous regions, 4 municipalities and 2 special administrative regions; 333 prefecture-level regions; 2,862 county-level regions; 41,636 township-level regions; and close to a million village-level regions (State Statistic Bureau, 2007). The capital city is Beijing, where the national government is located. The State Council is at the top of the national administrative unit, then following the commissions, ministries, bureaux within ministries and so forth. Provincial governments are the same bureaucratic rank as ministries, and provincial bureaux share the same rank as their
ministerial counterparts. Together with municipalities, autonomous regions, and the special administrative regions, provinces make up the first level of administrative division in China.

The economy has been growing rapidly over the last several years in China and it has become increasingly market-oriented economy, with a dominant manufacturing sector, although a large part of the population is still dependent on farming. The accession of China to the WTO in 2001 has accelerated the pace of reforms in the whole country, and Chinese companies are increasingly targeting global markets by moving up in the value chain. But with over a billion people, economic disparities are wide and increasing, especially the urban-rural difference. This is responsible for a large influx of migrants from the farms to the cities.

Since 1990, the Chinese government has been strengthening legislation on natural resource protection and environmental protection. Impressive environmental laws and regulations have been adopted; a dedicated environmental bureaucracy extends from Beijing down through the provinces, cities, and counties to the township level; and China participates actively in the global environmental community. It is one of the signatories of the Basel Convention and has issued several directives with regards to pollution prevention and control. The government has stressed the need to implement the strategy of sustainable development, intensifying law enforcement to strengthen ecological and environmental control, and promoting recycling and clean production.

1.7 Overview of methodology

In this research a case study methodology was used. To collect primary data, in 2005 and 2006 interviews with officers or experts from key relevant government departments and institutions involved in e-waste management/regulation, from electronic appliance producers, from customers at different levels of the value chain,
as well as direct and non-participant observations were carried out in six cities of China i.e. Beijing, Shanghai, Tianjin, Lanzhou in Gansu Province, Guangzhou and Shenzhen in Guangdong Province (Map 3.1). The key informants included officers in State Environment Protection Administration (SEPA) and in local environmental protection departments, authorities in environmental science or engineering departments of universities, and engineers in environmental engineering design institutions. Little other data are available, except for case study. For another perspective, a review of relevant departmental documents and publications was made to widen the scope of this research; this helped to increase the background knowledge of e-waste, the environmental and health issues arising from it and the detailed situations of the present legislation and management system on e-waste management. In this case study the analysis was more reliant on qualitative data and interpretive methods, based on information found in interviews/observations and what was written down in documents/literature. The main analysis methods included both vertical and horizontal comparison to develop explanations and then draw the conclusions. The detailed methodology for this research is explained in chapter 3.

1.8 Research process

The whole research process is illustrated as below in Figure 1.1.
Chapter 1 Introduction

Choose a topic as well as research issues, including problem statement

Literature review

Methodology and tools of data collection

Design general fieldwork plan

Data collection

Primary sources, including semi-structured interviews and observations

Secondary sources, mainly from documents and literature

Processing data and analysis

Conclusion

Writing a research report

Figure 1.1 Research process

1.9 Structure of the thesis

This thesis has been structured to provide a logical order of literature review, results from the fieldwork findings, conclusions and recommendations. Chapter 1 introduces the background of the e-waste issue, the justification, the scope and the context of this research. Chapter 2 reviews the basic information and the background knowledge of e-waste, such as the definition, the sources, the characteristics and the hazardous impact on humans and environment of e-waste; also the general situation of the current legislation and management systems on e-waste in both industrialized and
developing countries, especially in China. The methodology of this research including the objectives and data collection methods is explained in chapter 3. Chapters 4 and 5 describe the results from documents/literature and the results from interviews/observation in fieldworks respectively. Chapter 6 presents the discussions of the results based on the previous two chapters and refines into the implications of this study. Chapter 7 concludes the thesis with a summary of major conclusions and recommendations for further research.

1.10 Summary

E-waste is an emerging issue in developing countries. Its significance is driven by the rapidly increasing quantities, the hazards involved and the valuable materials in it. The poor quality e-waste recycling and disposal methods commonly practised in developing countries have serious and hazardous effects on the environment and the workers'/residents' health. Additionally, industrialized countries are exporting e-waste to developing countries, complicating the situation further. The relevant government needs to strengthen regulatory systems to ensure that the huge economic benefits from the e-waste recycling industry are not overshadowed by the negative impact on the workers'/residents' welfare and overall environmental sustainability. In response to the growing concern on e-waste, the government and other policy-making agencies in developing countries are continuously strengthening the legislative and institutional framework for regulating importation and industrial activities in e-waste recycling and disposal. This research focuses on the enactment and implementation of legislation by identifying the deficiencies in the legislation framework for e-waste management and the existing problems during the enacting and implementing process of legislation and regulations. The implications from the findings of this research are specific to the case study area - China, but could also be valid in other developing countries which meet similar e-waste problems and are at the same early stage of e-waste management.
Chapter 2 Literature Review

2.1 Introduction

This literature review covers the basic information and background knowledge on e-waste, such as the definition, sources, characteristics and its impact on humans and the environment. The general situation of the present legislation and management systems for e-waste in both industrialized and developing countries, especially in China, is introduced. By analyzing the existing documents and literature about e-waste and comparing the differences between e-waste legislation and management in industrialized and developing countries, problems on e-waste management in developing countries and in China can be found; then the specific research questions which were not answered by previous research are identified. In this literature review the main literature sources are the journals listed in Appendix 1 which were found to be very useful in providing published academic articles in e-waste management. These journals include both English ones and Chinese. The worldwide web pages of some international organizations provided useful specific information and data which are listed in Appendix 2. Some of these web pages contained published academic papers and reports that can be downloaded free of charge. In particular, most statistics and the information about regulations relating to China were obtained from the Chinese government websites which are also listed in Appendix 2.

2.2 The background of e-waste

2.2.1 The definition of e-waste

Electronic waste or e-waste has been the most rapidly growing solid waste problem in
the world. It is a collective name for discarded electronic equipment that enters the waste stream from various sources. It includes a broad and growing range of electrical and electronic equipment, such as obsolete computers, televisions and monitors, mobile phones, personal digital assistants (PDAs), video cassette recorders (VCRs), MP3 players, fax and copying machines, air conditioners, refrigerators and other electronic applications, products, components and accessories. There is no standard definition at present. Different countries or organizations have listed different categories of e-waste according to their own standards. Table 2.1 lists five selected definitions of e-waste, among which is the definition in the WEEE Directive of the EU that seems to be in the process of becoming a widely accepted standard.

Table 2.1 Selected definitions of e-waste

<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU WEEE Directive (EU, 2003a)</td>
<td>“Electrical or electronic equipment which is waste...including all components, sub-assemblies and consumables, which are part of the product at the time of discarding.” Directive 75/442/EEC, Article 1(a) defines “waste” as “any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force.”</td>
</tr>
<tr>
<td>Basel Action Network (Puckett and Smith, 2002)</td>
<td>“E-waste encompasses a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users.”</td>
</tr>
<tr>
<td>OECD (2001b)</td>
<td>“Any appliance using an electric power supply that has reached its end-of-life.”</td>
</tr>
<tr>
<td>Sinha (2004)</td>
<td>“An electrically powered appliance that no longer satisfies the current owner for its original purpose.”</td>
</tr>
<tr>
<td>StEP (2005)</td>
<td>E-waste refers to “…the reverse supply chain which collects products no longer desired by a given consumer and refurbsishes for other consumers, recycles, or otherwise processes wastes.”</td>
</tr>
</tbody>
</table>

2.2.2 The composition of e-waste

When disposed of in a landfill, e-waste becomes a conglomeration of plastic and steel casings, circuit boards, glass tubes, wires, resistors, capacitors, fluorescent tubes from
flat panel displays, and other assorted parts and materials. Given the diverse range of materials found in e-waste, it is difficult to give a generalized material composition for the entire waste stream. However, most studies examine five categories of materials in e-waste which are ferrous metals, non-ferrous metals, glass, plastics and "other". The major materials and components in e-waste are shown in Table 2.2 (Cui and Forssberg, 2003).

Table 2.2 Major materials and components in e-waste

<table>
<thead>
<tr>
<th>Materials and components</th>
<th>Description of hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries</td>
<td>Heavy metals such as lead, mercury and cadmium are present in batteries</td>
</tr>
<tr>
<td>Cathode ray tubes (CRTs)</td>
<td>Lead in the cone glass and fluorescent coating covering the inside of panel glass</td>
</tr>
<tr>
<td>Mercury containing components, such as switches</td>
<td>Mercury is used in thermostats, sensors, relays and switches (e.g. on printed circuit boards and in measuring equipment and discharge lamps); it is also used in medical equipment, data transmission, telecommunication, and mobile phones</td>
</tr>
<tr>
<td>Asbestos waste</td>
<td>Asbestos waste has to be treated selectively</td>
</tr>
<tr>
<td>Toner cartridges, liquid and paste, as well as colour toner</td>
<td>Toner and toner cartridges have to be removed from any separately collected WEEE (Waste of Electrical and Electronic Equipment)</td>
</tr>
<tr>
<td>Printed circuit boards</td>
<td>In printed circuit boards, cadmium occurs in certain components, such as SMD chip resistors, infrared detectors and semiconductors</td>
</tr>
<tr>
<td>Polychlorinated biphenyl (PCB) containing capacitors</td>
<td>PCB-containing capacitors have to be removed for safe destruction</td>
</tr>
<tr>
<td>Liquid crystal displays (LCDs)</td>
<td>LCDs of a surface greater than 100cm² have to be removed from WEEE</td>
</tr>
<tr>
<td>Plastics containing halogenated flame retardants</td>
<td>During incineration/combustion of the plastics halogenated flame retardants can produce toxic components</td>
</tr>
<tr>
<td>Equipment containing CFC HCFC or HFCs</td>
<td>CFC present in the foam and the refrigerating circuit must be properly extracted and destroyed; HCFC or HFCs present in the foam and the refrigerating circuit must be properly extracted and destroyed or recycled</td>
</tr>
<tr>
<td>Gas discharge lamps</td>
<td>Mercury has to be removed</td>
</tr>
</tbody>
</table>

According to the European Topic Centre on Resource and Waste Management (ETC/RWM), iron and steel are the most common materials found in e-waste and account for almost half of the total weight of e-waste which is shown in Figure 2.1
Plastics are the second largest component by weight representing approximately 21% of e-waste. Non-ferrous metals, including precious metals, represent approximately 13% of the total weight of e-waste (with copper accounting for 7%) (Widmer et al., 2005). But researchers also found that over time, the metal content has remained the dominant fraction in e-waste and would be over 50%, compared with pollutants and hazardous components and materials which have seen a steady decline (Empa, 2005).

![Figure 2.1 E-waste material compositions by weight](source: European Topic Centre on Resource and Waste Management, cited by Widmer et al., 2005)

E-waste contains over 1,000 different substances, many of which are toxic, and creates serious pollution upon disposal, such as lead and cadmium in circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs); mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; brominated flame retardants on printed circuit boards, plastic casings, cables; and polyvinyl chloride (PVC) cable insulation that will release highly toxic dioxins and furans when burned to retrieve copper from
Although e-waste contains hazardous materials, if recycled properly, the materials and some of the components in it can be used as replacement of raw materials and components required in the growing electronic industry and other fields of manufacture; this means that e-waste has a high residual value. Many valuable materials in e-waste, such as precious metals gold, platinum, cadmium, and barium have a high economic value. Early generation PCs used to contain up to 4 g of gold each; however this has decreased to about 1 g today (Widmer et al., 2005). The value of ordinary metals contained in e-waste is also very high. For example, 1 ton of e-waste contains up to 0.2 tons of copper, which can be sold for about 500 euros at the current world price (Widmer et al., 2005). The Association of Plastics Manufacturers in Europe released their statistics of material consumption in electrical and electronic products in Western Europe in 1995 (APME, 1995). Relatively the composition in e-waste in Western Europe at that time was as follows: 38% ferrous, 28% non-ferrous, 19% plastics, 4% glass, 1% wood, and 10% others. In general, printed circuit board scrap contains approximately 40% metals, 30% plastics, and 30% ceramics (Linton, 2000 and Zhang and Forssberg, 1997). The typical metal scrap in printed circuit boards consists of copper (20%), iron (8%), tin (4%), nickel (2%), lead (2%), zinc (1%), silver (0.2%), gold (0.1%), and palladium (0.005%) (Sum, 1991). Polyethylene, polypropylene, polyesters, polycarbonates and phenol formaldehyde are the typical plastic components. Most of these materials are valuable and could be recycled by proper technologies. Therefore environmentally sound recycling of e-waste has the potential to get a high economic value. E-waste recycling and disposal can also play an important role in the comprehensive utilization of resources.

2.2.3 The sources of e-waste

Electronic equipment, and computers in particular, are often discarded by individual households and small businesses, not because they are broken but simply because new
technology has left them obsolete or undesirable. New software or technology is often insufficient or incompatible with older hardware or styles so that customers are forced to buy new ones. Other sources of e-waste are large corporations, institutions and government which are the earliest users of electronic products and will upgrade employee electronic equipment regularly. E-waste also comes from original equipment manufacturers (OEMs) which generate e-waste when units coming off the production line do not meet the quality standards and have to be disposed of.

In developing countries, besides domestic e-waste, another most important issue is the trans-boundary movements of e-waste from industrialized countries to these developing countries. Developing countries, especially those in Asia, have become the e-waste landfill of the industrialized world. In the Basel Action Network’s investigation in 2002 (Puckett and Smith, 2002), it was reported that millions of pounds of e-waste from obsolete computers and TVs are being generated in the U.S each year and huge amounts – an estimated 50% to 80% collected for recycling – are now being exported to Asia’s developing countries and 90% of these are exported to China. In the name of donations or reuse or recycling, industrialized countries export e-waste to developing countries. In practice it becomes an indirect way to dump hazardous e-waste on these countries. This means that besides handling their own rapidly growing e-waste, developing countries now also have to manage the e-waste being dumped by other countries.

2.2.4 The characteristics of e-waste

The rapidly growing quantity of e-waste and the hazards in e-waste are two primary characteristics which make e-waste become a worldwide problem of crisis proportions.

2.2.4.1 The quantity of e-waste

Due to the extreme rates of obsolescence, e-waste produces much higher volumes of
waste in comparison to other consumer goods. It could represent as much as 5% of municipal solid waste disposal (Silicon Valley Toxics Coalition, 1999). That is more than beverage containers, more than disposable diapers, and about the same level as all plastic packaging. But no exact data are available on how much e-waste exists in the world. In industrialized countries several methods have been suggested and used to estimate the possible quantities of e-waste globally (Lohse et al., 1998) such as the ‘consumption and use method’ (used in the Netherlands to estimate the potential amount of e-waste); the ‘market supply method’ (used by the German Electrical and Electronic Industries Association to estimate e-waste); and the Swiss Environmental Agency’s estimates based on the assumption that private households are already saturated and for each new appliance bought, an old one will have reached its end-of-life. However, the results of e-waste estimation studies are various and it is difficult to compare the studies because of the differences between the methods used and the variations in basic assumptions from one study to another (Widmer et al., 2005).

Comparatively, in developing countries because the market penetration of electrical and electronic products is not saturated, estimations of the quantity of e-waste are more complex and difficult.

But qualitatively, million of tons of computers, televisions, stereos, mobile phones, electronic appliances and toys and other electronic gadgets become obsolete every year (Franklin and Associates, 1998). Considering only PCs, in 1994, it was estimated that approximately 20 million PCs became obsolete throughout the world. By 2004, this figure was to increase to over 100 million PCs, which means that about 500 million PCs reached the end of their lives in the period from 1994 and 2003 (Widmer et al., 2005). 500 million PCs contain approximately 2,872,000 tons of plastics, 718,000 tons of lead, 1,363 tons of cadmium and 287 tons of mercury (Puckett and Smith, 2002). This fast growing waste stream is accelerating because the global market for PCs is far from saturation and the average lifespan of a PC is decreasing rapidly – for instance for CPUs from 4-6 years in 1997 to 2 years in 2005 (Culver, 2005). Obsolete PCs are only a fraction of all e-waste. Similar quantities of e-waste
are expected for all kinds of portable electronic devices such as PDAs, MP3 players, computer games and other peripherals (O'Connell, 2002). And only a small fraction of this e-waste will be properly recycled. The majority is placed into garbage and skips, and landfilled.

Presently, the United States and other industrialized countries, which have highly saturated markets for electrical and electronic equipment, use most of the world's electronic products and generate most of the e-waste. In the United States alone, experts estimate that between the years 1997 and 2007, more than 500 million computers will be obsolete (Puckett and Smith, 2002) and by the year 2005, 130 million mobile phones will be discarded, resulting in 65,000 tons of cell phone waste (Fishbein, 2002). With the success of the electronics industry, the volume of e-waste, as the by-product of an extraordinary technological revolution, is rapidly growing. According to the US Environmental Protection Agency (EPA) in 1997 more than 3.2 million tons of e-waste ended up in US landfills (Computer Takeback Campaign and Californians against Waste, 2004). In the following year 1998, the overall e-waste volume was estimated at 5~7 million tons (Puckett and Smith, 2002). The figure is projected to be much higher today. European studies estimate that the volume of e-waste is rising by 3% to 5% per year – almost three times faster than the municipal waste stream (Arensman, 2000). In the former 15 European member countries (EU15) the amount of e-waste generated varied between 3.3 and 3.6 kg per capita from 1990 to 1999, and was estimated to rise to 3.4-4.3 kg per capita from 2000 to 2010 (EEA, 2003). This figure only assessed five electrical and electronic appliances, including refrigerators, PCs, televisions, photocopiers and small household appliances, which covered just 25% of the whole e-waste produced in EU15 countries. Hence these figures correspond to estimates of total e-waste which range from 14 to 20 kg per capita (Widmer et al., 2005). It was reported that the quantity of e-waste constitutes one of the fastest growing waste fractions accounting for 8% of all municipal waste (The Economist, cited by Widmer et al., 2005). At the same time e-waste has typically affected the waste stream in a noticeable manner through the successive addition of
new kinds of waste and also has further complicated the problems associated with solid waste management.

To make matters worse, now where once consumers purchased a computer or television with the expectation that it would last for a decade or more, the increasingly rapid evolution of technology combined with rapid product obsolescence has effectively rendered everything disposable. Consumers rarely take broken electronics to a repair shop as replacement is now often easier and cheaper than repair. Then broken electronics are thrown away, which becomes an important resource of e-waste. On the other hand, many consumers, unwilling to accept that the latest and greatest electronic products they paid top dollar for just two or three years ago are already obsolete, hang on to them in hopes that maybe they will be worth something to someone or reusable for some part of them. The US EPA estimates that three-quarters of all computers sold in the United States remain stockpiled in garages, closets, or storage. Other studies estimate that the number of these unused computers in US will soon be as high as 315 to 680 million units (Computer Takeback Campaign and Californians against Waste, 2004). These statistics quite simply mean that if every consumer decided to throw out their obsolete electronics at once, the quantity of e-waste would be a major budgetary and environmental catastrophe.

The level of generation of e-waste in developing countries is lower than the one in industrialized countries. However, the increased accumulation of e-waste in the former cannot be ignored. For example, in India around 1,050 tons of e-waste was being produced by manufacturers and assemblers annually. It was estimated that until 2002 about 1.38 million PCs had been discarded from the business sector and individual households (Toxics Link, 2003). The market penetration of electrical and electronic equipment in developing countries is not very high, compared with industrialized countries, but the developing countries showing the fastest growing consumption rates will cause the generation of large quantities of e-waste domestically. Unlike those obsolete in industrialized countries, most of these obsolete
electronics are incompatible old styles which cannot cater to present needs and have almost no value for reuse. Due to inadequate professional capacity and lack of environmentally sound technologies to dispose or recycle e-waste, in developing countries e-waste also becomes a critical issue (Puckett and Smith, 2002 and Widmer et al., 2005).

2.2.4.2 The hazards in e-waste

E-waste is a crisis not only because of its rapidly growing quantity, but also because of its toxic ingredients. E-waste contains over 1,000 different substances, many of which are hazardous, such as lead, mercury, cadmium, arsenic, selenium, hexavalent chromium, polychlorinated biphenyls (PCBs), and brominated flame retardants that create dioxin emissions when burned. In Appendix 3, the table shows the hazardous materials and their effects on humans and environment, as well as the use or location of these materials in e-waste (Puckett and Smith, 2002 and Computer Takeback Campaign and Californians against Waste, 2004).

2.2.5 The hazards of improper disposing and recycling of e-waste

This section summarises literature which shows that due to the hazards involved, disposing and recycling of e-waste has serious health, legal and environmental implications. If disposed improperly, e-waste will result in serious environmental pollution. When e-waste is landfilled or incinerated, it poses significant contamination problems. Landfills leach toxins into ground-water and incinerators emit toxic air pollutants including dioxins and furans.

2.2.5.1 The hazards of landfilling e-waste

All landfills leak. Even the best “state-of-the art” landfills are not completely secure throughout their lifetimes and a certain amount of chemical and metal leaching will
occur. This situation is far worse for older or less stringent dump sites. It was reported that consumer electronics already constitute 40% of lead found in landfills in the US (Silicon Valley Toxics Coalition, 1999). In e-waste, each computer or television display contains an average of 4 pounds of lead (Microelectronics and Computer Technology Corporation, 1996). Monitor glass contains about 20% lead by weight (Minnesota Office of Environment Assistance, 1995). About 70% of the heavy metals (including mercury and cadmium) found in landfills comes from electronic equipment discards. These heavy metals and other hazardous substances found in electronics can contaminate groundwater and pose other environmental and public health risks (US EPA, 2001).

For example, lead can enter drinking water by leaching from landfills and can contaminate the clothes of workers at improperly regulated recycling plants. When mixed with acid waters in landfills, significant amounts of lead ions are dissolved from broken glass containing lead (Nordic Council of Ministers, 1995). In a landfill where certain electronic devices are easily crushed and broken, mercury and polychlorinated biphenyls (PCBs) will be released and enter the environment. When plastics containing brominated flame retardants (BFRs) like polybrominated diphenylethers (PBDEs) or cadmium are landfilled, both PBDE and the cadmium may leach into the soil and groundwater.

2.2.5.2 The hazards of incinerating e-waste

Another method of disposing of e-waste is incineration. Because of the variety of different substances found in e-waste, incineration or any burning of e-waste, such as uncontrolled fires at a landfill, is particularly dangerous. For instance, copper is a catalyst for dioxin formation when flame-retardants are incinerated. This is of particular concern, since the incineration of brominated flame retardants (BFRs) at relatively low temperature (600-800°C) may lead to the generation of extremely toxic polybrominated dioxins (PBDDs) and furans (PBDFs) (Murphy and Pitts, 2001). PVC
(polyvinyl chloride) used in many electronic products, when burned, creates the toxic substances dioxins. Incinerating e-waste also produces high concentrations of metals in the incinerator, in the slag, the fly ash, the flue gas and the filter cake. It was found in 2001 that more than 90% of the cadmium put into an incinerator is found in the fly ash, and more than 70% of the mercury in the filter cake (Computer Takeback Campaign and Californians against Waste, 2004).

Municipal incineration is the largest point source of dioxins into the US and Canadian environments, and among the largest point source of heavy metal contamination into the atmosphere (Silicon Valley Toxics Coalition, 1999). Some producers send their e-waste to cement kilns for use as an alternative to conventional fuel. Smelting can also present dangers similar to those found in incineration.

While in developing countries, especially in Asia, this situation is more widespread and serious because of the lack of professional technology or equipment to dispose or recycle e-waste. In order to recover copper and other metals, open-air burning of plastics is used as a rudimentary method which is just about the most dangerous form of burning e-waste. The toxic fallout from open-air burning affects both workers' health and the local environment, becoming the most serious issues in these areas.

2.2.5.3 The hazards of improper recycling e-waste

While properly managed recycling may be the key to the effective management of e-waste, improper handling, weak regulation and environmentally unsound recycling may result in increased environmental, public, and worker exposure to hazardous materials. In the past, environmentally unsound recycling operations have resulted in toxic hazards and expensive treatment costs. The recycling of e-waste emits hazards containing heavy metals such as lead and cadmium. And another problem with heavy metals and halogenated substances in untreated e-waste occurs during the shredding process. Most electronic products are designed in a manner that makes disassembly
difficult. Components in these products are typically compacted and soldered into a tight enclosing space (Osibanjo and Nnorom, 2007). So when there is a lack of proper dismantling of e-waste, the shredder waste can have a high concentration of lead and about 95% of the PCB contained in capacitors ends up in the shredder dust in the US (Computer Takeback Campaign and Californians against Waste, 2004). This kind of contaminated shreddings has to be dealt with as dangerous waste. This means that improper recycling of e-waste just moves the hazards into another kind of waste stream or just into secondary products that eventually require disposal without truly solving this problem. Halogenated substances contained in e-waste, in particular brominated flame retardants, are also of concern during the extrusion of plastics, part of plastic recycling processes. These chemicals make e-waste recycling particularly hazardous to workers. So there are significant risks to handling the recycling and disposal of e-waste.

2.3 E-waste management in industrialized countries

2.3.1 Sustainable waste management

The concept of sustainable development is defined as ‘development that meets the needs of the present without compromising the ability of future generation to meet their own needs’ (WCED, 1987; Mitlin and Satterthwaite, 1990; Clayton, 1996; Drummond and Marsdon, 1999). Sustainable development focuses on environmental protection as well as economic development and social development. The concept of ‘more with less’ was introduced into sustainable development, which means the needs to produce more value from products and services with less material and energy consumption, and less waste and emission production. Sustainable waste management means using material resources efficiently to cut down on the amount of waste produced and also adopting the concept of ‘more with less’- more valuable products recovered from the waste with less energy and space consumption and less emissions (McDougall, 2001), and where waste is generated, dealing with it in a way that
actively contributes to the economic, social and environmental goals of sustainable development.

Concerns over the environmental impacts of waste production and the drive to conserve resources have led to the development and adoption of the waste management hierarchy as a sustainable waste management strategy. The waste management hierarchy is an ordered list of approaches to deal with solid waste, which ranks the options according to their environmental acceptability, with the most acceptable waste reduction and the least landfill disposal (Pescod 1993; Barret and Lawlor 1997; Shah, 2000). Despite being generally acceptable, the rigid use of the hierarchy will not always lead to environmentally and economically sustainable systems (McDougall et al., 2001; Lave et al., 1999). In order to achieve sustainable waste management, no single waste management option would be satisfactory. Integrated Solid Waste Management (ISWM) has emerged as a leading concept (Palmisano and Barlaz 1996; van Beukering et. al., 1999; Mc Dougall et al., 2001).

A valuable tool which is rapidly gaining recognition as a framework for measuring an organization’s performance or a company’s business is the ‘Triple Bottom Line’ (TBL). Triple bottom line captures an expanded spectrum of values and criteria for measuring organizational or societal sustainable success through economic, environmental and social dimensions (Elkington, 1994; AMO, 2005 and Brown et al., 2006) These three dimensions in the triple bottom line concept focus on (Davis, 2006):

- Economic: impacts on the economic circumstances of an organization’s stakeholders and on economic systems at all levels
- Environmental: impacts on living and non-living natural systems, including ecosystems, land, air, and water
- Social: impacts on the social systems within which the organization operates

The broadest concept implies that decisions on waste handling should take into account, environmental, social, economic and institutional dimensions. The
integrative aspect of ISWM lies in the trade-off between these four dimensions (van Beukering, 1999). Figure 2.2 shows the integrated solid waste management hierarchy which sets up a hierarchy of approaches and technologies for managing solid waste in order to retain as much as possible of that energy and those materials in a useful state and to avoid releasing that energy or matter into the environment as a pollutant. Generally, the further "up" the hierarchy from which the technology is chosen, the more benefits in efficiency and retained economic value. And the very highest option in the hierarchy is source reduction which puts ‘don't create the solid waste’ in the first place (Stokoe and Teague, 1995).

![Integrated Solid Waste Management Hierarchy](image)

Figure 2.2 The hierarchy of integrated solid waste management

Source: Stokoe and Teague, US Department of Agriculture, 1995

2.3.2 The e-waste treatment strategies in management system

In view of the characteristics of e-waste and the environmental problems caused by recycling and disposing of it, effective e-waste management systems should be established. At present, from the technical perspective, the e-waste management system mainly comprises collection, transportation, classification, pre-treatment processes, and five conventional end-of-life treatment strategies, complying with
Chapter 2 Literature Review

proper legislation and regulations. In accordance with the potential economic and environmental efficiency, the e-waste treatment strategies can be categorized as follows (Rose, 2000 and Rose et al., 1999):

- **Reuse:** In any e-waste management system the best method is direct reuse, where someone else can use the obsolete electronic products or their components as originally designed.

- **Refurbish and Repair:** Often electronic products can be refurbished by making minor repairs. Most electronic products are modular to some extent, that is, at least some parts can be replaced with the same parts or with upgraded parts, and then the useful life can be extended.

- **Remanufacturing:** When repairing or refurbishing the obsolete electronic products is not economically feasible, some valuable components may be able to be reused in new products. For example, these parts in computers include memory, disk drives, circuit boards, and microprocessor chips. Working cathode ray tubes from computer monitors may be sold and reused in the manufacture of televisions.

- **Recycling (with or without disassembly):** Recycling of e-waste is an important step in the e-waste management system. It includes the treatment, recovery, and reprocessing of materials contained in the obsolete electronic products or components in order to replace the raw materials in the production of new goods. The maximization of valuable materials recovery and the consequent minimization of disposal rely on the technologies used in this process.

- **Disposal:** After the reusable and valuable materials and components in e-waste are removed and recovered the residues will be disposed of through the processes of incineration (with or without energy recovery) or landfill.
2.3.3 General situation of management and legislation system on e-waste in industrialized countries

2.3.3.1 The e-waste management system in industrialized countries

Industrialized countries have established a comprehensive body of e-waste management systems which have been proven innovative and successful in many aspects. In these countries, when designing or characterizing an e-waste management system, five broad parameters have been identified and need to be considered (Widmer et al., 2005).

1. Legal Regulation: How elaborate is the legislation, i.e. how much detail does it specify for the operational management of the system?

2. System Coverage: One aspect of the coverage of a system is whether it is collective (all inclusive for any brand) or brand-specific (each brand owner is individually accountable). The other aspect would be whether to have a system that caters for all the product categories or have different systems for different kinds of products under the e-waste management regulations.

3. System Financing: Who pays for the costs in the e-waste management system, how much and for what? One choice is an entirely externally financed system - where the financial burden of the collection and recycling or disposal is borne by the consumer or producer or municipality by providing additional funds meant specifically for the end-of-life treatment of the product. On the other hand, an internal system would be one in which the collection and recycling or disposal fees are paid for by the product itself.

4. Producer Responsibility: In the e-waste management system, it is important to consider how much responsibility the producers should take, at which points, and how the responsibility is shouldered in practice. While each producer may be individually responsible for its products, several manufacturers can come together to construct a collective e-waste management system. Flexible systems allow for both individual and collective implementation of producer responsibility.

5. Ensuring Compliance: The system design needs monitors and balances. Penalties
for non-compliance and targets for collection or recycling or disposal are often used to ensure compliance. A system may have a high density of such measures, or relatively few, or even none in extreme cases.

With these key parameters, it is possible to characterize an effective e-waste management system. The industrialized countries with comparable economic indicators can have remarkably different e-waste management systems of grading the above five parameters. But the common point is that among these five parameters legal regulation is the basic one in the whole e-waste management system and all the others can be regulated and reflected through proper laws or regulations. The legislation framework sets out the desired results that solid waste management could achieve, establishes enforceable standards as well as assigning responsibilities to the administrative departments and other related institutions.

2.3.3 2 The legislation system on e-waste in industrialized countries

The growing quantity of e-waste is beginning to reach disastrous proportions and all the industrialized countries are beginning to deal with the problem. After initially turning a blind eye to the problem, governments have been forced to respond as e-waste begins to seriously inundate solid waste disposal facilities and programmes. Many countries enacted national e-waste legislation to regulate the manufacturers’ and importers’ responsibility for the collecting and recycling end-of-life electrical and electronic products (Wu, 2001; Zha, 2002 and Yamaguchi, 2002). Some of them even regulate the recovery goals in detail (Guo, 2002; Jofre and Morioka, 2005).

For example, in Japan the Specified Home Appliance Recycling (SHAR) Law and the Law for Promotion and Effective Utilization of Resources went into effect in April 2001 for recovering air conditioners, TVs, refrigerators, washing machines and computers, computer accessories as well as copy machines (Guo, 2002). A national programme requires manufacturers and importers to arrange designated take-back
sites, provide transportation of goods from retailers and local governments, take back products which the manufacturers or importers themselves have manufactured or imported, recycle products and reuse components (Li and Li, 2006). Retailers are requested to take back used home appliances that they sold and to transfer them to the corresponding manufacturers or importers. Local governments will collect and recycle products not covered by retailers. Consumers are obliged to cooperate in transferring used appliances to retailers or municipalities, and to pay the necessary fees for collection, transportation and recycling. Under the law, each manufacturer has to utilize five to six recycling plants in different areas. In addition to the above specified regulations, manufacturers must design their products for longer life and more rational material usage, and for enhanced recyclability and reusability. Recovery goals are as follows: more than 60% of air conditioners; more than 55% of TV sets; more than 50% of refrigerators and washing machines. For computers, there is a 2004 target of a 90% recycling rate (Guo, 2002 and Clean Japan Centre, 2002).

Another Asian country, South Korea, has also legislated e-waste recycling, requiring producers and importers to take back and recycle both their products and packaging. The legislation also created phased recycling targets for various electrical and electronic equipment. Manufacturers of computers and televisions must recycle 55% of their products in 2005 and 65% by 2006 (Lee et al., 2007). Mobile phone and audio equipment manufacturers are required to reach 60% by 2005 and 70% by 2006 (ENVICO, 2006 and Chappell, 2005). Although it has not mandated lead-free electronics within its own borders, it has enacted a voluntary compliance programme to phase out lead and the other five substances named in the European Directive initiative to ensure that its electronic products are able to maintain access to European markets.

In another large quantity electronic products manufacturing area, Taiwan, legislation, taken effect in March 1998, requires that computers and household appliances including TVs and air conditioners should be recycled (Lee et al., 2000; Teng and Lin,
2004). Printers were added in 2000. By the end of October 2001, about 1.4 million used computers had been recycled. This means that about 75% of all used computers are being recycled in Taiwan (Lee et al., 2004 and Californians against Waste, 2004). In addition many multinational companies in the electronics industry (European, U.S., and Japanese) have already instituted take-back programmes in some areas to recover their obsolete products (Guo, 2002; Teng and Lin, 2004; China Solid Waste Forum, 2004).

Europe has taken the lead in addressing the e-waste problem by proposing a system of Extended Producer Responsibility (EPR). The Organization for Economic Cooperation and Development (OECD) defines EPR as "an environmental policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle" (OECD, 2001b). This approach maintains that the producers have the greatest ability to realize environmental improvements and to influence changes in the upstream, manufacturing, and downstream phases of a product's life. EPR can stimulate product innovation and pollution prevention activities such as reducing materials, resources and energy usage; eliminating the use of toxic chemicals in the product; increasing recyclable and recycled content; streamlining and improving the efficiency of transportation systems and production processes; extending the useful life of the product; increasing opportunities for recovery and re-use of the product at end-of-life; and creating new forms of product delivery such as leasing or product service systems (McKerlie et al., 2006 and UNEP, 2006). EPR propels the transfer of costs from taxpayer funded municipal waste management systems to the private sector and consumers, enforcing the polluter pays principle and reflecting the environmental impacts of the product (McKerlie et al., 2006). Bearing the responsibility of these costs should prompt producers to examine waste reduction strategies and to consider waste as a resource for recovery.

EPR can be used to manage various kinds of solid wastes, and of course including e-
waste. For example, in Switzerland, national legislation requires manufacturers to take back their products. Consumers can bring their end-of-life electrical or electronic products to any retailer free of charge. The retailers send the products back to the manufacturers or importers, who must dispose of it according to the law and disposal of these products requires a special licence from the Swiss Agency for the Environment, Forests, and Landscapes (SAFEL) (Liniger, 2007). The take-back requirement applies to all electrical and electronic products, regardless of where they were bought. The e-waste is banned from landfills. The government will allow the exporting of materials only on a case-by-case basis that manufacturers must prove the products will be handled in an environmentally sound manner by the import country. Besides Switzerland, several European countries have implemented EPR through formal legislation to effectively manage e-waste around 2000. In Appendix 4 the detailed information about the legislations on e-waste management in industrialized countries or area (including some EU countries, Japan and Taiwan area) are listed.

2.3.4 The WEEE and RoHS Directives

Established on the basis of the member countries’ legislation, in February 2003, the European Union (EU) Parliament issued two Directives: the Directive on Waste from Electrical and Electronic Equipment (WEEE) (EU, 2003a) and the Directive on the Restriction on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) (EU, 2003b). These two directives cover a broad range of electronic products ranging from computers to hair dryers, refrigerators and electronic toys. There are ten product categories which are covered by these two directives, which are set out in Annex 1B of the WEEE Directive. Table 2.3 shows these ten product categories (EU, 2003a). Of the ten categories listed in Table 2.3, categories 1-4 account for almost 95% of the e-waste generated in Western Europe which is shown in Figure 2.3 (ICSG, 2003 and Widmer et al., 2005).
Table 2.3 The categories according to the EU Directive on WEEE (EU, 2003a)

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large household appliances</td>
<td>Large HH</td>
</tr>
<tr>
<td>2</td>
<td>Small household appliances</td>
<td>Small HH</td>
</tr>
<tr>
<td>3</td>
<td>IT and telecommunications equipment</td>
<td>ICT</td>
</tr>
<tr>
<td>4</td>
<td>Consumer equipment</td>
<td>CE</td>
</tr>
<tr>
<td>5</td>
<td>Lighting equipment</td>
<td>Lighting</td>
</tr>
<tr>
<td>6</td>
<td>Electrical and electronic tools (with the exception of large-scale stationary industrial tools)</td>
<td>E&amp;E tools</td>
</tr>
<tr>
<td>7</td>
<td>Toys, leisure and sports equipment</td>
<td>Toys</td>
</tr>
<tr>
<td>8</td>
<td>Medical devices (with the exception of all implanted and infected products)</td>
<td>Medical equipment</td>
</tr>
<tr>
<td>9</td>
<td>Monitoring and control instruments</td>
<td>M&amp;C</td>
</tr>
<tr>
<td>10</td>
<td>Automatic dispensers</td>
<td>Dispensers</td>
</tr>
</tbody>
</table>

Figure 2.3 The composition of e-waste for Western Europe according to the categories in WEEE Directive

Source: ICSG, 2003

The WEEE requires producers of electronics to take responsibility – financial and otherwise – for the recovery and recycling of e-waste before 13th August, 2005 (EU, 2003a). The member states have until 2005 to introduce take back systems and collection facilities for all electrical and electronic equipment. E-waste is banned from
municipal waste and must be handled separately. Producers should also establish a completed system which includes classification, recovery, regeneration and reuse of electronics and must ensure a collection rate of minimum four kilograms per person per year. Consumers must be able to return e-waste to collection points free of charge but producers also can charge consumers an additional front-end fee that varies depending on the particular products. In order to facilitate recycling, it also requires labelling of e-waste by identifying the different components and materials within those components. From the perspective of product design this directive mandates that products must be designed for dismantling and recovery. By 2006, industry has to recycle or reuse between 59 and 75 per cent (by weight) of the old equipment on the market, depending on the product category. The directive specifies that mandated recycling rates will increase over time, creating a major incentive for producers to research more recyclable materials and investigate ways to decrease the costs of reprocessing through design for disassembly.

The accompanying directive, RoHS requires manufacturers to phase out the use of hazardous materials including lead, cadmium, mercury, hexavalent chromium/chromium (VI), brominated flame retardants (BFRs) which include polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBB). This directive was carried out from 1st July, 2006 (EU, 2003b). The two directives showed that the European governing body recognized the scope and urgency of the e-waste problem and are building a meaningful response to the crisis.

2.3.5 The impacts of e-waste management regulations in industrialized countries

The adoption of the legislation or regulations on e-waste in industrialized countries has led to essential changes in the field of e-waste management. Several researchers have analyzed the impacts of WEEE directives in their respective countries, such as in Germany (Walther and Spengler, 2005), Switzerland (Hischier et al., 2005), Scotland (Feszty et al., 2003) and even in South Korea (Yoon and Jang, 2006). The European
directives, WEEE and RoHS have set a standard for global e-waste management and have had an immediate global impact on the electronics industry. There are researchers who have taken into account the future of WEEE laws and have developed new techniques to design products and supply chains that are both economically and ecologically feasible (Krikke et al., 2003). The importance of extending the life cycle of electrical household appliances has also been stressed (Truttmann and Rechberger, 2006).

A main achievement of the WEEE directive, which was heavily supported by some leading manufacturers, is the stipulation that producers will be individually responsible for all products put on the market after August 2005. Extended producer responsibility requires that electrical and electronic equipment producers handle their own brand e-waste by closing the feedback loop between front-end design decisions and end-of-life problems, promoting a greater incentive for greener design (McKerlie et al., 2006). For example, in Germany leading manufacturers such as Electrolux and Braun believe that a collective system would not reward design changes, that it is essential that recycling remains competitive, and that producers must have the option of designing their own recycling systems. Together with Sony Europe and Hewlett-Packard, they established the European Recycling Platform to promote company flexibility in meeting the requirements of the WEEE and RoHS Directives (European Recycling Platform, 2004).

The insistence on responsibility for new products by these companies is not only based on the desire to ensure competitive choice in the market place for recyclers, but also based on the firm belief that individual responsibility offers the best feedback for design change and provides the highest incentive to design for environment (McKerlie et al., 2006). Under the producer responsibility scheme, the cost of recycling and value of recycled products can be reflected in the choice of materials and can also affect product design, which will all prevent environmental pollution in the end-of-life product management, where the profits will automatically be created.
and the incentives for design improvement will be strengthened.

Moreover, political decisions and legal adoption will influence development of the e-waste treatment system (Walther and Spengler, 2005). While traditional prevention policy measures were used to remediate the environmental impacts of landfill and incineration, the European directives now focus on waste reduction, followed by product reuse and materials recovery, minimizing the environmental impact of e-waste at the end-of-life by improving the environmental performance of end-of-life operators. However, a diversity of tasks is performed within the e-waste treatment system, such as collection, transportation, sorting and disassembly of products, as well as storage and selling of material fractions (Walther and Spengler, 2005). Among the impacts of these activities focus was placed by producers on the increased cost.

Under the directives the costs and obligations of producing more environmentally friendly products and disposing of products will fall on the producer, who may be a manufacturer, importer and retailer in one or more EU countries. From the economic point of view, the WEEE Directive implements the principle of producer responsibility, since the manufacturers of electrical and electronic products are responsible for financing recycling and disposing of their own e-waste, which will obviously increase the operating costs (Barba-Guti’errez et al., 2007). Europe is one of the largest markets in the world and any company outside the EU wishing to sell electrical and electronic products in this market has to be able to comply with the European directives and has to participate in the systems to take back, reuse, and recycle or dispose of their products in an environmentally sound way. Additional recycling and disposal costs will be charged which will increase the production cost or will be transferred to the marketing price of the product. The historical e-waste disposal cost is requested to be shared according to the share of the production market, potentially increasing the production cost as well. The high recycling rate requires more advanced techniques and equipment as well as increased financial investment. Financing all the end-of-life operations concerning their own e-wastes will also be a
burden to producers as well. Compliance with the RoHS Directive, to substitute the
hazardous materials in electrical and electronic products or reduce the use of six kinds
of harmful chemicals in e-waste to the limitation, will require increased investment
for study and testing. All these costly requirements for producers will fundamentally
alter every high-tech company's business strategy in the EU as well as impact on the
global supply chain management decisions and planning (Rivlin et al., 2004). In this
regard, it is significant to balance the benefits from recycling e-waste with the
increased costs brought by the implementation of the directives to effectively manage
e-waste. The implementation of e-waste management regulations in industrialized
countries affects the electronics industry and the e-waste management systems not
only in those countries but also world wide.

2.3.6 The Basel Convention to control e-waste exporting

E-waste, such as computers, is not really designed for ease of recycling, and thus
dismantling e-waste is extremely labour-intensive work. Moreover, the existence of
hazardous components in e-waste poses a significant risk to recyclers and increasingly,
the disposal of these components and residues from recycling is more and more costly
to manage. For example, compared to the incineration of municipal solid waste, the
incineration of e-waste is a more expensive process (Puckett and Smith, 2002).
Further, obtaining valuable materials, especially precious metals contained in e-waste,
is very difficult because it is bound up in plastics and mixed with other contaminants
that make it expensive to separate. Environmentally sound techniques used in
dismantlement, disposal and recycling of e-waste are very limited. Very little
economic recycling is taking place in industrialized countries like the United States,
because due to cheaper labour and lack of environmental standards in Asian countries,
exporting becomes one of the major downstream pathways of e-waste (Puckett and
Smith, 2002; Boyd, 2003). This kind of irresponsible exporting behaviour has made
the e-waste problem worse and more complicated.
To prevent the economically motivated dumping of hazardous wastes from rich to poorer countries, the Basel Convention on the Control of the Trans-boundary Movement of Hazardous Wastes and Their Disposal was adopted in 1989 and came into force in 1992 (Secretariat of the Basel Convention, 1989). The Convention puts the responsibility on exporting countries to ensure that hazardous wastes are managed in an environmentally sound manner in the countries of import. In this Convention the trans-boundary movement of e-waste is regulated as it is considered to be dangerous to humans and to the environment under the List A of Annex VIII (UNEP, 2007). In 1995 the Basel Ban Amendment was adopted to prohibit all exports of hazardous wastes from member states of the Organization of Economic Cooperation and Development (OECD), the European Union (EU) and Liechtenstein to all other countries (Kummer, 1998). But the United States has not ratified the original Basel Convention and the Basel Ban Amendment. In the United States, which is the biggest producer of electronics and also the biggest producer of e-waste in the world, exporting e-waste to developing countries is still legal because of the government attitude, although it is contrary to all principles of environmental justice and international laws (Puckett and Smith, 2002). This exporting of e-waste puts huge pressures on e-waste management in developing countries.

2.3.7 The initiatives dealing with e-waste issues in industrialized countries

Table 2.4 lists several main initiatives for dealing with e-waste problems in industrialized countries as well as the activities to prohibit the exporting of e-waste from industrialized countries to developing countries.
<table>
<thead>
<tr>
<th>Initiatives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basel Convention and Basel Ban</td>
<td>A global agreement regulating movements of hazardous wastes, including WEEE, between countries, in force since 1992. However, an Amendment to the Convention, commonly known as the Basel Ban, which calls for prohibiting the export of hazardous waste from OECD to non-OECD countries, is still to come into force (UNEP, 2007).</td>
</tr>
<tr>
<td>StEP initiative (solving the e-waste problem)</td>
<td>A UN-led initiative started in 2004 at the ‘Electronic Goes Green’ Conference in Berlin to build an international platform to exchange and develop knowledge on WEEE systems among countries to enhance and coordinate various efforts around the world on the reverse supply chain (StEP, 2005).</td>
</tr>
<tr>
<td>Basel Action Network (BAN), Silicon Valley Toxics Coalition (SVTC) and computer take back campaign</td>
<td>A network of non-governmental organizations (NGOs) in the US working together on WEEE issues, including international advocacy for the Basel Ban, domestic collection and recycling events as well as investigative research to promote national solutions for hazardous waste management (Basel Action Network and Silicon Valley Toxics Coalition, 2002).</td>
</tr>
<tr>
<td>WEEE Forum</td>
<td>Founded in 2002, the WEEE Forum is a group of representatives of voluntary collective WEEE take-back systems in Europe, taking care of individual producers’ responsibility in Europe (WEEE Forum, 2002).</td>
</tr>
<tr>
<td>National Electronics Product Stewardship Initiative (NEPSI)</td>
<td>A multi-stakeholder dialogue to develop the framework of a national WEEE management system in the USA. The NEPSI dialogue includes representatives from electronics manufacturers, retailers, state and local governments, recyclers, environmental groups, and others (NEPSI, 2002).</td>
</tr>
<tr>
<td>Electronics Product Stewardship Canada (EPS Canada)</td>
<td>EPS Canada was created to work with both industry and government to develop a flexible, workable Canadian solution. An industry-led organization, the founding members are 16 leading electronics manufacturers (EPS Canada, 2006).</td>
</tr>
<tr>
<td>ERP (European Recycling Platform)</td>
<td>Set up at the end of 2002 by Hewlett Packard, Sony, Braun and Electrolux to enable the producers to comply with the WEEE directive. It aims to evaluate, plan and operate a pan-European platform for recycling and waste management services (European Recycling Platform, 2004).</td>
</tr>
<tr>
<td>Secco/Empa E-waste programme</td>
<td>A project set up in 2003 by SECO (Swiss State Secretariat for Economic Affairs) and implemented by Empa (Swiss Federal Laboratories for Materials Testing and Research) in cooperation with a number of local partners and authorities, to assess and improve WEEE recycling systems in different parts of the world by analyzing the systems and by exchanging knowledge on recycling techniques and frameworks (Empa, 2005).</td>
</tr>
</tbody>
</table>
All the efforts which industrialized countries have made in e-waste management will be good examples for developing countries to control their own e-wastes. And according to many industrialized countries' experiences, it is urgent to improve and ameliorate the existing legislation system on e-waste management in developing countries before the problem becomes worse.

2.4 Present situation of e-waste in developing countries

The level of generation of e-waste in developing countries is lower than the one in industrialized countries. However, the increased accumulation of e-waste in the former cannot be ignored. In the first instance, e-waste has become the fastest growing waste stream in some developing countries as well. In India alone, it was estimated that until 2002 about 1.38 million PCs had been discarded from the business sector and individual households, while 1,050 tons of e-waste was being produced by manufacturers or assemblers annually (Toxics Link, 2003). Secondly, examples described below show that due to inadequate professional capacity and lack of environmentally sound technologies to dispose or recycle e-waste, the processes utilized in developing countries are relatively primitive and extremely polluting. On the other hand, in the name of donations, reuse or recycling, industrialized countries export e-waste to the developing countries. Besides Asian countries (section 2.2.3), the serious environmental and health problems, caused by the dumping of the industrialized countries' e-waste, in west Africa, such as in Lagos, Nigeria and Accra, Ghana, have recently been highlighted in the British Press (Guardian, 2008). This is an indirect way of dumping hazardous e-waste on these countries. This kind of irresponsible exporting behaviour has aggravated the e-waste problem in developing countries. Besides handling their own rapidly growing e-waste, developing countries now also have to manage the e-waste being dumped within their national boundaries by industrialized countries. E-waste management is becoming a critical issue in some
developing countries.

2.4.1 The environmental and occupational impacts in Asia

The e-waste recycling and disposal operations found in China, India, Bangladesh and Pakistan are extremely polluting because, in these countries, there is always a lack of professional technologies or equipment to dispose or recycle e-waste (Puckett and Smith, 2002). In some small-scale e-waste dismantling factories or in some family work-sheds, workers use simple and even primitive methods to dispose of e-waste. Open burning of plastic waste, exposure to toxic solder, river dumping of acids and widespread general dumping, are all e-waste recycling and disposal operations that are extremely polluting and very harmful to workers' and residents' health. Table 2.5 shows the environmental and occupational impacts in Asia based on the Basel Action Network's investigation mainly in Guiyu city, Guangdong Province in China, Karachi in Pakistan and New Delhi in India in 2002 (Puckett and Smith, 2002; Brigden et al., 2005).

Limited investigations in both Pakistan and India have revealed that these countries are receiving and processing western originated e-waste in similar processes or even worse than what is happening in China (Habib, 2005). For example, in Pakistan, circuit boards are being de-soldered using blow torches with no ventilation fans, in the same way as acid operations take place in enclosed premises with inadequate ventilation. In India, open burning of circuit boards in the middle of New Delhi neighbourhoods is routine as is the use of child labour to accomplish these tasks. In Bangalore, India's hi-tech capital, home to more than 1,200 foreign and domestic technology firms, as many as 1,000 tons of plastics, 300 tons of lead, 0.23 tons of mercury, 43 tons of nickel and 350 tons of copper are generated annually (Habib, 2005). More than 300 small industrial units operate in metal extraction waste from obsolete computers, but most of its six million residents are largely unaware of the threat.
## Table 2.5 Environmental and occupational impacts in Asia

<table>
<thead>
<tr>
<th>Computer/e-waste components</th>
<th>Process witnessed in Asia</th>
<th>Potential occupational hazard</th>
<th>Potential environmental hazard</th>
</tr>
</thead>
</table>
| Cathode ray tubes (CRTs)    | Breaking, removal of copper wire, and dumping | • Silicosis  
• Cuts from CRT glass in case of implosion  
• Inhalation or contact with phosphor containing cadmium or other metals | Lead, barium and other heavy metals leaching into ground water, release of toxin phosphor |
| Printed circuit boards      | De-soldering and removing computer chips | • Tin and lead inhalation  
• Possible brominated dioxin, beryllium, cadmium, mercury inhalation | Air emission of same substances |
| Dismantled printed circuit board processing | Open burning of waste boards that have had chips removed to remove final metals | • Toxicity to workers and nearby residents from tin, lead, brominated dioxin, beryllium, cadmium, and mercury inhalation  
• Respiratory irritation | Tin and lead contamination of immediate environment including surface and ground waters  
Brominated dioxins, beryllium, cadmium, and mercury emissions |
| Chips and other gold plated components | Chemical stripping using nitric and hydrochloric acid along riverbanks | • Acid contact with eyes or skin may result in permanent injury  
• Inhalation of mists and fumes of acids, chlorine and sulphur dioxide gases can cause respiratory irritation leading to severe effects including pulmonary edema, circulatory failure, and death | Hydrocarbons, heavy metals, brominated substances, etc. discharged directly into river and banks  
Acidifies the river destroying fish and flora |
| Plastics from computer and peripherals, e.g. printers, keyboards, etc. | Shredding and low temperature melting to be reutilized in poor grade plastics | • Probable hydrocarbon, brominated dioxin, and heavy metal exposures | Emissions of brominated dioxins and heavy metals and hydrocarbons |
| Computer wires              | Open burning to recover copper | • Brominated and chlorinated dioxin, polycyclic aromatic hydrocarbons (PAH) (carcinogenic) exposure to workers living in the burning works area | Hydrocarbon ashes including PAHs discharged to air, water, and soil |
### Computer/e-waste components

<table>
<thead>
<tr>
<th>Process witnessed in Asia</th>
<th>Potential occupational hazard</th>
<th>Potential environmental hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Miscellaneous computer parts encased in rubber or plastic, e.g. steel rollers</strong></td>
<td>Open burning to recover steel and other metals</td>
<td>• Hydrocarbon including PAHs and potential dioxin exposure</td>
</tr>
</tbody>
</table>
| **Toners cartridges** | Use of paintbrushes to recover toner without any protection | • Respiratory tract irritation  
• Carbon black possible human carcinogen  
• Cyan, yellow, and magenta toners unknown toxicity | Cyan, yellow, and magenta toners unknown toxicity |
| **Secondary steel or copper and precious metal smelting** | Furnace recovers steel or copper from waste including organics | • Exposure to dioxins and heavy metals | Emissions of dioxins and heavy metals |

Source: Puckett and Smith, 2002 and Brigden et al., 2005

### 2.4.2 The e-waste management system in developing countries

Unlike the sophisticated collection, transportation, sorting, dismantling, recycling and disposal system in industrialized countries, the e-waste management system in developing countries is still in the early stages of development.

For example, in India, as electrical and electronic products started becoming obsolete, the already established scrap metal industry absorbed this new waste steam to recover metals, which are then used as a feedstock to steel mills and non-ferrous smelters and refiners. Industrial recycling networks or industrial symbiosis are systems of many different firms and other organizations and societal actors that cooperate through common waste material and waste energy utilization (Korhonen et al., 2004). Thus in India, the e-waste management system is a case of self-organized and market-driven industrial symbiosis (Desrochers, 2004). In contrast to industrialized countries, where consumers pay a recycling fee for e-waste management, in India and other developing
countries the waste collectors always pay consumers a positive price for their obsolete
electronic products. The private collectors in turn sell the e-waste to traders who
aggregate and sort different kinds of waste and then sell it to recyclers, who recover
the metals and other useful materials. Fieldwork during a pilot study in New Delhi
(Empa, 2004a) indicated that the entire industry is based on a network existing among
collectors, traders and recyclers, each adding value and creating jobs at every point in
the chain. As the volume of e-waste has grown, a noticeable degree of specialization
has emerged, with some waste processors focusing only on e-waste (Sinha-Khetriwal
et al., 2005). Given the low level of initial investment required to start a collection,
dismantling, sorting or recovery business, it is attractive for small entrepreneurs or
family work-sheds to join the industry. This recycling network is substantiated by
similar results of fieldwork on solid waste management in Chennai, India, which
found a series of private-private relationships among waste pickers, street hawkers,
dealers, wholesalers and recycling enterprises (Baud et al., 2001).

The literature shows that in developing countries, the main incentive for the operators
to deal with e-waste is financial profit, not environmental or social awareness or
legislation. Nevertheless, these e-waste recycling and disposal systems have provided
employment to many people. In the investigation in India e-waste recycling has
become a profitable business, flourishing as an unorganized sector, mainly as
backyard workshops, but given the unorganized nature of the business, there are no
figures available regarding the scale of the business or the number of people it
employs (Empa, 2004a). For Delhi, it was estimated that the number of unskilled
workers in recycling and recovering operations could be at least 10,000 people.
Environmental concerns among manufacturers and recyclers as well as the awareness
of consumers regarding environmental issues are not very high. While the government
has passed several environmental protection laws, their enforcement remains
questionable (Sinha-Khetriwal et al., 2005). Legally, e-waste is included under the
Hazardous Wastes (Management and Handling) Rule 1989, and as amended in 2000
and 2003 in India (MoEF, 2003). However, this does not stipulate the management
and handling of post-consumer waste generated within the country.

2.4.3 Illegal e-waste importing in developing countries especially in Asia

As shown above, in developing countries, although the quantity of e-waste per capita is still relatively small, populous countries such as China and India are already huge producers of e-waste in absolute terms and display the fastest growing markets for electrical and electronic equipment (Empa, 2005a). Besides the large increasing domestic e-waste, considerable quantities of e-waste have been imported or are being illegally imported to these developing countries, which means that developing countries have to face a rapidly increasing amount of e-waste both from domestic generation and illegal imports (section 2.2.3). For emerging economies, these material flows from e-waste imports not only offer a business opportunity, but also satisfy the demand for cheap secondhand electrical and electronic equipment (Widmer et al., 2005). In addition, the lack of national regulations and lax enforcement of existing laws are promoting the growth of a semi-formal or informal economy in developing countries (Widmer et al., 2005; Nnorom and Osibanjo, 2008). An entire new economic performance is evolving around reusing, repairing and recovering materials from obsolete electronic products (Hicks et al., 2005). While it is a source of livelihood for the urban and rural poor, it often causes severe risks to workers/residents and the local environment (Table 2.5). Most of the participants in this sector are not aware of the risks, do not know of better practices, or have no access to investment capital to finance profitable improvement. Figure 2.4 indicates the main e-waste traffic routes in Asia (Schwarzer et al., 2005). There is, however, no official data available on how substantial these trans-boundary e-waste streams and the quantities are (Widmer et al., 2005).

Indeed, China has banned the import of e-waste and is beginning to enforce and improve its laws and regulations to deal with this problem (Li, 2004). But in other developing countries such as India, the government has come up with a policy to
promote the import of old computers or other e-waste. For example, the government of India in its 2000-2001 budget has made a clear stipulation for the import of old computers as donations (Toxics Link, 2003), ignoring the fact that all these old computers will end their lives in India and then be recycled or disposed of in an environmentally unsound manner.

Who gets the trash?

Source: Schwarzer et al., 2005

Much of e-waste imported to developing countries is in the name of donations or reuse, recycling, but in practice, it becomes an indirect way to dump hazardous e-waste on these countries. It has also been reported that Gulf countries serve as transit
points where every kind of waste comes from the US, Europe and West Asian countries, including e-waste (Toxics Link, 2003). In Greenpeace China’s investigation in 2003 (Greenpeace China, 2003), investigators found that traders who came from Africa, such as South Africa, also bought e-wastes from Hong Kong and Guangdong province of China and then shipped them to their own countries for “recycling”. Thus exporting e-waste has become a serious global issue.

2.4.4 The problems of e-waste management in developing countries

2.4.4.1 The assessment method to measure and compare e-waste management systems in developing countries

To analyze the existing problems and to assess and compare the e-waste management system, a simplified model was developed as shown in Figure 2.5 (Empa, 2005a).

Figure 2.5 The simplified model describing the complex cross-linking of causalities in the e-waste recycling system and their interactions with humans and the environment

Source: Empa, Swiss E-waste Guide, 2005

This model describes a complex relationship between the e-waste recycling system, society (humans) and the environment. Humans and the environment are at the centre of the model. The e-waste recycling system has direct and indirect impacts on labour,
health and the environment. The recycling system is described through systemic and technological elements as well as the material and financial flows along the whole product life cycle. The recycling system is surrounded by a general framework. The prevailing economic situation, politics, legislation and its enforcement, science and technology, and cultural aspects influence the interactions within the system. This framework is again affected by changes in labour, health and environmental impacts. Table 2.6 lists the detailed indicators to measure and compare e-waste management systems (Widmer et al., 2005). This thesis relates to the criterion ‘politics and legislation’ in the structural framework in both Figure 2.5 and Table 2.6.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Criterion</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural framework</td>
<td>Politics and legislation</td>
<td>Ratification of Basel Convention and Ban Amendment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Status of a national waste legislation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Status of a national e-waste legislation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corruption perception index</td>
</tr>
<tr>
<td>Economy</td>
<td></td>
<td>Capital cost (industrial investments)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Secondary raw material market</td>
</tr>
<tr>
<td>Society and culture</td>
<td></td>
<td>Civil and political liberties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NGO activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recycling culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental awareness in society</td>
</tr>
<tr>
<td>Science and technology</td>
<td></td>
<td>Knowledge of WEEE recycling technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research in WEEE management / recycling technologies</td>
</tr>
<tr>
<td>Recycling system</td>
<td>Material flow</td>
<td>WEEE generation per capita</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed loop recycling management</td>
</tr>
<tr>
<td></td>
<td>Technologies</td>
<td>Efficiency of material recovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality of recovered material</td>
</tr>
<tr>
<td></td>
<td>Financial flow</td>
<td>Financial coverage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Externalities coverage</td>
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<tr>
<td></td>
<td></td>
<td>Financial incentives for eco-design</td>
</tr>
<tr>
<td>Impacts</td>
<td>Environment</td>
<td>Final disposal of WEEE in unsafe landfills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emissions of hazardous substances</td>
</tr>
<tr>
<td></td>
<td>Human health</td>
<td>Health and safety implementation at workplaces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exposure of neighbouring population to hazardous substances</td>
</tr>
<tr>
<td></td>
<td>Labour</td>
<td>Number of jobs generated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Income distribution</td>
</tr>
</tbody>
</table>

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2.4.4.2 Identified problems on e-waste management in developing countries

Using the above model and indicators to assess the e-waste management system and summarizing the above situations of e-waste in developing countries, some of the difficulties and problems can be found. Developing countries display the fastest growing markets for electrical and electronic products and, accompanying this growth, the quantity of domestic e-waste has increased rapidly. Some developing countries are illegally importing considerable quantities of e-waste which has aggravated the problem. The biggest drawback of the current e-waste management systems in developing countries is the uncontrolled emission of hazardous toxic pollutants that are going into air, water and soil. The health hazards from fumes, ashes and harmful chemicals affect not only the workers who come into contact with the e-waste, but also the environment.

In developing countries all these difficulties are amplified by the lack of regulations or lax enforcement in the recycling and disposal sector. Combined with the existence of a very creative and low-income informal sector, this lack permits a profitable e-waste recycling business thriving on uncontrolled and risky low-cost techniques (Agarwal et al. 2003). The lack of reliable data poses a challenge to policy makers wishing to design an effective e-waste management strategy and to an industry wishing to make rational investment decisions. Most of the participants in e-waste management systems are not aware of environmental and health risks and, either do not know better practices or have no access to investment capital to even finance profitable improvements or implement safety measures.

Researchers have found that first, in developing countries purely business-driven e-waste recycling systems have come about without any government intervention (Sinha-Khetriwal et al., 2005). The existing legislation and regulation system could not support the effective control of e-waste in developing countries. The e-waste
management system is self-organized and market-driven simultaneously (Desrochers, 2004), which has caused serious environmental pollution and health hazards. Any development in these e-waste sectors will have to be built on the existing set-up. Second, a complex e-waste handling infrastructure based on and executed by a very entrepreneurial informal sector has developed, reflecting the long tradition in waste recycling. Street hawkers, small-scale e-waste dismantling factories and household work-sheds easily adapted to the new waste stream and a large number of new businesses were created in re-using components or extracting secondary raw materials. For example in South Africa with its important (gold) mining sector and state of the art metal recycling, the existing industry had no difficulty integrating the new e-waste stream (Widmer et al., 2005). But the lack of a safe e-waste recycling infrastructure in the formal sector, and thus reliance on the capacities of this kind of informal sector, posed severe risks to the environment and human health.

Third, the relevant governments in some developing countries have been aware of the shortcomings of the current e-waste management systems. They have declared e-waste management as a priority issue and have started to formulate strategies for improvement. Low risk processes, such as collecting, pre-processing and the manual dismantling of e-waste, offer good job opportunities for low and medium skilled labour if given proper training and access to the necessary and affordable technologies. However, some of the recycling processes are extremely harmful and need to be transferred to formal industries. For instance, South Africa is relying on its efficient and large recycling industry, expecting that it will not encounter difficulty in managing the recovery of materials from e-waste (Widmer et al., 2005). However it currently lacks an efficient take back scheme for consumers and therefore only a fraction of the obsolete electronic products (estimated 10%) find their way to recyclers. Currently the e-waste management strategy group and private initiatives in Cape Town and Johannesburg are organizing Green e-Waste Channels which guarantee users minimum risk, but optimum value-added disposal of certain e-waste (Empa, 2005b).
The introduction of a comprehensive legal framework by some industrialized countries, and notably by the EU and its member states, is not only intended to bring forward elaborate e-waste management systems but also better product designs. The development of these legal frameworks is starting to transform perceptions and affect production in developing countries. Exporting electrical and electronic products to the EU countries has to face the restrictions on hazardous substances (RoHS Directive) and the requirement of compliance with the WEEE Directive, under which all electrical and electronic products imported into the EU have to be recycled (EU, 2003a). Some developing countries are rapidly becoming major electrical and electronic product manufacturers and are interested in recycling material to access urgently needed raw materials. At the same time this could offer business opportunities for labour intensive dismantling and recycling operations in low-income economies. However assessments have shown that severe shortcomings in capacities, skills and technologies put workers/residents and the environment at considerable risk (Widmer et al., 2005). Although awareness and readiness for implementing improvements is increasing rapidly, there are still many obstacles to manage end-of-life products safely and effectively in developing countries.

The international regulations mainly developed under the Basel Convention, focusing on a global ban for trans-boundary movement of e-waste, seem to face difficulties in being effectively implemented and the lack of corresponding standards for simple but efficient e-waste management systems delays their implementation (Widmer et al., 2005 and Sinha-Khetriwal et al., 2005). Besides handling their own rapidly growing e-waste, developing countries now also have to manage the e-waste being dumped within their national boundaries by industrialized countries. The need for e-waste management in developing countries is intensifying, and in some of these countries, is probably even higher than in industrialized ones.
2.5 Present situation of e-waste in China

E-waste was paid more attention by government and the public in China just after the activities in Guiyu and Taizhou two areas were reported in 2002. In February 2002, Basel Action Network and Greenpeace published the report *Exporting harm: the high-tech trashing of Asia*, which indicated the serious environmental pollution and health damaging situation in Guiyu area, an e-waste dismantling centre in Guangdong Province of China (Basel Action Network and Silicon Valley Toxics Coalition, 2002). In this report simple and even primitive methods to dispose of e-waste which are extremely polluting and very harmful to workers’ health were found, including the manual and unprotected removal of printer cartridge toner, the open incineration of wires to recover copper, the de-soldering of printed wiring boards and the use of open acid baths to retrieve precious metals from chips and other electronic components (Table 2.5). Three months later in May 2002 CCTV (China Central Television), which is the national governmental television network, reported another e-waste dismantling centre in Wenling City, Taizhou region in Zhejiang Province. From then on, more provinces and cities have been involved in the e-waste issue. The government and related administrative departments or institutions from national to local level began to find effective measures to control e-waste and regulate e-waste management in an environmentally sound way. Map 2.1 shows the main provinces and cities where the e-waste issue is most concerned in China, including Zhejiang province and Qingdao, the city in Shandong province, which were set by the Development and Reform Commission (NDRC) as experimental province and city for construction of the recycling and treatment systems for waste and old household electric appliances and electronic products (NDRC, 2004).
2.5.1 The large quantity of e-waste

At present China is one of the leading countries that produces, consumes and exports electrical and electronic products in the world, and hence cannot escape from dealing with environmental pollution from e-waste and its harmful effects on workers'/residents' health. Especially in recent years, China has become the leading producer and consumer of computers in the world, given the current rapid development in information and communication industries, coupled with the high population numbers (Zhou, 2004a). The electronic industry has become one of the most rapidly growing industries in the whole country, which has been increasing at an average of over 20% per annum in the past decade (ibid). According to preliminary
findings, in 2003 there were 350 million televisions, 130 million refrigerators and 170 million washing machines in use in the whole country, most of which were produced in the second half of the 1980s. Assuming the lifespan of these household appliances to be ten to fifteen years, there have been at least 5 million televisions, 4 million refrigerators and 5 million washing machines scrapped every year since 2003 (Zhang and Zou, 2004).

Additionally, the consumption of computers and mobile phones has increased dramatically. There were about 20 million computers and 190 million mobile phones in use in 2003 in China (Zhang and Zou, 2004). In contrast to the extremely increased rates of production, the average lifespan of a computer has shrunk from five or four years to three or two years. Because the replacement of computers and mobile phones is much faster than any other electronic productions, obsolete computers and mobile phones will grow more rapidly and become the most important part of e-waste in China. For example, based on the Statistic Yearbook of China (State Statistic Bureau, 2001), in 1986 the production of personal computers was 42,100 in one year, while in 2001 the production was 7.58 million which is almost 180 times more than that in 1986. Table 2.7 shows the estimated quantities of five main electronic products in use in 2003 and annual waste from them (Zhang and Zou, 2004; Xinhuanet, 2005). The material composition by weight (%) of the four large obsolete electronic products in China is indicated in Table 2.8 (Li et al., 2005). It is estimated by SEPA (State Environmental Protection Agency) that at present about 1,110,000 tons of electronic products became obsolete annually in China and constitute about 1% of municipal solid waste (Xinhuanet, 2005).

Some researchers using mathematical models have estimated the amount of waste from obsolete electronic products in China (Lin et al., 2003a; Liu et al, 2005; Li et al., 2005). Table 2.9 shows the estimated annual waste of five main obsolete electronic products: TVs, refrigerators, washing machines, air conditioners and PCs (Li et al., 2005). Most of the products will be consumed within the native market which will put
a huge pressure on e-waste management.

Table 2.7 Electronic products in use and annual waste from them in 2003

<table>
<thead>
<tr>
<th>Category</th>
<th>Electronic Products in Use (Units): Millions</th>
<th>Annual Waste of Obsolete Electronic Products (Units): Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV sets</td>
<td>350</td>
<td>5</td>
</tr>
<tr>
<td>Refrigerators</td>
<td>130</td>
<td>4</td>
</tr>
<tr>
<td>Washing machines</td>
<td>170</td>
<td>5</td>
</tr>
<tr>
<td>Computers</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Mobile phones</td>
<td>190</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: Zhang and Zou, 2004; Xinhuanet, 2005

Table 2.8 Material composition by weight (%) of the four large obsolete electronic products in China

<table>
<thead>
<tr>
<th>Category</th>
<th>TV set</th>
<th>Refrigerator</th>
<th>Air Conditioner</th>
<th>Washing Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Copper</td>
<td>3</td>
<td>4</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Iron</td>
<td>10</td>
<td>50</td>
<td>55</td>
<td>53</td>
</tr>
<tr>
<td>Plastics</td>
<td>23</td>
<td>40</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td>Glass</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>3</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Li et al., 2005

Table 2.9 The estimated annual waste of five main obsolete electronic products

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Annual Waste of Five Main Obsolete Electronic Products (10,000 Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TV sets</td>
</tr>
<tr>
<td>2004</td>
<td>1,485.15</td>
</tr>
<tr>
<td>2005</td>
<td>1,573.32</td>
</tr>
<tr>
<td>2006</td>
<td>2,041.25</td>
</tr>
<tr>
<td>2007</td>
<td>2,324.63</td>
</tr>
<tr>
<td>2008</td>
<td>3,088.52</td>
</tr>
<tr>
<td>2009</td>
<td>3,718.75</td>
</tr>
<tr>
<td>2010</td>
<td>5,833.94</td>
</tr>
<tr>
<td>2011</td>
<td>3,251.85</td>
</tr>
<tr>
<td>2012</td>
<td>3,917.88</td>
</tr>
<tr>
<td>2013</td>
<td>4,041.73</td>
</tr>
<tr>
<td>2014</td>
<td>4,251.48</td>
</tr>
<tr>
<td>2015</td>
<td>4,449.13</td>
</tr>
</tbody>
</table>

Source: Li et al., 2005
Most of the obsolete computers and other electronic products in China come from individuals, small businesses, large-scale corporations, educational institutions, government and original equipment manufacturers. Moreover, as previously discussed, among the 80% (approx.) of e-wastes exported from industrialized countries, such as USA, Japan, South Korea, to Asia, 90% of them will be exported to China, which means that every year besides the native produced e-waste, there will be 70% of the whole world’s e-waste to be disposed in China. Figure 2.6 indicates the illegal imported e-waste ratio from industrialized countries or areas which was found in Guiyu area in 2002 (Zhou, 2004b). It shows that 60% of the illegal imported e-waste came from USA and e-waste from Japan and South Korea could not be ignored either. The volume of e-waste is already a serious problem in China and is escalating at a rapid rate. All these large and increasing quantities of e-waste need a clear policy, institutions and legislative infrastructure for effective management and control.

Figure 2.6 The illegal imported e-waste ratio from industrialized countries or areas found in Guiyu area, Guangdong Province, in 2002
2.5.2 Downstream pathways of e-waste in China

Currently, the vast majority of e-waste ends up in China in three main ways (Li, 2004; Xiamen Evening News, 2004; Dong and Fan, 2005). The first is that after simple repair or refurbishment by individual brokers, parts of obsolete electronic products will be sold to low-income customers or rural areas where consumers cannot afford the money to buy new ones. Because most of these products have reached their maximal lifespan, they will sometimes be potentially dangerous to users and of course will come to the end of their lives very quickly. The second way is that some brokers or retailers dismantle obsolete electronic products to get the still usable components and then resell or reuse them in secondhand market. Some old style components are even reused in new products to cheat customers. The third way is direct dismantling and disposal in landfills or incinerators by small-scale e-waste dismantling factories or family work-sheds. But due to improper handling and unprofessional methods of disposal, e-waste brings the most serious and hazardous effects on both environment and human health.

There are no formal e-waste recovery systems in China. The public sectors in solid waste management did not separate the e-waste with other municipal solid wastes (MSWs) yet. Small electrical and electronic items end up with MSWs in landfills or incinerators. There are no special collection points and take-back plans for e-waste or large household appliances serviced by public sectors (Dong and Fan, 2005). Then the private sectors play the main role in e-waste management in China (Liu et al., 2006). Most e-waste is recovered by private sectors, such as by individual brokers or retailers, from consumers directly and then resold to small-scale dismantling factories or family work-sheds for environmentally unsound recycling (Yu and Cen, 2004). Only a small part of e-waste which comes from government or large-scale corporations will be sent to the formal recycling companies. The private sectors also involve in e-waste dismantling, sorting, transportation, recycling and final treatment, that is in all operations in e-waste recycling and disposal processes.
The current financial flows of e-waste in China are shown in Figure 2.7 (Liu et al., 2006). Consumers have no knowledge of the hazards of e-waste and do not realize the seriousness of the environmental issues posed by e-waste. Most consumers will not pay for the recycling of e-waste but instead they resell obsolete electronic products to individual brokers or retailers for some money back. As shown in Figure 2.7, individual collectors, small-scale dismantling factories and private repair shops recover e-waste from consumers directly or even bought illegally imported e-waste from importers. They get economic profits from reselling usable items or components to secondhand market or reselling to small-scale dismantling factories or family work-sheds for recycling and material recovery. Due to the environmentally unsound recycling and disposal, the private recyclers do not need to pay for the final disposal of e-waste. Informal e-waste recycling companies get economic profits from selling recovered components or materials to the secondhand market or the regenerative resource market.

![Figure 2.7 E-waste recycling financial flow in China](image)

Figure 2.7 E-waste recycling financial flow in China

Source: Liu et al., 2006
Chapter 2 Literature Review

The public sectors met the difficulties in e-waste recycling and disposal processes (Li, 2004). If the government or other formal recycling companies want to recover e-waste, they must buy it from these brokers or retailers, which increases the disposal cost of e-waste. At the same time, because the environmentally sound recycling and disposal of e-waste also needs a lot of money and there are no policies in government to support the recycling of e-waste, most producers as well as large formal recycling companies are reluctant to recover e-waste. They meet the difficulties to get economic profit from this business. As a result, only individual brokers, retailers and small-scale e-waste dismantling factories or family work-sheds become the main operators of e-waste. For example, in Beijing, a survey suggests that there are approximately 5000 individual collectors or street hawkers and 17 secondhand markets. These individual collectors do not have business licences and fixed workshops and they collect all kinds of e-waste. About 60% of the total discarded e-waste in Beijing is collected by individual street hawkers (Beijing Morning News, 2005). They get a lot of money from selling obsolete electronic products to the secondhand market or small-scale e-waste dismantling factories, as well as family work-sheds where e-waste is dismantled to get precious metals, but at the cost of destroying the environment and workers' health.

2.5.3 The environmental and health impacts of e-waste in China

The existing informal e-waste recycling and disposal system in China has caused serious consequences to the surrounding environment and human health.

2.5.3.1 The negative environmental impacts of e-waste

An on-site survey and pollutant monitoring was carried out by researchers from Hong Kong Baptist University in the Guiyu area, Guangdong province during 2003-2004 (Leung et al. 2004). The researchers collected sediment and soil samples from the Liangjiang River (the main water resource in this area), from a residential area that is
adjacent to the recycling sites, and from the dumping sites of burnt plastic and waste printer rollers, and analyzed the samples in the laboratory. The results indicated that the concentration of total polycyclic aromatic hydrocarbons (PAHs) was fairly high with the highest being 593 μg kg⁻¹ in the sample sediment from the waste printer rollers dumpsite. Sediment from the Lianjiang River was found to be the most contaminated by polychlorinated biphenyls (PCBs, 743 μg kg⁻¹). This concentration exceeded the Canadian Environmental Quality Guidelines Probable Effect Level of 277 μg kg⁻¹ by 2.7 fold. Polybrominated diphenyl ethers (PBDEs, 1140-2196 ng g⁻¹) in soils near direct dumping sites were between 10 and 60 times higher than those reported in other contaminated locations in the world. The highest concentrations of total heavy metals appeared in the river sediments and the soils collected from the burnt plastic dump sites. Cu, Pb and Zn were the most abundant metals which are listed in Table 2.10 (Leung et al., 2004 and Liu et al., 2006). Guiyu’s ground water is now so polluted that drinking water has to be trucked in from a distance of 30 km (Yu et al., 2006b). Another preliminary investigation of The Basel Action Network (2002) found that a water sample collected from the river near e-waste open burning sites contained 1.9 mg l⁻¹ lead (Pb), which is 190 times over the World Health Organization (WHO) Pb threshold (Puckett and Smith, 2002).

<table>
<thead>
<tr>
<th>Location</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>River sediment</td>
<td>531.2</td>
<td>84.3</td>
<td>240.1</td>
</tr>
<tr>
<td>Soil of burnt plastic dump site</td>
<td>490.7</td>
<td>104.2</td>
<td>241.5</td>
</tr>
<tr>
<td>Soil of waste printer roller dump site</td>
<td>711.9</td>
<td>189.9</td>
<td></td>
</tr>
<tr>
<td>Dutch target value</td>
<td>36</td>
<td>85</td>
<td>140</td>
</tr>
</tbody>
</table>

Note: data as presented in the original references, though reporting data to 4 significant figures is probably inappropriate.

2.5.3.2 The hazardous impacts of e-waste on workers’ and residents’ health

The studies found that the long-term informal dismantling and recycling of e-waste in
Guiyu area appeared to have not only negative impacts on the environment but also a hazardous health impact on the people working/living there (Leung et al., 2004 and 2008; Qu et al., 2007). A survey among 165 children aged between one and six at four Guiyu kindergartens found that 82% of the Guiyu children had blood Pb levels of more than 100 µg l\(^{-1}\), which will affect young children's IQ and the development of their central nervous systems (Peng et al., 2005). A report by the Shantou Medical University Hospital found a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers in the population of the Guiyu area (Qiu et al., 2004). This report details the social and health effects of the informal e-waste dismantling and recycling system in Guiyu, which has existed for more than 10 years and involves approximately 80% of the local families. The local residents organized and controlled the whole system and have made substantial profits from e-waste recycling. But actually most recycling and treatment processes are carried out by poorly paid migrant workers from outside this area who numbered more than 100,000 at the time of the survey. These migrant workers suffer from many cases of respiratory tract infection and kidney stones, and studies found that the incidence of these health problems is higher among these migrant workers (Anthropology Department in Shantou University, 2003 and Greenpeace, 2008).

After the Basel Action Network's investigation in the Guiyu area, Guangdong Province, another e-waste dismantling centre was found in WenLing City, Taizhou region in Zhejiang Province (Lai, 2004a). The same problem happened. Although the local government organized a censorial team to rectify and clear illegal e-waste dismantling work-sheds and regulated that all the extracting and processing should be done in the appointed factories by environmental units and the unit of industry & commerce, and any private extracting and processing would be punished severely in economic terms, the family dismantling work-sheds are still there today (Lai, 2004b). The main sources of the e-waste found in this area are Japan, USA and the domestic market (Lai, 2004c). E-waste dismantling and recycling processes are increasingly industrialized and became fundamental parts of the local economy and society. Apart
from the two areas already mentioned, other such dismantling/recycling and illegal e-

circuit boards (Zhao et al., 2004; Wen et al., 2004 and 2005). Studies on pyrolysis of

Several government supported research centres and university research institutions


e-waste recycling technologies and studies for the recycling of e-waste

have been published (Liu et al., 2003; Lu and Ma, 2003; Wang et al., 2004; and Wei et

initiated the National High Tech Research and Development Program on e-waste

recycling technology with the aim of promoting research and development on

technological aspects of e-waste management (MST, 2003 and He et al., 2006).

2.5.4 The recycle technologies to treat e-waste in China

With the aggravation of the environmental impacts caused by e-waste, strategies for e-

treatment have begun to arouse wide attention in China. Many articles

introducing e-waste recycling technologies and studies for the recycling of e-waste

have been published (Liu et al., 2003; Lu and Ma, 2003; Wang et al., 2004; and Wei et

In July 2003, the Ministry of Science and Technology of China (MST)

recycling technology with the aim of promoting research and development on

technological aspects of e-waste management (MST, 2003 and He et al., 2006).

Several government supported research centres and university research institutions

have done much to explore innovative and practical technologies to dismantle and

recycle e-waste in an environmentally sound manner. For example, mechanical

processes were industrialized to recover copper or other metals from waste printed

circuit boards (Zhao et al., 2004; Wen et al., 2004 and 2005). Studies on pyrolysis of

waste printed circuit boards were carried out under various conditions with

thermogravimetry (Sun et al., 2001, 2002 and 2003). In another research work, Mou

et al. presented a practical physical process for recycling waste printed circuit boards

as well as the reusing process for epoxy resin recovered from printed circuit boards

(Mou et al., 2004). A special crusher with extra extruding, impacting and shearing

forces was developed. With this crusher, the glass-encased printed circuit boards

could be readily crushed to proper granularity. After the powder-making and

separation process, the liberation degree of metals from non-metals exceeded 95%. A
cooling-spray system, multilevel leaching device and labyrinth-type backwash were used to improve the environmental condition of the crushing and separation processes. The entire recycling process was built as a closed loop system and almost no waste air and water were let out (He et al., 2006). Besides these lab researches on e-waste recycling and disposal, some pilot practices have been promoted. In January 2004, the Development and Reform Commission (NDRC) set Zhejiang province and Qingdao City, which is in Shandong province, as experimental province and city for construction of the recycling and treatment systems for waste and old household electric appliances and electronic products. These were approved by the State Council, with the purpose of addressing the problems in the draft legislation and the difficulties in establishing a WEEE recycling system (NDRC, 2004 and Widmer et al., 2005). These two programmes were also required to make use of technology and processes suited to China's circumstances, carry out analysis of recycling costs, and develop relevant technical standards.

2.5.5 Present legislation and management situation on e-waste

In 1996, China passed the Law on Prevention of Environment Pollution Caused by Solid Waste (Second version was effective as of April 2005), which prohibits the import of solid wastes which are unusable as raw materials and strictly regulates the import of solid wastes that can be used as raw materials (Lin and Wang, 2003b). This is the first law on solid waste management in China and it is also the basic legislation to regulate the management of hazardous solid waste. Beside this law there are several regulations to manage municipal solid waste as well as hazardous solid waste and regulations to control the transfer of hazardous solid waste. Table 2.11 lists the national laws and regulations on solid waste and hazardous waste management in China and the corresponding issue authorities.
<table>
<thead>
<tr>
<th>Laws and regulations</th>
<th>Brief description</th>
<th>Issue Authority</th>
<th>Date of becoming effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law of the P.R China on Prevention of Environmental Pollution Caused by Solid Waste</td>
<td>First law to regulate the management of MSW</td>
<td>National People’s Congress Standing Committee</td>
<td>1st April, 1996 (Second version was effective as of April 2005)</td>
</tr>
<tr>
<td>Cleaner Production Promotion Law of P.R. China</td>
<td>From each step of production, the manufacturers should take measurements to reduce pollution</td>
<td>National People’s Congress Standing Committee</td>
<td>1st January, 2003</td>
</tr>
<tr>
<td>Law for Environment Impact Assessment of P.R. China</td>
<td>Emphasizes the importance of preventing environmental pollution from source; any new construction must obtain EIA approval before breaking ground</td>
<td>National People’s Congress Standing Committee</td>
<td>1st September, 2003</td>
</tr>
<tr>
<td>City Appearance and Environmental Sanitary Management Ordinance</td>
<td>Principal guidelines on city appearance and environmental sanitary management; local government would work out practical measurements</td>
<td>The State Council</td>
<td>1st August, 1992</td>
</tr>
<tr>
<td>Regulations Regarding Municipal Residential Solid Waste</td>
<td>Regulations regarding the management of collecting, transferring and treating residential solid waste</td>
<td>The Ministry of Construction of P.R. China</td>
<td>1st September, 1993</td>
</tr>
<tr>
<td>Comments on Promoting the Industrialization of Municipal Solid Waste Treatment</td>
<td>An important signal for attracting private and foreign investment into municipal waste water and solid waste industry</td>
<td>State Development &amp; Planning Committee, The Ministry of Construction, and SEPA</td>
<td>September, 2002</td>
</tr>
<tr>
<td>Measures on the Management of Duplicated Form for the Transfer of Hazardous Waste</td>
<td>Regulations regarding the registration, generation and transfer of hazardous solid waste</td>
<td>SEPA</td>
<td>1998</td>
</tr>
</tbody>
</table>
2.5.6 The activities and pilot programmes to e-waste management

As stated above, e-waste is more and more serious in China now, so although at present the laws or regulations on how to recycle and dispose e-waste may not control the problem, the government and related administrative institutions have already worked out and ameliorated the legislation system on this foundation. In fact, China was one of the first global proponents for an international ban on the export of toxic waste from industrialized to developing countries. The Basel Convention on the Control of the Transboundary Movement of Hazardous Waste and Their Disposal was adopted in 1989 and entered into force in 1992. In March 1990, China ratified the Convention (Li, 2004b). On May 1st, 2001, China ratified the Basel Ban Amendment which will effectively prohibit all exports of hazardous waste from member states of the OECD, the EU (European Union), and Liechtenstein to all other countries including China and will enter into force after it receives 62 ratifications. This demonstrates China’s support for the Basel Convention and its obvious goal of national self-sufficiency in waste management.

The National Basic Research Program (also called 973 Program) is China's on-going national keystone basic research program, which was approved by the state government in June 1997 and is organized and implemented by the Ministry of Science and Technology (MST, 2003). The Program has gathered together expertise to launch innovative studies on major scientific issues relating to sustainable development such as energy, information, resources and environment, population and health and materials, in line with the national goals and tasks for economic and social development. The Science and Technology Framework for Sustainable Development is intended to guide science and technology work for sustainable development across the country. One of the priority areas under this framework is environmental pollution control which facilitates and promotes the development of technologies for monitoring and controlling pollutants, cleaner production, as well as treatment and disposal technologies for waste including hazardous waste and obsolete household
appliances. In July 2003, MST started up one of the ‘863 Projects’, which is the Hi-Tech Research and Development Program of China, a whole set of research techniques on the reuse of obsolete electronic appliances. This project is managed by Tsinghua University and Haier Group, one of the biggest electronic product manufacturers in China (MST, 2003).

On 30th October 2003, SEPA subscribed to a Proposal on Environmental Protection Activities for Mobile Phones. The sponsors included seven famous mobile phone manufacturers in China, Motorola, Samsung, Nokia, Haier, Haisence, Capitel and TCL (Li, 2003). Actually as early as 2001, Nokia launched its ‘Future is in Your Hands’ campaign in the Asia-Pacific area, and in China in 2002, more than 200 recycling bins were placed in and around 100 major cities at Nokia service centres (Li, 2004a and Hicks et al., 2005). But at this stage, Nokia China has only collected approximately 0.5 tons of batteries and chargers, as consumers prefer to sell old mobile phones on the secondhand market. The demand for recycled materials and the potential new regulatory framework are contributing to industrial scaling-up and increased interest among companies in investing in e-waste processing (Hicks et al., 2005). Large international electronics companies are extending their corporate responsibility programs to China. Instead of relying on the Chinese regulatory system, a number of companies are developing their own initiatives, and sending external auditors to check compliance with corporate social responsibility principles. China’s Huaxing Group was choosing a site in Beijing for a pilot e-waste recycling and treatment plant (People’s Daily, 2005). New, large-scale recycling and treatment plants were also being planned to be set up in Nanjing and Wuxi, Jiangsu province, by the Singaporean e-waste recycling. Private e-waste take-back schemes are still limited in China, although mobile phone producers have begun to collect waste phones and accessories.

As stated above, in January 2004, Zhejiang province and Qingdao City were set by NDRC as experimental province and city for construction of recycling and disposal
systems for e-waste. Qingdao is host to China’s largest appliance manufacturers, such as Haier, Aucma and Haixin corporations. The Qingdao Economic and Trade Commission directs this pilot programme, and will trial a producer-owned recycling plant model, aiming to establish a plant with the capacity to process 600,000 items of e-waste per year (Zhang and Li, 2005 and China Business Herald, 2005). Another e-waste management pilot programme in Zhejiang province will follow a special disposal plant model, with the establishment of an e-waste treatment facility by a special company. The administrative institution responsible for the management of this pilot is the Zhejiang Provincial Economic and Trade Commission (ZETC). It was reported that the Hangzhou-based company, DADI Environmental Protection Co. Ltd, has been commissioned to construct a centralized disposal centre, which will make use of a network of collection and recycling points across the whole province (ZETC, 2004). After its establishment, Zhejiang province aims to recycle 800,000 units of e-waste each year.

As well as the national pilot programmes, local government initiatives on e-waste management are being developed in Tianjin, Shijiazhuang and Shanghai. Tianjin, for example, is currently attempting to revive the government-owned recycling network that existed from 1955 to 1990. The Tianjin Green Angel Co. Ltd. is setting up a ‘1,9,3,1’ system, referring to 1000 neighbourhood recycling stations, 9 transfer stations, 3 exchange centres for recycled materials, and one e-waste treatment plant (Economic Observer, 2004). The Shanghai city government is also planning to establish its own facility, with a capacity to treat 500,000 items per year (Bao, 2004).

In April 2004, in the 2004 International Conference on Electronic Waste and Extended Producers Responsibility in China, organized by Greenpeace and the Chinese Society for Environmental Sciences, the politicians and experts in environmental protection indicated that there were two directives being drafted. One is the Ordinance on Collection and Reuse of Obsolete Electronic Appliances and the other is the Management Methods on Pollution Prevention in Electronic Industry. These two
regulations were seen as the Chinese WEEE and RoHS, and are considered to be the most important steps in e-waste management (CCIA, 2004; Li, 2004 and Zhou 2004). Four months later, in August 2004, a National Forum on New Partnership for the Environmentally Sound Management of Hazardous and Other Wastes with Partnership Initiatives was held in Qingdao (BCRC China and Qingdao EPB, 2004). The main topic of this conference was also about e-waste control in China and the impacts of the two directives, WEEE and RoHS, to the electronics industry in China as well as the countermeasures.

2.5.7 Producers’ responses to international e-waste regulations

China is also facing incentives to comply with the international environmental standards, especially the EU WEEE and RoHS directives. According to statistical data, exports from the electrical and electronic products sector earned China US$227.46 billion in 2003, accounting for 51.9% of the country’s total export value (Guo et al., 2005). Of these exports, approximately 25% went to the EU. It was estimated that products affected by the WEEE and RoHS directives will account for around 71% of the China Electronics Import and Export Corporation’s exports to the EU market, worth more than US$31.7 billion and, unless full compliance with the new standards can be achieved, there is a risk that these exports will be reduced by 30–50% (Business Weekly, 2004 and Wang, 2004). These international directives have a profound impact on the electronics industry in China due to the large proportion of electrical and electronic products exported to the EU countries. As a major global electronics manufacturing and components supply country, it is clear that China must be in compliance with these two new directives or otherwise suffer massive export declines.

Recognizing the considerable impacts of the WEEE and RoHS directives, some studies have been carried out to determine the preparedness of electronic products manufacturers in China (Wu, 2004; HKPC, 2005 and Yu et al., 2006a). In Hong Kong,
the readiness for WEEE and RoHS seems to be much more worrying. According to the result of a survey conducted by the Hong Kong Productivity Council in February 2005, half of the 100 manufacturers interviewed were not aware of the RoHS (48%) and WEEE (53%) directives (HKPC, 2005). Among those who were familiar with the directives, 30% had not adopted any measures to prepare for compliance, with about half of them quoting 'no ideas on how to prepare for RoHS and WEEE compliance' as the key reason for non-adoption (HKPC, 2005). Nevertheless, in general, most of the existing empirical studies seem to be rather non-comprehensive and more like a quick survey.

Although a number of theoretical studies addressing the impact of WEEE and RoHS on China's electronics industry have also been available (Wu, 2003 and Wang, 2004), very little empirical research has been conducted to investigate the current status of the industry in response to these two directives. One empirical study carried out by Wu attempted to evaluate the progress of WEEE and RoHS compliance among China's electrical and electronic products manufacturers (Wu, 2004). According to the findings, 40% of suppliers were taking actions to address the issues of toxic chemicals while another 20% were doing nothing. However, since the objectives of Wu's survey only targeted the suppliers and staff of one company, it appears to be an inadequate evaluation of the whole industry. And the producers' responses to the domestic e-waste management system and related regulations are also very limited (Yu et al., 2006a).

2.5.8 Public responses to e-waste management

There has been no specific study to examine the reaction of the public to e-waste management in China. Various media, such as websites and newspapers, have designed some simple questionnaires for environmental promulgation or educational purposes. Figure 2.8 and Figure 2.9 show the results of an informal survey undertaken during 2005 in Beijing, China (SOHU, 2005, Cited by Liu et al., 2006). The survey
was carried out on the website and the number of responders was 1100. Nearly 57% of them were willing to sell their obsolete electronic appliances to the street hawkers or private workshops and only about 17% of them would send their e-waste to the producers or formal recyclers. In theory, the e-waste collected by private collectors passes to the small-scale workshops and is recycled by informal processors driven by economic incentives. Less than 10% of people were willing to store e-waste in their homes because of the high population density in Beijing and the fact that the majority of houses are small apartments. Around 9% of the responders thought that it was their responsibility to pay for the recycling and the disposal of e-waste. Most people (around 64%) thought that the producers should pay for it. The other two surveys carried out in Xian, capital city of Shanxi Province and Hangzhou, capital city of Zhejiang Province, indicated similar results (Huang et al., 2006). These surveys showed that the Chinese citizens traditionally look at their obsolete electronic products as valuable goods and they would prefer to sell them to get some money back rather than to pay for the treatment of e-waste (Liu et al., 2006).

![Figure 2.8 Percentage of Beijing residential options for obsolete e-waste](image)

Source: SOHU, 2005, Cited by Liu et al., 2006
2.6 The problems in e-waste management in China

The literature shows that there is no special management system for e-waste in China at present. It is not even clear which institution or department should be responsible for the management of e-waste (Li, 2004; Dong and Fan, 2005; Yan and Liu, 2006). For example, solid waste management belongs to the SEPA and local environmental and sanitary department, while the management of recovery and reuse of waste is the main work of the Department of Resource Multipurpose Utilization (Zhou, 2004). And also the process of recycling and disposal of e-waste should be controlled by the environmental protection department due to the hazards and pollutants in e-waste. This situation makes the management of e-waste very complicated. Sometimes the management department will shirk its responsibility because the duty is not explicit. So if all of these departments cannot coordinate very well, the laws or regulations will be poorly enforced (He, 2004).

There still exist other problems in legislation on e-waste in China. The list of hazardous wastes, especially e-waste, is not clear. Because e-waste is a totally new problem in the recent one or two decades, with the rapid development of information
and electronic industries, there are no special standards to define e-waste and to evaluate the hazards in e-waste, which will make it difficult to interpret some laws or regulations. Some experts in SEPA said that at present even the obsolete computers are not included in the existing resource recovery lists (Li, 2004).

At the same time other countries' legislation brings very serious influence on e-waste management and will significantly affect the electronics industry in China (Daily Science and Technology, 2004). Undoubtedly, complying with the industrialized countries' regulations will have to involve the whole electronics supply chain including suppliers, manufacturers, sellers, distributors and recyclers. Companies along the supply chain have to change their materials, design and manufacturing processes simultaneously, and most of the industry needs to change together. Suppliers and manufacturers are encouraged to incorporate the thinking of green-design into their product design strategies. Nevertheless, while some leading electronics manufacturers, such as Sony and HP, have proactively developed initiatives to address the WEEE and RoHS Directives, a large part of the electronics supply chain in China seems ill prepared for these changes (Wu, 2004; Shi and Li, 2005). The economic imperative of complying with e-waste standards overseas is therefore an encouraging factor in the development of a domestic e-waste management system.

China is a resource-poor country, with per capita distribution of natural resources at 58% of the world average (SEPA, 2004). In addition, China's growing electrical and electronic products manufacturing requires large amounts of raw materials and components, and recycled materials are regarded more favorably than they are in industrialized countries. So e-waste recycling and disposal can play a role in resource re-utilization and income generation. But the present unregulated recycling and disposal of e-waste results in the recycling of only the most precious and easily extracted materials, such as copper wiring, lead solder and gold plating. Other more difficult to process or less valuable components, such as toner cartridges and de-
soldered printed wiring boards, are often discarded. It is a waste of useful resources.

The e-waste industry provides income generating opportunities for both individuals and enterprises, as waste is sold and traded among collectors, processors, secondhand dealers and consumers. For example, the extensive e-waste processing industry in Guiyu has been valued at about RMB 600 million per year, or approximately US$72 million (Dayoo Daily News, 2004, Cited by Hicks et al., 2005). Cheap labour and a favourable investment environment have already seen the relocation of recycling business in general from industrialized countries to China. But the current lack of a regulatory framework for such enterprises has limited almost all the investment (Li, 2005; Han and Hu, 2005). For example, the pilot programme in Qingdao has reportedly been put on hold, as no local e-waste management regulations have been prepared. According to a representative from Haier, environmentally sound processing measures account for fully one half of recycling costs, and if the company pays more for waste to compete with private collectors, it will make a loss of tens of millions of RMB (China Business Herald, 2005). In Zhejiang province, another national pilot programme has also experienced difficulties in collecting e-waste and covering the costs of environmentally sound processing (Yan and Liu, 2006). Similarly, according to Mr. Hong Liang, DADI’s vice general manager, the company has slowed down its collection activities due to the high cost of paying for e-waste, which averages RMB 110 (US$13) per item, not including transport and personnel costs (Hicks et al., 2005).

As in Zhejiang and Qingdao, local initiatives in other areas are also facing collection difficulties, as e-waste is dismantled of valuable components and dumped or sold to secondhand market and private small-scale workshops.

Another problem is smuggling. At the international level China has banned imports of certain e-wastes, but the literature shows that on the local level the illegal smuggling via corrupt officials continues (Lee, 2002 and Xu et al., 2004). The government has begun to reinforce the legislation system to strictly forbid importing e-waste into China. But some local officials have poorly enforced the laws or regulations in order
to gain money from illegal import (Xu et al., 2004; Yan and Liu, 2006). In an investigation made by Greenpeace China, a retailer told investigators that if he paid more money to the relevant management department, obsolete circuit boards and other computer accessories could easily pass the inspection of Customs and then be transported to anywhere in Guangdong Province by ship or by container truck (Greenpeace China, 2003). This is a very serious problem in China and is one of the main reasons that the laws or regulations appear to be poorly enforced.

2.7 Summary

The fastest growing quantity of e-waste and the hazards in it are two primary characteristics which make e-waste become a worldwide problem of crisis proportions. This literature review has given the basic information and the background knowledge of e-waste in general and has reviewed the present legislation and management on e-waste both in industrialized and developing countries. Although e-waste contains hazardous materials, if recycled properly, the materials and some of the components in it can be used as replacement of raw materials and components required in the growing electronics industry and other manufacture fields. Therefore environmentally sound recycling of e-waste has the potential to get a high economic value.

Industrialized countries have established a comprehensive body of e-waste management systems. Many of them enacted national e-waste legislations to regulate the manufacturers’ and importers’ responsibility for the collecting and recycling end-of-life electrical and electronic products. And several initiatives for dealing with e-waste problems as well as the activities to prohibit the exporting of e-waste from industrialized countries to developing countries have been conducted. The implementation of e-waste management regulations in industrialized countries, especially the two directives WEEE and RoHS of EU, has led to essential changes in the electronics industry and in the field of e-waste management not only in those
countries but also world wide. All the efforts which industrialized countries have made in e-waste management will be good examples for developing countries to control their own e-wastes.

Developing countries display the fastest growing markets for electrical and electronic products and, accompanying with this growth, the quantity of domestic e-waste has increased rapidly. Besides handling their own rapidly growing e-waste, developing countries now also have to manage the e-waste being dumped within their national boundaries by industrialized countries, which has aggravated the e-waste problem. The biggest drawback of the current e-waste management systems in developing countries is the improper recycling and disposal of e-waste which has caused serious environmental pollution and affected the workers' and residents' health. The lack of enforceable regulations and lax enforcement has limited the effective control of e-waste in developing countries.

E-waste is an emerging issue in developing countries including China, driven by the rapidly increasing quantities, as well as its toxic nature and the economic value of the recycled substances. Regulating e-waste calls for clear policies, regulations and institutions for effective management, monitoring and control. The existing legislative and regulatory framework in developing countries should be strengthened to be able to (i) effectively control environmental pollution caused by e-waste; (ii) regulate the secondhand market of electronic products; (iii) comprehensively utilize valuable materials in e-waste; (iv) develop a regulated recovery system for e-waste; (v) control e-waste import from industrialized countries, and (vi) harmonize internal management systems with international legislative frameworks and institutions for effective competition on the international market. By analyzing the detailed situations of the present legislation and management on e-waste in developing countries, especially in China, some problems on e-waste management were found. But there still exist other problems to be identified in the future research and this is also one of the main objectives of this research. All the knowledge above will be used as a platform for
Although there are many other elements of strategies to manage e-waste, first of all, through analyzing the legislation and management systems on e-waste in both industrialized and developing countries and studying the experiences of many industrialized countries, lack of regulations and lax enforcement have obstructed the effective management of e-waste in developing countries. It is a priority to improve and ameliorate the existing legislation system on e-waste management in developing countries before the problem becomes worse. So this research is to find how legislation and regulations can be used to improve management of e-waste in developing countries and especially in the case of China.
Chapter 3 Methodology

3.1 Introduction

This chapter considers the methodology adopted in this research. The rationale behind the methodological approaches is explained. The objectives of the research and both the primary and specific research questions are illustrated. The research design including the main research strategy is explained. The instruments used to maximize the validity and reliability of this research are stated. The data sources and methods of data collection are explained. Then the process of the fieldworks as well as the detailed contents and timetables are described. The database summary, the analytical framework and the modifications to the methodology are also explained in this chapter. A case study methodology was used to collect data from key relevant government departments/institutions involved in e-waste management/regulation, from electronic appliance producers, as well as from customers at different levels of the value chain. The main methods used for data collection were review of relevant departmental documents/publications, key informant interviews and field observations.

3.2 Objectives

As stated in the first chapter the main purpose of this research is to find how legislation and regulations can be used to improve management of e-waste in developing countries and especially in the case of China. In order to achieve this aim, this research focuses on the legislation framework of e-waste management and the implementation of legislation, as well as the links between these and the administrative institutions.
The objectives of this research are:

1. To identify the present situation of e-waste management in China
2. To find the existing problems during the enacting and implementing process of legislation on e-waste management
3. To evaluate the linkages and relationships of policy formation, legislation, institutions and other influences
4. To survey the implementation, review and feedback processes of the laws and regulations on e-waste management
5. To assess the effects of existing e-waste management regulations
6. To investigate the effects of public or official attitudes and recycling systems on e-waste legislation

3.3 Research questions

3.3.1 Primary research question

How can legislation and regulations be used to improve the management of e-waste?

3.3.2 Specific research questions

In order to achieve the above objectives of this research, a number of specific research questions leading towards answering the primary research question are developed after undertaking the literature review. The specific research questions are divided into four main blocks which can also be considered as four perspectives on the primary research question. The four blocks are:

1. policy formation and the framework of legislation and the administrative institutions
2. implementation, review and feedback processes of the laws or regulations on e-waste management
3. other influences on e-waste legislation
4. effects of e-waste management regulations
Identifying the present situation of e-waste management and finding the existing problems during the enacting and implementing process of legislation are important to understand the process of developing the legislation. Part of these two purposes can be reached through literature review in the second chapter while most of them can be achieved through finding the answers to the specific research questions in block one. E-waste is not only an environmental issue but also a social problem. Many administrative departments and institutions are involved. To address it, it needs different institutions and organizations to cooperate. So besides the policy formation process, the specific research questions are also developed to evaluate the linkage and relationships of legislation/regulations, and institutions. Policy development as well as development of laws and regulations is a dynamic process, changing in significance along with continuous changes in its social and political conditions. It should always be reviewed and improved, made more efficient, more responsive and more flexible. So in this research the review and feedback process will be an important part to be considered. The related specific research questions are raised in block two, to survey the implementation, review and feedback processes of the laws and regulations on e-waste management.

The other influences mainly focus on the other countries’ or international legislation which will directly affect the policy formation process in China. From another perspective public and official attitudes, recovery systems and recycling technologies are all factors will also affect the effective management on this issue. So in the third block the specific research questions are raised to investigate respectively the attitudes (producers’ and consumers’) on e-waste, and the recycle system of e-waste. In addition another necessary step is to assess the effects of existing e-waste management regulations. These can also be considered as a part of the policy review process. All the related specific research questions are put into the last block. The main specific research questions and relevant objectives are shown in Table 3.1.
Table 3.1 Main specific research questions

<table>
<thead>
<tr>
<th>Blocks</th>
<th>Specific research questions</th>
<th>Objectives(3.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy formation and the framework of legislation and the administrative institutions</td>
<td>What deficiencies exist in the legislation for effective e-waste management in China?</td>
<td>1; 2; 3</td>
</tr>
<tr>
<td>Implementation, review and feedback processes of the laws or regulations on e-waste management</td>
<td>How are regulations on e-waste in China enforced and monitored?</td>
<td>1; 3; 4</td>
</tr>
<tr>
<td>Other influences on e-waste legislation</td>
<td>What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?</td>
<td>1; 6</td>
</tr>
<tr>
<td>Effects of e-waste management regulations</td>
<td>What effects do the regulations have on e-waste management?</td>
<td>2; 5</td>
</tr>
</tbody>
</table>

3.4 Research design

Research literally implies repeating a search for something and implicitly assumes that the earlier search was not exhaustive and complete in the sense that there is still room for improvement (Sufian, 1998). Research, therefore is a process of query based on earlier knowledge. It can be defined as a systematic way of asking questions, a systematic method of inquiry. Research involves a quest for knowledge, one that is conducted in a rational way using scientific methodologies (Berger and Patchner, 1998). The research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research question or problems. It shows the logical sequences that connect the empirical data to a study's initial research questions and ultimately lead to its conclusions (Yin, 1994). In this research, after the literature review which was conducted to gain the understanding of the existing knowledge of e-waste management, the primary research question was defined. Then the most important step was to choose the appropriate research strategy.
3.4.1 Menu of research strategies

The main research strategies include experiments, surveys, histories, the analysis of archival information and case studies (Denscombe, 2003 and Yin, 2003). Each is a different way of collecting and analyzing empirical evidence, following its own logic. And each strategy has its own advantages and disadvantages, depending on three conditions: (a) the type of research question posed, (b) the extent of control an investigator has over actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events (Yin, 2003). Based on these conditions the matching research strategy to the primary research question will be chosen. Table 3.2 displays these three conditions and shows how each are related to the four major research strategies.

Table 3.2 Relevant situations for different research strategies (Yin, 2003)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Form of research question</th>
<th>Requires control of behavioural events?</th>
<th>Focuses on contemporary events?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>how, why?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Survey</td>
<td>who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Archival analysis</td>
<td>who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes/No</td>
</tr>
<tr>
<td>History</td>
<td>how, why?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Case study</td>
<td>how, why?</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.4.2 Selection of research strategy

According to Table 3.2, to differentiate the various research strategies, the first and most important condition is to identify the type of research question being asked. "What", "who" and "where" questions are likely to favour survey strategies or the analysis of archival records, but "how" and "why" questions are likely to favour the use of experiments, histories or case studies because such questions deal with operational links needing to be traced over time rather than mere frequencies or
incidence. The primary research question in this research is “How can legislation and regulations be used to improve the management of e-waste?”. Then this type of “how” question may be tackled by experiment, history or case study.

A further distinction among experiment, history and case study is the extent of the researcher’s control over and access to actual behavioural events. Experiments involve the manipulation of circumstances while histories and case studies do not. This research focuses on the e-waste issue in developing countries which cannot be controlled. So experiments can be excluded. Histories are used when there is no access to actual behavioural events. The historical method is in dealing with the past and relies on primary documents, secondary documents, and cultural and physical artifacts as the main sources of evidences. The case study is preferred in examining contemporary events. It relies on many of the same techniques as a history but it adds two more important sources of evidence: direct observation of the events being studied and systematic interviews of the persons involved in the events. To summarize, when a “how” or “why” question is being asked about a contemporary set of events, over which the researcher has little or no control, case study will be preferred. In this research the e-waste issue is a contemporary event and based on the considerations mentioned above case study has been chosen as the main research strategy.

3.4.3 Advantages of the case study

Case studies focus on one instance (or a few instances) of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance (Denscombe, 2003). It is the main benefit of using a case study approach. This research spotlights one instance, the e-waste issue in China, and focuses on the legislation framework of e-waste management and the implementation of legislation, as well as the links between these and the administrative institutions. It can deal with the case as a whole and thus have the chance of being able to discover how the many parts affect one another, and then
explaining why certain outcomes might happen. Another advantage of a case study approach in this research is that it allows the use of a variety of research methods and fosters the use of multiple sources of data. All of these can help this research to become an in-depth study, delving into things in more detail and discovering things that might not have become apparent through more superficial research.

3.5 Maximizing validity and reliability

There are four tests which have been commonly used to establish the quality of case studies (Sedlack and Stanley, 1992; Rudestam and Newton, 2001; Yin, 2003).

1. Construct validity: establishing correct operational measures for the concepts being studied

2. Internal validity (for explanatory or causal studies only, and not for descriptive or exploratory studies): establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships

3. External validity: establishing the domain to which a study's findings can be generalized

4. Reliability: demonstrating that the operations of a study — such as the data collection procedures—can be repeated, with the same results

Table 3.3 lists these four widely used tests and the recommended case study tactics as well as a cross-reference to the phase of research in which the tactic is to be used (Yin, 2003). These tactics will be used not just at the beginning of this case study but throughout the whole investigation process.
Table 3.3 Case study tactics for four design tests (Yin, 2003)

<table>
<thead>
<tr>
<th>Tests</th>
<th>Case study tactic</th>
<th>Phase of research in which tactic occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>Use multiple sources of evidence</td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>Establish chain of evidence</td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>Have key informants review draft case study report</td>
<td>Composition</td>
</tr>
<tr>
<td>Internal validity (for</td>
<td>Do pattern-matching</td>
<td>Data analysis</td>
</tr>
<tr>
<td>explanatory or causal</td>
<td>Do explanation-building</td>
<td>Data analysis</td>
</tr>
<tr>
<td>studies only, and not for</td>
<td>Address rival explanations</td>
<td>Data analysis</td>
</tr>
<tr>
<td>descriptive or exploratory</td>
<td>Use logic models</td>
<td>Data analysis</td>
</tr>
<tr>
<td>Research design</td>
<td>Use theory in single-case studies</td>
<td>Research design</td>
</tr>
<tr>
<td></td>
<td>Use replication logic in multiple-case studies</td>
<td>Research design</td>
</tr>
<tr>
<td>Reliability</td>
<td>Use case study protocol</td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>Develop case study database</td>
<td>Data collection</td>
</tr>
</tbody>
</table>

Generally validity and reliability are the two most important quality control factors in research design. This research is an exploratory case study so for validity only construct validity and external validity will be considered both in research design and the data collection process. The research design and data collection methods were developed and refined by peer review. Data were gathered from various sources and collected in multiple ways. The study was also reviewed by peer researchers, participants and interviewees. Findings were matched against similar cases for checking generalization potential. All of these ways were used to improve the validity of this research.

Reliability means that if another researcher followed the same procedures as described by the earlier researcher, and conducted the same case study all over again, the same findings and conclusions would be reached. The objective of reliability is to minimize the errors and bias in the research. To increase the reliability of a case study the protocol plays an important role. The case study protocol can guide the researcher in carrying out the data collection. The case study protocol has four main sections which are an overview of the case study project, field procedures, case study questions and a guide for the case study report (Yin, 2003). In this research the
overview covered the background knowledge of e-waste, the issues arising from it, the detailed situations of the present legislation and management system on e-waste in developing countries, especially in China, and the relevant readings about e-waste. Two fieldworks were carried out to access the key interviewees and institutions. Before interviews the introduction to this research as well as its purpose, the issues about e-waste and the research plan were offered to all interviewees. Specific research questions to be asked in the interviews and potential methods for each question were carefully prepared and the objectives of this research were always kept in mind when collecting data. A clear schedule of the data collection activities in the fieldworks was made and completed within specified periods of time which is illustrated in Appendix 5. The procedures are all documented for repeatability. The database for this research was prepared to conveniently analyze the evidence. All of the above factors were carefully controlled to maximize the reliability of this case study.

3.6 Data collection

This research uses both primary and secondary data sources. The primary data come mainly from the interviews with experts in related e-waste management administrative department or institutions, concerned authorities, electronic appliance producers and customers plus direct and non-participant observations. The secondary data sources generally include the documents of government publications, early research reports, project reports, conference documents, theses, journal papers, newspaper articles, books and the internet. Recording instruments include making notes at the time or afterwards, taking pictures etc. All the different methods will be combined to increase the credibility of this research. Every specific research question will correspond to its own potential methods.
3.6.1 Primary sources

3.6.1.1 Interviews

In this research interviews were adopted as the main instrument to collect the first-hand data. The interview is particularly good at producing data which deal with topics in depth and in detail (Denscombe, 2003). To find the existing problems during the enacting and implementing process of legislation on e-waste management as well as the interviewees' own opinions about the e-waste issue, open-ended questions were prepared, which is the main characteristic of semi-structured interviews. One advantage of the semi-structured interviews is to let the interviewees develop their own ideas and speak more widely on the issues raised in the research. The clear lists of specific research questions and more detailed questions to be asked during the interviews were prepared to guide the topics of the interview and control the degree of it. In Appendix 6 the semi-structured interview questions are listed according to different informants. All these questions are flexible in terms of the order and adjustments can be made during the interview itself. Data can be checked for accuracy and relevance as they are collected. To reduce the dependence on interviewees and negative impacts, such as individual bias, documents and non-participant observations were combined with interviews to corroborate the facts.

3.6.1.2 Observations

Observation can directly record what people do, as distinct from that they say they do, or they say they think. It requires the researcher to go in search of information first hand, rather than relying on secondary sources (Denscombe, 2003). To identify the present situation of e-waste management in China and to investigate public attitudes to e-waste including the background of this issue, recycling system, etc. direct non-participant observations were conducted in several selected cities. The non-participant observations range from formal to casual data collection activities. Formal ones involve observations of e-waste collection points, the secondhand market for
electronic products, the regenerative resources market for reusable materials in e-waste, electronic appliance shops and e-waste treatment plants. Activities include the observations of e-waste management workshops in electronic appliance and communication facility factories. These observational evidences can be useful in providing additional information and gaining rich insights into this e-waste issue.

3.6.2 Secondary sources (documents and literature)

Documents and literature not only provide background information which is used as a platform for a research but can also be sources of data in their own right. They can provide specific details to corroborate information from primary data sources. This research focuses on the enactment and implementation of legislation. Much of the information about the legislation system and important articles in regulations will come from government documents therefore systematic searches for relevant documents are very important parts in this research. The required information can also be extracted from early research reports, thesis, conference literatures, project reports, journal papers, newspaper articles and books. The internet offers a convenient instrument for data collection but information was carefully selected and combined with other sources to improve the reliability.

3.6.3 Triangulation

Triangulation is used to describe collection of evidences by different methods and from various sources (Frankfort-Nachmias and Nachmias, 2000). Each method of data collection can look at the topic from a different perspective and produce different kinds of data on the same topic. At the same time each has certain unique advantages as well as disadvantages. Triangulation can overcome the deficiencies of any data collection method used by complementing each with another. Using multiple sources of evidences, the essence of triangulation, is the most important characteristic of a
case study and is also the best way to increase the validity and reliability of the research. In this research documents, literature and field observations were used to triangulate the findings from the semi-structured interviews.

3.7 Fieldworks

To collect the data and get relevant information two fieldworks were conducted in China. The first period of fieldwork was from 12\(^{th}\) January, 2005 to 2\(^{nd}\) March, 2005 in the cities, Beijing, Shanghai and Lanzhou. The second period was from 3\(^{rd}\) January, 2006 to 4\(^{th}\) March, 2006. In addition to the three cities already mentioned, Guangzhou, Shenzhen in Guangdong province and Tianjin were visited. Map 3.1 shows the main cities visited in these two fieldworks.

The main purpose of the first field visit was to identify the existing situation of the e-waste issue in China and to get the basic knowledge and information of this issue. Some questions asked in the interviews were tentative. According to the replies to these questions and findings from the first fieldwork, the topic was narrowed down and examined in more depth. The purpose of the second field visit was more explicit. The specific research questions and inquiries to be asked in the second field visit were reviewed and revised to focus more on the aim of this research. Another important function of the first field visit was to improve interview skills. Because the interviews were semi-structured and the questions were open-ended there was more emphasis on the interviewees’ points of interest. Sometimes the topic could not be controlled and moved away from the key point. At the beginning, while writing the field notes it was easy to lose the thread of the discussion. All of these shortcomings in the interviews were given more attention and improved as much as possible in the second field visit.

The observations were carried out in both fieldwork periods to identify the present situation of e-waste management in China and to investigate the public attitudes to e-
waste management. The main activities included the observations of e-waste collection points, the secondhand market for electronic products, the regenerative resources market for reusable materials in e-waste, electronic appliance shops, formal/informal e-waste recovery and treatment plants; and e-waste management workshops in electronic appliance and communication facility factories. The observations can support the information got from the interviews about the factors which will affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations.

Map 3.1 The main cities visited in the fieldworks

Source: Map of China, 2006
3.7.1 Selection of provinces and cities

The process of selecting the cities for the research was started by consulting existing literature and personal communication with relevant authorities in China. Six cities of China i.e. Beijing, Shanghai, Tianjin, Lanzhou in Gansu Province, Guangzhou and Shenzhen in Guangdong Province were visited in the fieldworks.

Beijing, as the national capital city, is recognized as the political and educational centre of China. All the national administrative institutions are located there. At the same time there are a great number of domestically or internationally well-regarded universities and academic institutions. Owing to its status as the political and cultural capital of China, a larger proportion of such institutions are established there than in any other city in China. Several conferences about e-waste management have been held in these institutions in the past few years. To gain knowledge of governmental policy of e-waste management, enactment and implementation of the laws or regulations about e-waste, it is the most suitable place to visit.

Shanghai serves as one of the most important cultural, commercial, financial, industrial and communications centres of China. It is regarded as the citadel of China's modern economy. Many large multinational corporations are located there including many electronic appliance manufacturers and communication facilities producers. It is one of the best places to collect such information about e-waste from these producers. Shanghai is also home to many of China's top and oldest universities. In these universities, as well as the ones in Beijing, there are some researchers who first noticed the e-waste issue in China and have begun to conduct some useful research in this area. Another reason for choosing Shanghai is that the researcher studied and lived there for about seven years. So it is easy to find suitable interviewees and get information from diverse sources such as local libraries, reference centres and academic websites as well as connecting with relevant authorities in this area.
Since 2002 when the Basel Action Network reported the export of e-waste from the industrialized countries to China and other developing countries of Asia, Guangdong Province has always paid more attention to this e-waste issue because Guiyu, the focal centre of e-waste import and maybe the world’s largest e-waste dismantling centre is located in this province. So in the second period of fieldwork Guangzhou, the capital city of Guangdong province, and its peripheral towns and cities such as Shenzhen were chosen to observe the present situation of e-waste management. The local relevant authorities were also contacted. This area is one of the richest areas in the nation and its economy is based on manufacturing and export, especially the manufacturing of small household electronic appliances. For example Shenzhen, the city located south of the provincial capital Guangzhou and bordering on Hong Kong, has more than four hundred of the world’s five hundred biggest companies. A number of foreign I.T companies also have facilities in this city. It is also home to some of China’s most successful high-tech companies. To get the information from electronic appliance producers and to investigate the facts of e-waste in this area, plus all of the above factors are important reasons for fieldwork in these places.

There is a research student who is conducting similar research in Tianjin, a municipality city near Beijing, and he participated in a local research project on e-waste treatment. It is very important to communicate with peer researchers and discuss the topic from different perspectives. So Tianjin is another city chosen in the second fieldwork visit.

Lanzhou, located in the northwest part of China, is the capital city of Gansu province. In contrast to the upper municipality or sea-coast cities, Lanzhou is in the backland of mainland China and is an economically underdeveloped area. So it was chosen for comparison with other cities to find the differences in e-waste issues. The main activities were to interview some consumers to investigate their attitudes to e-waste. Lanzhou, Beijing and Shanghai were all visited in both fieldwork visits.
3.7.2 Selection of interviewees

The interviewees include concerned authorities, electronic appliance producers, consumers, street hawkers who collect obsolete electronic products from consumers and workers in the secondhand electronic production market. Concerned authorities in both fieldwork visits were seven professors or lecturers in environmental science or engineering department of different universities, four research students on solid waste management topics, two engineers in environmental engineering design institutions and nine experts in relevant administrative departments. Three professors and one research student were interviewed repeatedly in both fieldwork visits.

Some authorities are authors of the journal papers found during the literature review process. Some were recommended and introduced by peer researchers or professors in the researcher’s graduate university. Electronic appliance producers were first contacted as much as possible through email or via staff who work in such companies, both in Shanghai and Guangdong province where electronic products manufacturers are concentrated. Then interviews were conducted on the basis of response of these producers. Because the purpose of the unstructured interviews with consumers was just to investigate the effects of public attitudes on e-waste legislation, the interviewees were selected at random according to availability. All interviews were made by appointment to ensure availability of the interviewees. The research questions were in English when designing this research, but before interview they were all translated into Chinese for the interviewees’ convenience. Appendix 7 lists the detailed timetable and contents of fieldworks, including all detailed information about interviewees.
3.8 Database summary

Fieldwork notes and documents are the main materials to compose the database of this case study. The fieldwork notes were written in Chinese during the interviews and then translated into English. In Appendix 8 samples of key informant interview transcripts are illustrated. All the documents gathered both in the literature review process and fieldworks were catalogued according to the importance and contribution to this research. In Table 3.4 the interview data summary in both fieldworks and observational locations are illustrated.

Table 3.4 Data summary

<table>
<thead>
<tr>
<th>Fieldwork</th>
<th>Location</th>
<th>Interviews</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Concerned authorities</td>
<td>Producers</td>
</tr>
<tr>
<td>First time</td>
<td>Shanghai</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Beijing</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Lanzhou</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Second time</td>
<td>Beijing</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shanghai</td>
<td>5</td>
<td>8 + 1(^b)</td>
</tr>
<tr>
<td></td>
<td>Lanzhou</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Guangdong</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Tianjin</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>27 to 23(^a)</td>
<td>9</td>
</tr>
</tbody>
</table>

a. Three professors and one research student were interviewed repeatedly in both fieldworks.
b. One producer replied to the research questions through email.
c. Observations of e-waste management workshops in three electronic appliance and communication facility factories took place during the interviews.

3.9 Data analysis

Data analysis consists of examining, categorizing, tabulating, testing, or otherwise recombining both quantitative and qualitative data to address the primary research question of the study. In this case study the analysis is more reliant on qualitative data and interpretive methods than quantitative data and statistical procedures. This is
because of the character of this case study and methods used in the data collection process. The analysis will be based on what is written down in documents and literature found in both the literature review process and fieldworks, which means that analyzing the existing policies on e-waste management is an important part in this research. But because e-waste management is only just beginning to enter the government's eyeshot, a large part of the policy is unwritten and therefore part of the analysis has relied on what was recorded, written and analyzed in the fieldworks. Interviews were transcribed from field notes, verbatim as much as possible. All the administrative documents, formal studies and organizational records or reports as well as interview notes from the fieldworks were developed into the database for the research. Patterns, processes, commonalities and differences were used in analysis and development of explanations. Generalization and conclusions were drawn from the refined explanations. The textual data were handled manually using basic software such as Microsoft Excel. The main analysis methods included both vertical and horizontal comparison to develop explanations and then to draw the conclusions.

The procedure of formulating policies or regulations can be divided into several phases according to the different periods. Reviewing these phases will help to discover the formulation process of these regulations, why these regulations were amended with social or industrial development, what kind of limitations there were in former regulations and then how these regulations were improved. Policy is not about the present. We can learn from the past in order to develop more suitable ones relevant to contemporary issues. The emerging risk of e-waste has only aroused government attention in China in recent years. So the regulations in this field are not very complete, but it is also worth identifying the whole procedure.

By comparing with other similar policies it will be easier to find the loopholes or contradictory parts in existing regulations on e-waste management as well as the shortages of these regulations, thus developing suitable strategies or improving these regulations to effectively manage e-waste in China. The effective parts in the policies
or regulations will be kept as reference.

The horizontal comparison can be divided into two parts. From the domestic viewpoint, reviewing the development procedure of regulations or policies on hazardous solid waste management or batteries or white goods management will be helpful to find the similar development procedure based on the current situation of China. The targets, backgrounds and whole process will be similar. Then under the same conditions some of the policies will be adopted to be implemented in the field of e-waste management. The limitation in these regulations will be avoided in e-waste management. The other way is by reviewing some other industrialized countries' policies and regulations on e-waste management. This will also be helpful for solving the same problems in China. Although the social background, economic conditions and industrial development levels are totally different, their successful experiences will give some useful suggestions to developing countries while their failures will be avoided during the policy development procedure. Reviewing the development procedure of policies or regulations and how the regulations were amended and improved will be important and significant to this research. Actually China also faces incentives to comply with international environmental regulations. The international regulations and industrialized countries' directives on e-waste management will bring positive or negative effects to e-waste management in developing countries. Complying with those regulations or finding our own regulations suitable for the present situation is therefore an encouraging factor in the development of a domestic e-waste management framework.

To analyze the qualitative data from the interviews, the information got in the fieldworks were categorized by the responses given by the informants. The data were analyzed mainly from the following four perspectives, which are corresponding to the four specific research questions (Table 3.1): (1) legislation framework of e-waste management and the administrative institutions; (2) implementation, review and feedback processes of the laws or regulations; (3) other influences on e-waste
Chapter 3 Methodology

legislation and (4) effects of e-waste management regulations. For perspectives (1) and (2) the key informants mainly come from state or local administrative departments, who participated in drafting relevant e-waste management regulations or are responsible for enforcing such regulations at local level. The information from these authorities can be representative samples to the relevant research questions. The similar key points were generalized from the replies to the research questions. For perspectives (3) and (4) the information were categorized and coded as the following main factors, which were identified during the interviews:

- The industrialized countries' legislation or policies
- The recycling system for e-waste including: (1) the recovery system of e-waste; (2) the secondhand market; (3) the regenerative resources market for reusable materials in e-waste; (4) and the registration of recycling and disposing enterprises
- The pilot projects on e-waste recycling and disposal
- Public attitudes (producers' and consumers') on e-waste legislation

The analysis and discussions were conducted according to these factors and specially for perspective (3), the information were supported or proved by the observations during the fieldworks. The producers who responded to the interviews all come from multinational corporations. The information from them just represented the large-scale electronic product manufacturers. Small-scale enterprises were very reluctant to be interviewed and therefore the information which can represent the middle- or small-scale electronic product manufacturing enterprises come from the secondary data source, such as published literature, or from other interviewees' responses to relevant research questions or from fieldwork observations.

Through the qualitative data analysis the generalizations are developed which can formulate implications to effectively manage e-waste in China. Then by comparing the implications got from the case of China and the analyzed conclusions from the literature review about the existing problems of e-waste management in other developing countries (section 2.4.4.2), the general implications for developing
countries which are facing the same e-waste problem as China are summarized. The chance of biased conclusions, if any, will be further minimized by peer review triangulation and objective manner of data collection.

3.10 Limitations of the research

Strict adherence to the designed data collection and analysis scheme is not always possible in practice. Modifications were made to accommodate real conditions. However, in making modifications maintaining the quality of data was given the highest consideration.

At the beginning the researcher contacted interviewees, including electronic appliance producers and related authorities, as much as possible through emails. In the first fieldwork no producers replied. In China it is almost impossible to visit those electronic appliance companies or directly interview producers without appointment. So the interviews were not able to be conducted in the first field visits. In the second field visits just eight producers showed interest in this issue and agreed to accept the interviews. Among them two were interviewed by telephone because they were not available at that time. Another one replied through email answering part of the research questions. Based on this situation the data had to rely on the other sources. For example the research students who were conducting similar researches in China offered important information about the producers’ attitudes to e-waste management although their researches were focused on the technologies of disposal of e-waste or how to recover valuable materials from e-waste. The same problems were met when trying to contact the relevant authorities. Not all the relevant authorities or experts in administrative institutions gave positive replies to the required emails. Some key authorities were difficult to contact because for them this was personal informal research. To a certain extent the data depended on the number of available interviewees and therefore the data from interviews were not very abundant. When the
researcher visited some secondhand markets and collection points the stakeholders or workers were also reluctant to be observed. All these shortcomings had to be overcome by triangulating all possible data collection methods and combining other secondhand sources.

In the interviews the interviewees did not always give direct answers to the questions but gave a wealth of information relating to the queries. This required the researcher to always keep the purpose of the research and the key points of the research questions in mind. Sometimes it was so easy to lose the thread of the discussion, especially in the first fieldwork, and in this situation the topic could not be easily controlled. In the second fieldwork some of the interviews were conducted when accompanied by another research student who could help in recording the conversation. The research questions asked in the interviews were also changed and revised several times according to the replies from the former interviewees.

When translating the fieldwork notes, literature and documents from Chinese into English, key points were noticed but some details were so easy to ignore. And in the analysis process the quantitative data were limited and, as a result, the analysis became more reliant on qualitative data. It was difficult to avoid bias particularly when some results did not meet original expectations, but peer review and triangulation were used in the whole process to maximize the reliability of this research.

3.11 Summary

Case study was selected as the research strategy of choice in this research. The main purpose of this research is to find how legislation and regulations can be used to improve management of e-waste in developing countries and especially in the case of China. The primary research question is: How can legislation and regulations be used
to improve the management of e-waste? The specific research questions were divided into four main blocks according to different objectives of this research and detailed questions researched or asked in the fieldworks were carefully prepared according to the potential data collection methods which are listed in Appendix 6. To maximize validity and reliability of this case study data were gathered from various sources and collected in multiple ways. Two fieldwork visits were made in China to gather the literature and relevant information. The database was created to analyze and interpret the guiding research questions and the objectives. The data will be analyzed from four perspectives: policy formation and the framework of legislation and the administrative institutions; implementation, review and feedback processes of the laws or regulations on e-waste management; other influences on e-waste legislation and effects of e-waste management regulations. The following chapters will focus on these perspectives respectively.
4.1 Introduction

In this chapter the main findings from the documents and literature which constitute the main secondary sources of data in this research are described. The first part is about the legislation framework on e-waste management in China including the formation process of the laws or regulations and the hierarchy of the legislation system on e-waste management. The detailed laws or regulations on prevention of pollution from e-waste and on e-waste import are described, listing also the corresponding purpose, the main points and the respective function of each law or regulation in e-waste management system. It not only provides background information which is used as a platform for this research but also can give sources of data to analyze the shortcoming or loopholes in the e-waste management system in China. The second part in this chapter describes the main administrative departments or institutions responsible for e-waste management, their relationships and enforcement of the legislation and regulations in China. Finally some information about the other influences on e-waste legislation is illustrated to triangulate the findings from the semi-structured interviews in the fieldworks. E-waste in this research refers to all wastes of electrical and electronic equipment as a single category, unless the special definition in relevant regulations. Much of the information about the legislation system, the important Articles in regulations and the organizational structure of the main administrative departments or institutions comes from government documents in Chinese.
4.2 The legislation framework on e-waste management in China

4.2.1 The formation process of the laws or regulations on e-waste management

E-waste was paid more attention by government and the public in China just after the activities in Guiyu and Taizhou two areas were reported in 2002. As stated in the literature review (section 2.5), in February 2002, Basel Action Network and Greenpeace published the report 'Exporting harm: the high-tech trashing of Asia', which indicated the serious environmental pollution and health damaging situation in Guiyu region, an e-waste dismantling centre in Guangdong Province of China (Basel Action Network and Silicon Valley Toxics Coalition, 2002). In this report simple and even primitive methods to dispose of e-waste which are extremely polluting and very harmful to workers' health were found, including the manual and unprotected removal of printer cartridge toner, the open incineration of wires to recover copper, the desoldering of printed wiring boards and the use of open acid baths to retrieve precious metals from chips and other electronic components. Three months later in May 2002 CCTV (China Central Television) reported another e-waste dismantling centre in Wenling City, Taizhou region in Zhejiang Province. The same problems happened. In both of these areas small-scale e-waste dismantling factories or unlicensed family work-sheds are the main operators of e-waste, which was domestically produced as well as illegally imported. Dismantling e-waste to get precious metals and selling obsolete electronic products to the secondhand market became the fundamental part in their local economy. But due to improper handling and environmentally unsound methods of disposal, these processes bring the most serious and hazardous effects to the environment as well as to workers' and residents' health which were described in Table 2.5.

After these two areas were brought to light by media, environmental administrative departments and relevant institutions began to recognize the serious influences brought by e-waste. The large and continually increasing quantities of e-wastes
produced domestically as well as the illegal imported ones need a clear policy, institutions and legislative infrastructure to effectively manage and control them. In the following year 2003 the EU issued two directives, WEEE (EU, 2003a) and RoHS (EU, 2003b). These two directives not only brought significant influence to the e-waste management in industrialized countries but also aroused intensive discussions in China. The incentive of complying with international environmental standards and finding countermeasures to deal with the effects brought by these directives, as well as addressing the environmental problems caused by domestic e-waste, urged the development of new legislations on e-waste management.

From late 2002 several national level legislations which were built on and strengthened the earlier regulations had been drafted in response to the perceived problem of e-waste in China. In December 2004 the State Environment Protection Administration (SEPA) promulgated the second version of the Law on Prevention of Environmental Pollution Caused by Solid Waste, the basic legislation on solid waste management in China, which has been effective since 1st April, 2005 (SEPA, 2004). In this version, for the first time, special articles about prevention of environmental pollution caused by e-waste were added, which shows that the administrative department thinks highly of the importance of controlling environmental pollution caused by e-waste. Besides SEPA another two departments the National Development and Reform Commission (NDRC) and the Ministry of Information Industry of the P.R China (MII) also drafted their respective regulations about e-waste management. These regulations play different roles in the legislation system on e-waste management and focus on different stages in this system which will be illustrated in detail in the following section 4.2.3. With the goal of addressing the problems in the draft legislation and the difficulties in the enforcement process of these regulations, pilot projects and relevant research programmes were being implemented at the same time. The regulation drafts were discussed several times by authorities in relevant administrative departments, consulted with experts in environmental institutions and released on the official website for public comments. The legislation system on e-
waste management is being constructed and improved gradually.

4.2.2 The hierarchy of the legislation system on e-waste management

At present the legislation system on e-waste management in China can be divided into five main levels according to the legal effectiveness and the issue authorities. The hierarchy of the legislation system on e-waste management is shown in Figure 4.1.

Figure 4.1 The hierarchy of the legislation system on e-waste management in China

1. The Constitution of the P.R China (GOV, 2004) is the highest and ultimate source
of legal norms in China. It establishes the framework and principles of government and lists the fundamental rights and duties of its citizens. In Article 26, 9 (2) and 10 (5) environmental protection is stated as one of the basic national policies.

2. The Environmental Protection Law of the P.R China is enacted for the purpose of protecting and improving people's environment and the ecological environment, preventing and controlling pollution and other public hazards, safeguarding human health and facilitating the development of socialist modernization (SEPA, 1989). The legal liability is in accordance with the provisions of relevant laws such as Criminal Law (GOV, 2006) and General Principles of the Civil Law of the P.R China (GOV, 2007). At the same time the International Conventions or Treaties such as the Basel Convention, which China has ratified, have the same legal effectiveness on environmental protection as the Environmental Protection Law.

3. The third level in the e-waste legislation system is the special purpose environmental laws. The Law of the People's Republic of China on Prevention of Environmental Pollution Caused by Solid Waste, which become effective on 1st April 1996, is the most important one (SEPA, 1995). It regulates that the people's government at the county level or above shall coordinate the prevention of environmental pollution caused by solid waste with environmental protection plans and shall adopt economic and technological polices and measures conducive to the prevention of environmental pollution caused by solid waste. The administrative department under the State Council in charge of environmental protection is responsible for establishing the monitoring system for environmental pollution caused by solid waste, formulating unified monitoring standards, and organizing a monitoring network in conjunction with other relevant departments. This is the basic legislation on solid waste management in China. But in this first version there are no special articles about prevention of environmental pollution caused by e-waste.

4. National administrative environmental or relevant laws and regulations issued by
the State Council and its directly affiliated departments are the fourth level in the system. This level can be subdivided according to the issue authorities. The laws issued by the State Council are in a higher position than the regulations or rules issued by the directly affiliated departments. At present in the fourth level there are four major regulations listed in Table 4.1. The effectiveness of these regulations is nationwide.

5. Provincial, municipal city and autonomous zone administrative environmental or relevant laws and regulations, legal explanations and treaty norms constitute the fifth level in this system. The relevant e-waste management regulations will be described in 4.2.4.

4.2.3 National laws and regulations on prevention of pollution from e-waste

Besides the Environmental Protection Law there are five main national laws and regulations related to e-waste management in China. Each law or regulation focuses on the different points in e-waste management and plays a different role in the whole legislation system which is reflected through respective purpose, the key words, the main content and the specific articles. The main national law and regulations related to e-waste management in China and corresponding issue authorities are shown in Table 4.1. The key laws and regulations are described and discussed in detail below from the original documents in Chinese.
### Table 4.1 National law and regulations on e-waste management

<table>
<thead>
<tr>
<th>Laws and regulations</th>
<th>Date of Effectiveness</th>
<th>Issue Authority</th>
<th>Section of Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Law of the P.R. China</td>
<td>December 1989</td>
<td>National People’s Congress Standing Committee</td>
<td>4.2.2</td>
</tr>
<tr>
<td>Law of the P.R China on Prevention of Environmental Pollution Caused by Solid Waste</td>
<td>April 1996 (Second version to be effective as of April 2005)</td>
<td>National People’s Congress Standing Committee</td>
<td>4.2.3.4</td>
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<tr>
<td>Announcement on Reinforcing the Environmental Management of the Waste of Electrical and Electronic Equipment</td>
<td>August 2003</td>
<td>SEPA</td>
<td>4.2.3.1</td>
</tr>
<tr>
<td>Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal</td>
<td>draft for comments released in September 2004</td>
<td>NDRC (Development and Reform Commission)</td>
<td>4.2.3.2</td>
</tr>
<tr>
<td>Management Methods on Pollution Prevention in Electronic Industry</td>
<td>July 2005</td>
<td>MII (Ministry of Information Industry)</td>
<td>4.2.3.3</td>
</tr>
<tr>
<td>Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products</td>
<td>draft for comments released in September 2005</td>
<td>SEPA</td>
<td>4.2.3.5</td>
</tr>
</tbody>
</table>

#### 4.2.3.1 Announcement on Reinforcing the Environmental Management of the Waste of Electrical and Electronic Equipment

In August 2003, SEPA published an Announcement on Reinforcing the Environmental Management of the Waste of Electrical and Electronic Equipment (SEPA, 2003). It is the earliest national regulation to manage e-waste. The enforcement of this regulation also aims to address the environmental issue caused by e-waste in those two areas in Guangdong and Zhejiang provinces where e-waste was highlighted by the media and even by international environmental protection organizations (section 2.5.3).

In this Announcement there are five main points to effectively manage e-waste.
All producers of e-waste, including producers of electrical and electronic equipment, electronic equipment repairing businesses and large electronic-using corporations or institutions should offer the data on e-waste to the local environmental protection department.

Obsolete batteries, switches containing mercury, CRTs and capacitors containing PCBs are all hazardous wastes. E-wastes which have the above components and other hazardous materials are also hazardous wastes.

The backward methods and equipment used to dispose of e-waste, such as the open burning and acid baths to recover metals, which will pollute the environment are forbidden.

The remnants and the sludge produced in the e-waste recycling or disposal process should pass the state hazardous waste appraisal. If they belong to hazardous waste, they should not be disposed with municipal solid wastes by landfill or incineration.

Provincial level environmental protection administrations should issue hazardous waste processing licences to enterprises that can meet environmental requirements for e-waste recycling in according with the Law on Prevention of Environmental Pollution Caused by Solid Waste.

4.2.3.2 Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (Drafted for Comment)

In January 2004, NDRC set Zhejiang province and Qingdao City, in Shandong province, as experimental areas for the construction of recycling and treatment systems for waste and old household electric appliances and electronic products, approved by the State Council (NDRC, 2004). It was hoped to supply valuable experiences in making interrelated policies and criteria and promote e-waste management as well as sustainable economic development. It was also expected to find suitable technologies and processes to recycle and dispose of e-waste in China’s current circumstances and to develop relevant technical standards.
Actually since 2001 NDRC has begun to prepare a draft of the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal. The draft for comments was released in September 2004 on their official website (NDRC, 2004) and has now been submitted to the State Council for approval. The main points in this Ordinance are as follows.

- Waste of household electrical and electronic products refers to both unusable electronic products and those which can be sold or used as secondhand products after being tested under relevant safety and functional standards control. It includes obsolete TV sets, refrigerators, washing machines, air conditioners and computers.

- E-waste shall be recovered through all kinds of recovery systems and be disposed of centrally. The enterprises which will recycle and dispose e-waste have to be granted qualification by the administrative department.

- In Article 7 the government will establish a special fund to assist in the financing of e-waste recycling and disposal. The government will also encourage the establishment of e-waste recycling and disposal enterprises as well as support the development of relevant technologies, methods and education.

- In Article 9 it regulates the responsibility of producers who use their own trademarks to manufacture and sell electrical and electronic products and those who offer their trademarks to other manufactures and other distributors as well as electronic product retailers and importers. Producers are requested to use designs beneficial to recycling, choose non-toxic, non-hazardous substances and recyclable materials and provide information to aid recycling. Producers, retailers and service providers have the responsibility to recover e-waste from consumers. Producers can dispose of e-waste by themselves or consign the task to professional and qualified disposal enterprises. They shall report to the local administrative department in charge of comprehensive resource utilization, the information about their products' outputs, distribution and export quantities.

- To ensure the safe and environmentally sound disposal process of e-waste, a
certification system and relevant standards for secondhand appliances and recycling and disposal enterprises will be established. The secondhand electronic products should be sold on the designated secondhand market and the products' name, the amount and the sources should be strictly registered.

The purpose of this Ordinance is to regulate the e-waste recycling and disposal process, promote resource recycling and comprehensive utilization, protect the environment and ensure the health of human beings. In this Ordinance, from product design to e-waste recycling and disposal, from producer's responsibility to consumer's obligations, the whole processes in e-waste management are generally regulated but are not in detail. This will be considered as the key and basic regulation on e-waste management, like WEEE of EU, after it has been officially issued.

4.2.3.3 Management Methods on Pollution Prevention in the Electronic Industry

Another regulation about e-waste is the Management Methods on Pollution Prevention in Electronic Industry. It was drafted by the Ministry of Information Industry of China together with another six administrative departments from late 2002 and was issued on 28th February, 2006. It entered into force on 1st March, 2007. The purpose is to control and reduce environmental pollution caused by obsolete electronic information products, to promote manufacture and to sell environmentally low-polluting products and protect the environment.

In this regulation:

- The electronic information products refer to any products which are produced by using electronic information technologies, such as broadcasting and television products, electronic communication products, electronic detection instruments, household electronic appliances and other components and accessories. It includes computers, televisions and CD/DVD or MP3 players but does not include refrigerators, washing machines and air conditioners. In this regulation
The environmental safety lifespan and the potential pollutants from electronic products are defined.

- The toxic or hazardous materials and elements in electronic information products include lead, cadmium, mercury, hexavalent chromium/chromium (VI), brominated flame retardants (BFRs) which include polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBB). A catalogue listing special electronic products which need essential pollution prevention and control will be compiled. In this catalogue the products are all those that have been confirmed to have found suitable materials to substitute for the above hazardous materials in them or those in which the levels of these hazards can comply both technically and economically with the relevant standards because substitute materials cannot be found.

- Before the hazardous materials listed in the catalogue are phased out, all the electronic information products should be labelled to indicate the name of the toxic or hazardous materials or elements and in which components or parts of the products they occur. Also the environmental safety lifespan and its recyclable character should be labelled according to relevant national or industrial standards.

- This regulation also regulates all the processes in the electronic industry in detail from design, manufacture and package to indication of measures to prevent environmental pollution. The main focus is on the design, manufacture, distribution and import processes of electronic information products to reduce the potential environmental pollution after they become obsolete rather than on the recovery, disposal and recycle processes of e-waste.

The Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (NDRC) and the Management Methods on Pollution Prevention in Electronic Industry (MII) are built on the Law on Prevention of Environmental Pollution Caused by Solid Waste and Cleaner Production Promotion Law. This law is enacted to promote cleaner production, increase the efficiency of utilization rate of resources, reduce and avoid the generation of pollutants and protect
and improve the environment (SEPA, 2002). This means that the government of China has realized the seriousness of e-waste and gradually reinforced and ameliorated the legislation in e-waste management. Another improvement was reflected in the amendment of the Law on Prevention of Environmental Pollution Caused by Solid Waste.

4.2.3.4 Law on Prevention of Environmental Pollution Caused by Solid Waste (Second Version)

In December 2004 SEPA promulgated the second version of the Law on Prevention of Environmental Pollution Caused by Solid Waste which has been effective since 1st April, 2005 (SEPA, 2004). In this version, for the first time, special articles about prevention of environmental pollution caused by e-waste were added.

- In Article 5 it regulates that producers, distributors, importers and consumers shall all take the responsibility of preventing environmental pollution caused by the solid waste they produce.
- In Article 37 it regulates that dismantling, utilizing and disposing of e-waste shall be in accordance with the relevant laws and regulations. And during these processes operators shall take measures for preventing environmental pollution caused by e-waste.

4.2.3.5 Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products (Drafted for Comment)

Based on this Law and to strengthen the management of e-waste SEPA released the draft of the Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products on the official website for comments in September 2005 (SEPA, 2005), but it has not yet been finalized and issued. This regulation is to reduce the overall volume of e-waste, increase the recycle rate of e-waste and reduce the negative and harmful environmental and health impacts of e-waste. Unlike the
Management Methods on Pollution Prevention in Electronic Industry this one focuses on the dismantling, utilization and disposal processes of e-waste.

The main points in this regulation are:

- Utilization of e-waste refers to the extraction of materials from e-waste then using them as raw materials or fuel but not including the refurbishment and reuse of e-waste. E-waste is defined as obsolete electrical and electronic products or equipment and other obsolete electronic components and accessories. Dangerous electronic waste refers to the dangerous electronic waste material which is placed on the national list of dangerous waste or which is specified as dangerous waste by the differentiating standards and methods established by the state. Such waste includes the obsolete electrical and electronic products or equipment which contains lead-acid batteries, Ni-Cd batteries, mercury switches, cathode ray tubes or polychlorinated biphenyl (PCB) containing capacitors.

- Any unit or person who produces e-waste shall be responsible for the prevention of pollution caused by e-waste, using environmentally sound technologies or methods to recover, store, dismantle, utilize and dispose of e-waste.

- It repeats the Articles in the Announcement on Reinforcing the Environmental Management of the Waste of Electrical and Electronic Equipment promulgated in 2003 (4.2.3.1) that outdated methods and equipment used to dismantle, utilize and dispose e-waste, such as the open burning and acid baths to recover metals, are forbidden.

- The enterprises which will recycle and dispose of e-waste have to be registered by the local environmental protection department. Manufacturers who produce industrial e-waste shall declare and register to the relevant department all e-waste outputs i.e. downstream pathways, storage, dismantling, utilization and disposal information.

- SEPA has already planned to formulate associated technological policies and standards on e-waste management.
4.2.4 Local regulations on prevention of pollution from e-waste

At the local level very few provinces or cities have drafted regulations to manage e-waste, except for Guangdong and Zhejiang Provinces where e-waste is the most serious issue in local environment protection and economic development processes. Regulations of Guangdong Province on Prevention of Environment Pollution Caused by Solid Waste were effective as of 1st May, 2004, at a time earlier than the second version of Law of the P.R China on Prevention of Environmental Pollution Caused by Solid Waste. In its Article 29 seven environmental pollution activities are prohibited including the open burning of electrical wires, cables, circuit boards, batteries and other electronic wastes. Disposing of or utilizing imported e-waste and running importing e-waste business in Guangdong province are also prohibited. This regulation is the first provincial regulation to control and manage e-waste.

Another province, Zhejiang, was appointed as the only experimental province to construct a recycling and disposal system to treat e-waste as early as 2004. But there were no relevant regulations until the beginning of 2005. Before the national Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products (Drafted for Comment) entered into force Zhejiang Provincial Economic and Trade Commission regulated standards for the certification of secondhand electronic appliances for resale; and a provincial temporary e-waste management regulation came into effect as of 1st January, 2005. This provincial regulation was implemented to fill in the blank in e-waste management in Zhejiang province before the national regulation was enforced and will be revised once the national regulation is enforced (NDRC, 2005).

At city level on 24th May, 2006 Provisional Administrative Rules of Waste Household Electrical and Electronic Products Recycling and Disposal was issued in Qingdao City, Shandong province (NDRC, 2006), the city appointed by NDRC for experimental e-waste management. The local government planned to start up a pilot e-waste recovery
and disposal project to deal with e-waste centrally in the whole city and to construct the recovery network to effectively collect e-waste. The manufacturers who do not have the ability to deal with e-waste themselves have to consign the pilot recovery centre to dispose of their e-waste as well as that from other government administrative departments and institutions. It is the first city level regulation to manage e-waste although it is just the interim regulation. In Shanghai its own provisional administrative rules to deal with e-waste are also being drafted.

4.2.5 Regulations to control importing e-waste to China

Small-scale e-waste dismantling factories or unlicensed family work-sheds were found by the media to obtain e-waste not only from the domestic market but also from illegal import. From the investigations both at Guiyu, Guangdong Province, and Taizhou, Zhejiang Province, the main non-domestic sources of e-waste are the USA, Japan, Canada, South Korea and Europe (Basel Action Network and Silicon Valley Toxics Coalition, 2002 and Lai, 2004). The government only permits a few types of waste and old materials to be imported, such as waste steel and waste paper, but e-waste is excluded. But a high proportion of e-waste is always mixed into the waste steels imported. Cheaper labour, lower recycling or disposal costs and lack of environmental standards and regulations have caused the industrialized countries to export e-waste to China. Although the demand for recycled materials and the higher economic profits have resulted in the illegal import of e-waste this has brought serious environmental pollution problems. Strict control of e-waste imports and reinforcement of relevant legislations are very necessary components of e-waste management.

4.2.5.1 International Convention

The government has made great efforts. China was one of the first global proponents for an international ban on the export of toxic waste from industrialized to developing countries. The Basel Convention on the Control of the Transboundary Movement of
Hazardous Waste and Their Disposal was adopted in 1989 and entered into force in 1992. As early as March 1990, China ratified the Convention.

4.2.5.2. National regulations on e-waste import

In 1995, an Urgent Circular of the General Office of the State Council on the Strict Control on Transference of Foreign Waste to China regulated that the import of foreign waste should be administered in two categories: first, waste that is forbidden to be imported; and second, waste that can be used as a raw material but the import of which shall be under strict control (SEPA, 1995b). In the Law on Prevention of Environmental Pollution Caused by Solid Waste published in 1996, dumping, piling or disposing of solid waste from outside of China and the import of solid waste which cannot be used as a raw material are all forbidden. It restricts the import of solid waste that can be used as raw material. The list of solid waste which can be imported for use as raw materials shall be stipulated, adjusted and announced by the administrative department in charge of environmental protection together with the department in charge of foreign trade and economic cooperation under the State Council.

In February 2000, China made public a document, the Notification on Import of the Seventh Category of Wastes, which announced that the seventh category of wastes approved by the SEPA for import shall not include abandoned computers, monitors, CRTs, copiers, microwave ovens, air conditioners, video cameras, electric cooking devices, rice cookers, telephones (except for pay-phones), video games (except for processing for re-export), televisions, picture tubes and refrigerators (SEPA, 2000). And from 1st April, 2000, the Customs Administration will not allow the entry of the above mentioned abandoned electrical appliances.

On 1st May, 2001, China ratified the Basel Ban Amendment which will effectively prohibit all exports of hazardous waste from member states of the OECD, the EU, and Liechtenstein to all other countries including China and will enter into force after it
receives 62 ratifications. This demonstrates China’s support for the Basel Convention and its obvious goal of national self-sufficiency in waste management.

In July 2002, SEPA and the Customs Administration issued a new list of wastes (SEPA, 2002) that China has banned for import, the Fifth List of Prohibited Goods for Import, which includes automatic data processing machines and units thereof; input or output units, whether or not containing storage units in housing; printers, including laser and ink-jet printers, other input or output units and other units of automatic data processing machines, printed circuits etc.

After the Law on Prevention of Environmental Pollution Caused by Solid Waste (Second Version) (4.2.3.4) was promulgated in 2004, and every year since, SEPA would publish lists of the appointed companies or plants which can import, utilize and treat solid wastes that can be used as raw materials, not including any prohibited electronic wastes. All these companies should register their imported wastes and should be supervised by both SEPA and the Customs Administration to control illegal e-waste import.

4.3 The administrative departments or institutions responsible for e-waste management

At the national level the main administrative departments and institutions responsible for the regulation and management of e-waste are the following four units, among which three of them, SEPA, NDRC and MII, have drafted or promulgated relevant laws or regulations to manage E-waste as illustrated in section 4.2.3.

- State Environment Protection Administration of the P.R China (SEPA)
- National Development and Reform Commission of the P.R China (NDRC)
- Ministry of Information Industry of the P.R China (MII)
- General Administration of Customs of the P.R China (CGA)
Besides these four departments the other three administrative units that also participate in part of the management of e-waste and cooperate with the upper four ones are:

- General Administration of Quality Supervision, Inspection and Quarantine of the P.R China (AQSIQ)
- State Administration for Industry and Commerce of the P.R China (SAIC)
- Ministry of Commerce of the P.R China (MOFCOM)

The respective functions and relationships of these institutions or departments are described below.

4.3.1 The enforcement administrative departments or institutions

4.3.1.1 SEPA

In China, the State Environment Protection Administration (SEPA) takes environmental pollution prevention as the main task and is the main administrative unit in charge of the general solid waste management and the import of all kinds of wastes including e-waste. The main departments and divisions related to e-waste management in the internal SEPA are shown in Figure 4.2. The Department of Policies, Laws and Regulations, the Department of Pollution Control and the Department of Science, Technology and Standards are the three main departments which are responsible for the management of e-waste.
The Department of Policies, Laws and Regulations is divided into three main divisions. The responsibility of this department is to formulate general and specific policies, laws and regulations and administrative rules and regulations such as the Announcement on Reinforcing the Environmental Management of the Waste of Electrical (4.2.3.1) and Electronic Equipment Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products (Drafted for Comment) (4.2.3.5).
The Division of Solid Wastes and Toxic Chemicals Management in the Department of Pollution Control is the most important enforcement department in SEPA. It is the main and the direct administrative unit for management of all kinds of solid wastes including e-waste. The enforcement of the national laws and regulations related to solid waste management is the main responsibility of this division and includes the ones related to e-waste management. The responsibility for formulating and organizing the implementation of laws, regulations and rules on pollution prevention of solid wastes, toxic chemicals as well as e-waste, undertaking the examination and approval of the import and export permits for the wastes to be used as raw materials are also key activities of this division.

The Department of Science, Technology and Standards is divided into four divisions and takes the responsibility of formulating national environmental protection standards and undertakes the filing of local standards. It undertakes the organization of key researches and technical demonstration projects, the environmental label certificating in the whole country and the implementation of the certification regime of qualification for environmental protection.

4.3.1.2 NDRC

Another important institution which is responsible for e-waste management is the National Development and Reform Commission of the P.R China (NDRC). It is a macroeconomic management institution directly under the State Council, which studies and formulates policies for economic and social development, maintains a balance of economic aggregates and guides the overall economic system restructuring. As the issue of e-waste comes under resource conservation and comprehensive utilization as well as sustainable development, the Department of Resource Conservation and Environmental Protection in NDRC is also involved in the management of e-waste and drafted the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (Drafted for
4.3.1.3 MII
The issue of e-waste involves not only the environmental protection problems after the electronic products become obsolete, but also the whole production processes of all kinds of electrical and electronic products which are managed by the Ministry of Information Industry. As one of the results the Management Methods on Pollution Prevention in Electronic Industry was drafted and promulgated by MII (4.2.3.3) to reduce the environmental pollution caused by obsolete electronic information products from the perspectives of product design, raw material purchasing and manufacture, and to comply with the international management regulations on e-waste such as RoHS in EU.

4.3.1.4 Other relevant administrative departments or institutions
In addition to the above three administrative departments which have already drafted or promulgated e-waste management regulations, the General Administration of Customs (CGA) plays an important role in controlling the import and export of e-waste along with AQSIQ. Table 4.2 shows the responsibilities of each national administrative department involved in e-waste management in China.
Table 4.2 Indicative responsibility-national administrative department matrix for e-waste management in China

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>SEPA</th>
<th>NDRC</th>
<th>MIIT</th>
<th>CGA</th>
<th>AQSIQ</th>
<th>SAIC</th>
<th>MOFCOM</th>
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<td>National environmental protection plan</td>
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<td>National policies, laws and regulations for environmental protection and administrative rules and regulations</td>
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<td>Implementation of laws, rules and regulations on pollution prevention of solid wastes and toxic chemicals</td>
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<td>Administrative penalty of environmental protection and penalty review</td>
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<td>National environmental protection technology policies and standards and the filing of local standards</td>
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<td>Key researches and development, technical demonstration projects of environmental protection</td>
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<td>Examination of the projects in environmental protection system subsidized by the central government</td>
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<td>Supervision of the secondhand market and the regenerative resource market</td>
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<td>Registration of enterprises, organizations or individuals and issues business licenses</td>
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<td>Examination, approval and registration of the import and export permits of waste to be used as raw materials</td>
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<td>E-waste import control (attacking smuggling) and penalties for illegal acts</td>
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Responsibility  ☀ Involvement
4.3.2 The relationship of these departments or institutions

Basically SEPA, especially the Division of Solid Wastes and Toxic Chemicals Management in the Department of Pollution Control, is responsible for the general management of e-waste. Other institutions or administrative departments will collaborate with SEPA to control e-waste. But as stated in section 4.3.1.1, SEPA focuses the management of e-waste on the treatment and disposal stage as well as the control of the environmental pollution caused by e-waste, but does not include the production and consumption systems which are important in the whole process management.

MII controls the manufacture of electronic products and limits the use of toxic or hazardous materials or elements in these products through legislation as well as developing advanced technologies to meet the standards of green design and clean production. SAIC controls the distribution of electronic products and domestic trade market including the secondhand market for obsolete electronic products and the regenerative resource market of reusable materials in e-waste. MOFCOM cooperates with CGA to control the import and export of electronic products, while the control of imported e-waste is controlled by SEPA and CGA as well as AQSIQ. The e-waste recycle system, which involves the utilization of regenerative materials in the production system, is managed by MII in cooperation with SEPA. Theoretically the NDRC (section 4.3.1.2) is responsible for the management of e-waste from the perspective of macroeconomic control and maintains the balance of economic development and environmental protection. As a result the Department of Resource Conservation and Environmental Protection in NDRC participates in the whole e-waste management processes from the manufacture of electronic products to the e-waste recycling and disposal processes.
4.3.3 The enforcement process of the regulations (from national to local level)

From the national level the laws and regulations issued by SEPA or other administrative institutions such as NDRC or MII (Table 4.1) have the same legal effect and are enforced by corresponding institutions respectively. For example, the three major, national-level legislations discussed in section 4.2.3 were drafted by three different administrative institutions which have the same legal effect on e-waste management but emphasize different points in the e-waste control system.

In the enforcement process of the regulations different departments in the same administrative institution need to collaborate. In SEPA, the Department of Policies, Laws and Regulations formulates e-waste management law or regulations according to the results of policy research and the national environmental protection plan. Then the Department of Pollution Control implements all the laws and regulations through the local environmental protection agency as well as gathering and managing all enforcement information. The Department of Science, Technology and Standards constitutes corresponding technology policies and standards to assist the enforcement of the laws and regulations. The Bureau of Environmental Supervision organizes the national inspection and supervision on environmental law enforcement. NDRC or MII enforces the laws or regulations by similar means. When the enforcement of the law or regulation is related to several administrative institutions at the same time there will be special personnel or workgroups to harmonize the relationship.

Generally the enforcement of the legislations in China will get the support from several administrative institutions. For example, to control the imported e-waste, SEPA, according to its responsibility, as well as Customs General Administration (CGA) and General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), will compile the list of prohibited wastes for import and will subscribe or issue approval for imported solid waste. AQSIQ will supervise and quarantine the imported waste. It will also inspect the allowable imported waste landing and then
issue the permit of disembarkation. Customs, according to the above inspection and disembarkation certifications, carry out the tax collection methods and at the same time attack illegal behaviour of importing waste.

SEPA and NDRC are at the top of a hierarchy of environmental protection bureaux (EPBs) and development and reform commission (DRCs) at, respectively, the township, county, city, and provincial levels. The organizational structure of EPBs and DRCs at local level is the same as the SEPA and NDRC, and both are responsible for the management of solid waste including e-waste at local level.

Another important process in the enforcement of legislation is the localization of the national legislation. After the national law is issued and has entered into force, the local relevant administrative department will develop corresponding detailed enforceable regulations and rules consistent with the national legislation. Generally local regulations will be stricter and more detailed than the national ones. This is the most important step in the whole enforcement process. For EPA Figure 4.3 shows the hierarchy of local environmental protection institutions. The hierarchy of local development and reform commissions (DRCs) is the same as for the EPBs. The organizational structure of the internal administrative departments and divisions in local environmental protection bureaux is always the same as for the SEPA (Figure 4.2).
Figure 4.3 The hierarchy of local environmental protection institutions
* The provincial environmental protection administration includes 22 provinces, 4 municipalities, 5 autonomous regions, excepting two special administrative regions, Hong Kong and Macao, and Taiwan province.

4.4 The other influences on e-waste legislation

In 2003 the European Union (EU) Parliament issued two directives that significantly affect electronic industries in China: one on Waste from Electrical and Electronic Equipment (WEEE) and the other on Restriction on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS). These two EU-wide directives have a profound impact on the electrical and electronic industry globally (section 2.3.5). In particular, China’s electronic industry will be affected due to its large proportion of electrical and electronics products exported to the EU. As a major global electronics manufacturing and components supply base, it is clear that China must be in compliance with these two directives or otherwise suffer massive export declines.

Complying with the new EU directives will have to involve the whole electronics supply chain including suppliers, manufacturers, sellers, distributors and recyclers. Companies along the supply chain will have to change their materials, design and manufacturing processes simultaneously, and most of the industry needs to change
Suppliers and manufacturers are encouraged to incorporate the thinking of green design into their product design strategies. Nevertheless, while some leading electronics manufacturers, such as Sony and HP, have proactively developed initiatives to address the WEEE and RoHS Directives, a large part of the electronics supply chain in China seems ill-prepared for these changes (Wu, 2004).

In the research conducted by Yu et al., the producers' responses to EU directives were investigated (Yu et al., 2006a). It identifies key difficulties encountered by manufacturers in fulfilling the requirements and evaluates the effectiveness of these two directives in promoting environmental reform. The findings indicate that the extent of producers' responses largely depends on their market structure and client requirements. Supply chain management, raw material testing and cost implications appear to be key challenges in addressing issues caused by the EU directives. Yu (2006) found little evidence to suggest that these directives have effectively driven China's electronic products manufacturers towards systematic green design although some relevant actions have been taken by the electronic product manufacturers. Data showed that many producers have tackled issues surrounding WEEE and RoHS through supply chain management, training and technological innovation. The most common approach that producers adopted was to require suppliers to provide material testing reports and/or material declarations certified by authoritative third-party organizations in order to ensure that new products were free of the six restricted substances. Overall, it seems that effort was largely concentrated on RoHS compliance. Very few companies passed the responsibility or requirement related to WEEE to their suppliers, mainly due to the lack of pressure from their own clients. Some producers pointed out that WEEE is not seen as an urgent issue, since it is not perceived as a 'punitive' regulation in the way that RoHS is. Moreover, the adoption of WEEE in EU member states is at varying stages (Wilson, 2006) and some of the implementation procedures are still under development, which make producers hesitate in responding to it.
Supply chain management appears to be the most significant challenge in order to ensure legal compliance. Since almost all the producers need to source raw materials or components from others, it would put producers at a high risk if their suppliers did not meet the requirements of WEEE and RoHS. One of the key issues relating to supply chain management seems to lie in the difficulty of sourcing RoHS-compliant materials and components at a competitive price (Yu et al., 2006a). Another issue appears to be the risk associated with the consistency of product quality in mass production, as material testing reports are normally for sample testing only.

Material testing and verification was identified as the second most significant challenge (Yu et al., 2006a). The key difficulty could be partially attributed to the high cost of material testing to ensure RoHS compliance due to the limited number of professional certification organizations available in China. Some confusion regarding what should be tested and how to test it may also arise on account of insufficient information or the ambiguous interpretation of RoHS. Indeed, producers are often unclear about what is needed and what the exemptions are (Veleva and Sethi, 2004).

The cost is another major concern of responding producers with regard to the adoption of WEEE and RoHS (Wu, 2003; Zhao et al., 2004b; Wang, 2005). When electronic products are exported to European countries, the producers are required to pay for the costs pertaining to recovery and recycling of e-waste. These costs are computed according to the existing labour costs in Europe, which are much higher than those in China. These anticipated recycling costs will invariably increase the overall production cost of electronic products and force some local Chinese electronic producers to bow out of the competitive markets. On the other hand, if the electronic products are manufactured at lower costs such that they do not conform to the EU environmental protection standards, they will not get access to the markets of the industrialized countries. These EU directives are therefore perceived to be a green trade barrier to electronic products manufactured in China (Xie, 2004). In order to remain competitive in the electronic industry on the global market, China needs to
develop relevant policies, regulations and institutions for effective e-waste management, and be able to effectively synchronize with international trends.

4.5 Summary

This chapter described the main results obtained from the secondary sources of data: documents and literature in the Chinese language. The documents mainly referred to the government documents including the detailed information about the integrated legislation system on e-waste as well as the administrative institutions responsible for the management of e-waste in China. From the overview of the legislation system on e-waste management and the relevant administrative departments or institutions, it can be summarized that at present the e-waste management in China is just at the beginning stage and the lack of relevant laws and regulations has become the most serious obstacle in the whole management system. The lack of systematic and enforceable national laws and regulations will also limit the formation of provincial or city corresponding regulations. The formation procedure of the regulations was prior to the systematic and practical research which decreased the feasibility of these regulations and there are no subsequent regulations and standards to assist the enforcement of these laws and regulations. This chapter provides background information about the e-waste management system in China especially the legislation framework which is used as a platform for this research and as the secondary source data. This system will be further discussed in Chapter 6 and triangulated with the results from the interviews.
Chapter 5 Results from Interviews and Observations

5.1 Introduction

In this chapter the main findings from the interviews and observations are described which constitute the primary data in this research and the results are then discussed in chapter 6. The interviews were carried out in early 2006 in China during the fieldworks, with officers or experts from key relevant government departments or institutions in China involved in e-waste management, from electronic appliance producers and from customers at different levels of the value chain. The direct and non-participant observations were also carried out in six cities during the fieldworks.

5.2 Findings from the interviews about the legislation framework for e-waste management

All the above laws and regulations (section 4.2) constructed the basic legislation system for e-waste management in China. But there still exist many problems in this system. In the fieldwork four interviewed authorities in SEPA who participated in drafting relevant e-waste management regulations mentioned the hidden weakness in the present legislation system and gave some examples to illustrate the unreasonable points in the legislation formation process in e-waste management, as well as the negative results of these deficiencies which are all generalized and listed in Table 5.1. The specific research question is: What deficiencies exist in the legislation for effective e-waste management in China? Two of these interviewed authorities are officers who are working in the Policy Research Centre for Environment and Economics of SEPA. One is in the Service Department of the Sino-Japan Friendship
for Environmental Protection Centre. Another is an associate professor as office director of SEPA and Basel Convention Asia-Pacific Regional Center for Hazardous Waste Management Training and Technology Transfer.

Table 5.1 Summary of the findings from the informants about the legislation framework

<table>
<thead>
<tr>
<th>Key points</th>
<th>Examples Description</th>
<th>Negative results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process of formulating these regulations disobeyed the normal legislation formulation procedure. The three main regulations were drafted on the basis of insufficient research work.</td>
<td>• Until recently there was no official data on e-waste produced in China as well as no systematic measures to trace the upstream and downstream pathways of e-waste. • How serious the e-waste issue is in China is not very clear especially in areas such as Guiyu. Actually the environmental condition in Guiyu has been changed considerably but the foreign media has always reported very negatively which may not reflect the true facts there.</td>
<td>The pressures on the government made it urgent to enact regulations to control e-waste while systematic and practical research was ignored or behind the schedule. The data on e-waste are too limited to support the formulation of the regulations.</td>
</tr>
<tr>
<td>There is no economic analysis about e-waste in China at all - financial support and the payment system are the key points in the whole management system.</td>
<td>• In the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal, although it regulates that the government shall establish a special fund to assist the financing of e-waste recycling and disposal, the enforceability of this is very low. The detailed function of this fund, the source, and the governing unit in charge of this fund are not explained in the regulation.</td>
<td>To be in line with the international regulations some articles in the regulations are too general to be enforced. This has caused the two drafts of NDRC and SEPA to be discussed and commented on for a very long period and until now they have not been passed by State Council. And as a result this has directly affected the formation of local regulations to control e-waste.</td>
</tr>
<tr>
<td>There are no subsequent regulations and standards to assist the enforcement of these laws and regulations.</td>
<td>• Basically there are no standards to classify e-waste separately from all other municipal solid waste or the use of special technologies to dispose and recycle such waste. The definition of e-waste is not clear. • Due to the difficulty of finding suitable materials to substitute the six hazardous materials in e-waste, the catalogue listing special electronic products which need essential pollution prevention and control is empty now. • The licensing system for obsolete electronic appliance recycling and disposal enterprises does not yet exist although the e-waste registration system is required by the regulations.</td>
<td>There are no special standards to define e-waste and to evaluate the hazards in e-waste and no licensing system to control the treatment enterprises; many environmentally unsound treatment companies or even illegal family plants have become the main units to deal with e-waste. It is difficult to interpret the laws and regulations which has weakened the enforceability of these laws and regulations.</td>
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5.3 Findings from the interviews about the implementation of the regulations and relations of administrative institutions

The enforcement of the legislation is the most important step in the e-waste management system. Although there are several laws and regulations on e-waste management in China, the environmental problems caused by e-waste have not been controlled effectively and have become even more serious recently. To find the existing problems during the enacting and implementing process of legislation on e-waste management and the deficiencies in the enforcement process, the interviews with related authorities in environmental protection institutions were conducted in the fieldwork. The main interviewees are listed in Table 5.2. Three interviewees are from authorities in SEPA who participated in drafting relevant e-waste management regulations and are still responsible for the topic of policy research on e-waste management now. Another three interviewees come from local environmental protection bureaux, who are responsible for enforcing such regulations at local level. One is from an authority in a city-level environmental protection bureau. The other two are working in district-level environmental protection bureaux.

Table 5.2 The main interviewees in environmental protection institutions

<table>
<thead>
<tr>
<th>SEPA or Local EPBs</th>
<th>Department</th>
<th>Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Environmental Protection Administration (SEPA)</td>
<td>Policy Research Centre for Environment and Economic (PRCEE)</td>
<td>Manager on Policy Advisory Service</td>
</tr>
<tr>
<td></td>
<td>Policy Research Centre for Environment and Economics (PRCEE)</td>
<td>Researcher in Environmental Law</td>
</tr>
<tr>
<td></td>
<td>Sino-Japan Friendship for Environmental Protection Centre</td>
<td>Manager in Service Department</td>
</tr>
<tr>
<td>Shanghai Environmental Protection Bureau</td>
<td>Shanghai Academy of Environmental Science</td>
<td>Manager in Department of Environmental Engineering Design</td>
</tr>
<tr>
<td></td>
<td>Jingan District Environmental Protection Bureau</td>
<td>Engineer in Jingan District Environmental Protection Department</td>
</tr>
<tr>
<td>Shenzhen Environmental Protection Bureau</td>
<td>Nanshan District Environmental Protection Department</td>
<td>Engineer in Nanshan District Environmental Protection Department</td>
</tr>
</tbody>
</table>
The specific research question for this section is: How are regulations on e-waste in China enforced and monitored? The main questions asked in the interviews were the following and the detailed questions are listed in Appendix 6.

1. How do different institutions or departments, which are responsible for e-waste management, work with each other and what kind of relationship do they have?
2. What deficiencies are there in the present legislation system on e-waste management? If the law on e-waste appears to be poorly enforced, which process in management is deficient or wrong?

5.3.1 Findings from interviews with the informants who worked in SEPA

From the national level the three interviewees who worked in SEPA mentioned the relationship of SEPA with other relevant departments and the responsibilities of each administrative department involved in the legislation enforcement process on e-waste management. Table 5.3 summarizes the key points from the interviews, the detailed examples they gave and the negative results aroused.

5.3.2 Findings from interviews with informants who worked in local environmental protection bureaux

The local relevant administrative departments are practical units to effectively manage e-waste. According to the local social and economic conditions, relevant administrative departments will develop corresponding detailed, enforceable regulations and rules, consistent with the national laws or regulations, and implement them. From the interviews with three informants who work at the city level or district level in environmental protection bureaux (Table 5.2), the findings are summarized in Table 5.4.
### Table 5.3 Findings from the interviews with the informants who worked in SEPA

<table>
<thead>
<tr>
<th>Key Points</th>
<th>Examples Description</th>
<th>Negative Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The administrative function of NDRC is questionable.</td>
<td>* SEPA is the main administrative department which is responsible for all the affairs about environmental protection and should be the main unit to implement the relevant regulations. But actually all the programmes and enforceable plans related to the environmental protection industry have to be examined and approved by NDRC first. On the e-waste issue, SEPA met the same situation. * Besides environment protection, because NDRC is responsible for the national development and socio-economic reform, it is the participant in almost all industries. Now because the issue of e-waste has brought remarkable influences on the electronics industry, one of the most important industries for economic development of China, NDRC would like to be the principal administrative unit leading the management of e-waste. * NDRC drafted a regulation (4.2.3.2). Some of the articles in it are repeated with the other regulation drafted by SEPA (4.2.3.5). But NDRC do not have corresponding personnel or workgroups to implement it and do not detail the enforcement process of the regulation. Then all the problems of e-waste have to be handled by SEPA. As a result the function of NDRC is questioned.</td>
<td>The administrative power of SEPA is undermined by NDRC. Parts of the responsibilities of these two administrative departments overlap which has made it difficult for SEPA to regulate and implement related e-waste management regulations effectively.</td>
</tr>
<tr>
<td>The responsibilities of each administrative department involved in e-waste management are not explicit.</td>
<td>* MII regulates that it is responsible for the reduction of e-waste through recycling and minimizing the environmental pollution caused by e-waste and producers should take the responsibility for e-waste control. But in fact MII does not participate in the e-waste collection after consumption. * SEPA also regulates the e-waste management through environmentally sound recycling and disposal. But it is just from the perspective of environmental protection. It is responsible for the control of the environment pollution caused by e-waste while the e-waste collection, the recovery of valuable materials and the secondhand market of obsolete electrical and electronic products are not included. * NDRC should be responsible for adjusting the relationship of the environmental protection industry with other industries such as the electronics industry, and balance the relationship of different administrative institutions. But in fact, NDRC lacks the ability to adjust the collaboration of different departments.</td>
<td>The recycling of e-waste has not been implemented as practically and effectively as it could be. Different administrative departments lack effective collaboration to manage e-waste. The management of e-waste is not integrated.</td>
</tr>
<tr>
<td>The inspection and supervision system of regulation enforcement is imperfect.</td>
<td>* Bureau of Environmental Supervision in SEPA organizes the national inspection and supervision of environmental law enforcement. But there are not enough personnel in this bureau and there are no standards to regulate the punishment system.</td>
<td>There is no systematic monitoring system to supervise the enforcement of the regulations to control e-waste.</td>
</tr>
</tbody>
</table>
Table 5.4 Findings from the interviews with the informants who worked in local environmental protection bureaux

<table>
<thead>
<tr>
<th>Key Points</th>
<th>Examples Description</th>
<th>Negative Results</th>
</tr>
</thead>
</table>
| The localization of the national legislation has become the weak link in e-waste management. | • The functions of local environment protection departments are always limited by other institutions such as provincial or city development and reform commission and environmental protection bureaux. All the regulated programmes for recycling and disposal of e-waste have to be approved by local DRCs and in fact there are no practical activities to implement these regulations.  
• The highest priority of local governments is to develop the economy, especially in the economically backward areas. When the government can gain profit from a special industry, such as improper e-waste recycling and disposal, even if it is environmentally unsound, the environmental protection will always be ignored.  
• Some local officials have poorly enforced the laws or regulations in order to gain money from illegal import. | There is lack of local regulations and rules to effective manage e-waste.  
Actually at local level there are no practical activities to implement national regulations to control e-waste and illegal import of e-waste is still found in some areas. |
| The monitoring system becomes ineffective. | • Local environmental protection bureaux also set the department to inspect and supervise the enforcement of relevant regulations. But due to the shortage of personnel it is difficult to exercise this supervisory authority.  
• These supervision units in the local environmental protection department have no rights of administrative punishment which has made it difficult to supervise the enforcement of local regulations to effective manage e-waste. | There is no systematic and effective monitoring system to supervise the enforcement of local regulations to manage e-waste. |
| The collaboration of different administrative departments at local level is not effective. | • Two departments are responsible for the recovery of e-waste from consumers and the disposal of e-waste respectively. The collection of solid waste is the responsibility of the urban environmental sanitation institution which belongs to the city construction bureau, which is at the same level as the EPB. The local EPB is only responsible for the recycling and disposal of e-waste after it has been collected from all kinds of consumers. The urban environmental sanitation institution cannot recover e-waste through a regulated system. Then the local EPB cannot recycle or dispose of e-waste in an environmentally sound manner.  
• Local industry and commerce bureaux do not strictly regulate the registration system to manage the e-waste recycling and disposal enterprises, which needs the collaboration of EPB to supervise operations and ensure that these enterprises measure up to environmental standards. | There is no regulated recovery system organized or supervised by the administrative department which has caused environmentally unsound enterprises to become the main operators to recycle and dispose of e-waste. |
5.4 The other influences on e-waste legislation

5.4.1 The impact of other countries’ legislation or policies

In the European Union, Japan and other industrialized countries the governments have introduced laws and regulations on the production and disposal of obsolete electronic wastes which have brought great influences on e-waste management in China. As stated in the literature review WEEE and RoHS are the most important directives to deal with the e-waste issue in European Union Member States and even other industrialized countries. The issue of these two directives is one of the main reasons to urge the government of China to enact its own e-waste management laws and regulations.

The primary aim of the WEEE and RoHS Directives is to reduce the impact of disposal of electrical and electronic equipment at end-of-life. The WEEE Directive aims to reduce the amount of WEEE sent for disposal to landfill or incineration by requiring producers to arrange for collection and recycling. The RoHS Directive restricts the use of hazardous materials including lead, cadmium, mercury, hexavalent chromium/chromium (VI), brominated flame retardants (BFRs) which include polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBB). The European Union is one of the largest trade markets in the world and since August 2005 (WEEE) and July 2006 (RoHS) respectively, any company wishing to sell electronic products in this market has had to comply with these directives. The setting out and implementation of these two directives has influenced electrical and electronic companies, not only in their own member states and other industrialized countries, but also in developing countries with manufacturers and distributors needing to amend working practices accordingly.

WEEE applies to a wide spectrum of electronic products. There are ten product categories which are covered by it (Table 2.3). The key point in WEEE is using the
extended producer responsibility principle to manage e-waste. It requires producers of electronics to take responsibility – financial and otherwise – for the recovery and recycling of e-waste after 13th August, 2005. Producers should establish a completed system which includes classification, recovery, regeneration and reuse of electronics. RoHS means that products containing more than the permitted levels of restricted substances will have to be redesigned or withdrawn by July 2006. For the manufacturers and suppliers of electrical and electronic products in industrialized countries there will be a huge cost increase e.g. research and development costs to develop, test and re-qualify products, components and accessories using alternative substances, and increased energy consumption. Similarly for the companies in developing countries they too will have to participate in this system for collection, treatment, recycling and recovery of e-waste in EU member states.

After these two directives were issued several conferences were held in China to discuss the impact they will have on the electronics industry of China and on the domestic management of e-waste (section 2.5.6). Two opposite attitudes to the impact of EU directives were formed which were also reflected in the interviews for this research. To investigate this impact the interviews were conducted with both related authorities and producers in the electronics industry.

The interviews with related authorities were conducted in both fieldworks. A total of 17 interviewees answered the following question:

What effect does other countries' legislation, such as WEEE and RoHS, have on e-waste management in China?

5.4.1.1 Findings from the interviews with related authorities

- 12 of the interviewees thought that these two directives would obviously bring negative impacts to the electronics industry in China as would be the case for European countries. It was considered not only to be an environment protection
barrier but also a green trade barrier to electronic product manufacturers in China.

As with the negative impacts on the enterprises in European countries, the most serious problem caused by these directives was the focus on increased cost. This cost mainly includes the following four parts.

1. Additional recycle cost is charged, especially on the large household electrical appliances. This increases the production cost and influences the marketing sales and competition.

2. The method of sharing the historical e-waste disposal cost according to the production market share has been queried. For Chinese electronic appliance manufacturers who have been increasing their exports of electrical and electronic products to European countries annually it means that they will be responsible for higher and increasing costs in this market.

3. The recycle ratio of e-waste in WEEE is as high as 80%, which requires more advanced techniques and equipment as well as increasing the production cost.

4. Some of the six restricted hazardous materials are difficult to replace, so the investment to study and explore substitute materials will also increase the cost.

When electronic products are exported to European countries, the producers have to pay these extra costs for the recovery and recycling of e-waste. These costs will depend on the recovery and recycling costs in European countries, which are much higher than those in China and even higher than the production cost of some products. So these costs will increase the whole production cost of electronic products and if producers cannot find proper ways to deal with this problem, it will be difficult for them to compete with producers in other countries. And if the electronic products cannot conform to the European countries’ environmental protection standards, they will not be imported and producers will suffer heavy losses in the world electronics market.

- 5 interviewees showed opposite opinions to the above and thought that these two
directives would not have a negative effect on the electronics industry and e-
waste management in China. However they urged the government to take actions
to improve e-waste management gradually. They felt that any negative impact
would be for a short period only. If these two directives were understood as both
an environmental protection and a green trade barrier, this barrier is not only set
before China, but also before other developing countries.

These two directives really will bring some impact to China’s electronics industry.
But this can be divided into two categories.
1. Those large-scale companies in the electronics industry whose policies are to
manufacture locally and buy raw materials internationally. For example Haier Group,
which is the biggest electronic appliance manufacturer in China, in order to compete
with local manufacturers in industrialized countries, has constructed several factories
overseas, hired local labourers, purchased raw material locally, used foreign
technologies and sold their products to these countries directly. It uses the local
environmental standards which are the same as for other manufacturers in the local
area. Now they are all facing the two directives. They will change their management
and technology at the same time as the industrialized countries. They will be
responsible for their products and pay for the fees according to local legislations or
regulations. So it will not affect the export of electronic products too much. Their
experiences on e-waste management will give domestic companies useful information
and help the development of the whole industry.

2. Those middle- or small- scale manufacturers whose exports of electronic products
might be affected if they cannot satisfy the industrialized countries’ requests
mentioned in these two directives. It will force them to increase the production cost as
they have to pay more for recovery and disposal of their products. But such
challenges have happened before. It is natural in the market economy. With the
increase in production of electrical and electronic appliances, the pollution and
disposal of obsolete products have harmed the environment greatly, which will affect
more countries and consumers. It is the trend of the times to set forth strict
environment protection laws and the action of European Union will absorb more and
more countries and areas into this trend and will of course include China. It is not a
negative impact. On the contrary it will motivate these manufacturers to renovate and
improve their products and urge government to improve e-waste management.

5.4.1.2 Findings from the interviews with producers

The interviews with producers were conducted in the second fieldwork in both
Shanghai and Guangdong provinces where electronic products manufacturers are
concentrated. Six EHS (Environment, Health and Safety) specialists and two
managers in seven electronic appliance corporations accepted the interviews in
Shanghai. One replied to the research questions through email. Two of them
belonging to the same company were reluctant to publicise their company's name.
The others come from the following seven corporations, Samsung Investment Ltd.
Shanghai Subsidiary Company, Royal Phillip Electronics, Sharp Corporation, Asia
Pacific of Husky Injection Molding Systems (Shanghai) Ltd., Amokor Assembly &
Test (Shanghai) Co., Ltd., J.S.T. Mfg. (Shanghai) Co., Ltd., and Shanghai Hua Hong
NEC Electronics Company, Ltd.

The common characteristic of these companies is that they are all multinational
corporations. They all have special departments to collect information about
environmental protection laws or regulations and to control their own industrial
wastes including solid wastes. All of them knew the industrialized countries' legislation on e-waste management, especially the WEEE and RoHS.

- Six of these companies indicated that these legislations would not bring a
  negative effect to their production and export trade.
- Two of them are Japanese companies which also have to comply with the
  regulations and environmental standards of Japan. The Specified Home
Appliance Recycling Law of Japan and the Law for Promotion and Effective Utilization of Resources were enforced in 2001, two years earlier than the two EU directives and are stricter. These two companies have improved their management on e-waste since then. From raw materials purchase to production design they had already considered minimizing the production of hazardous solid wastes. They do not think the WEEE and RoHS will influence their production and export trade. Otherwise they thought this was a good opportunity for electronic product manufacturers to compete in an environmentally sound way as well as improving the management level of the whole industry.

- The other four companies indicated that their policies on production and environmental responsibility would be complied with and changed according to the parent companies overseas. After WEEE and RoHS were published, they, as well as the parent companies, had begun to develop strategies to cope with the potential negative effects and had invested a great deal to find substitute materials for the six prohibited hazardous materials in their products. To compete with other electronic product enterprises in European and industrialized countries this investigation is really necessary.

- Two producers among these interviewed companies thought that these two directives would have a negative effect on their production and export trade especially from the perspective of increasing costs.

To substitute the six hazardous materials means they have to spend more to buy raw materials which can measure up to the standards and to spend more to test their products to ensure that they meet the environmental requirements. To label the products will also increase the costs. They also have to invest more to develop advanced technologies, to improve the design and to meet the related environmental regulations. It is also necessary to formulate effective strategies to deal with the end-of-life products after they are sold to European countries. But they showed a positive attitude to these negative effects. They thought it was an inevitable process in the whole electronics industry. They would like to change their products according to the
requirement of their foreign customers and the market economy. They also agreed with the standpoint supported by the previous six companies that it will lead to an improvement throughout the whole electronics industry.

5.4.1.3 Conclusions

The following conclusions can be drawn from the assessment of the impact of other countries’ legislation or policies on e-waste management in China.

1. Most authorities agreed that other countries’ legislation, especially the WEEE and RoHS, have brought negative impacts to the electronics industry in China. The increased cost will be the most serious impact factor to e-waste management.

2. Some authorities thought that these regulations would motivate producers to improve their product design and utilize environmentally-friendly materials. These regulations have urged the government to enact corresponding regulations to improve e-waste management as well, which is a positive impact.

3. Producers of multinational or large scale corporations did not think other countries’ related regulations would have a negative effect on e-waste management in China. On the contrary they thought these regulations would offer an opportunity for environmentally sound competition and improvements in the management of e-waste, although some of them were also worrying about the increased cost after these regulations entered into force.

4. The negative impacts for middle- or small- scale electronic product manufacturing enterprises are greater than for large corporations. To compete in the international electronics product market they need more support from government through legislation.
5.4.2 The recycle system for e-waste (Findings from interviews and observation)

5.4.2.1 The recycle system for e-waste

The general recycle system for e-waste includes the recovery of e-waste from consumers, repair, dismantling, sorting, reuse and disposal processes. In this system the recycling and disposal enterprises are the main units for dealing with e-waste. The secondhand and the regenerative resource markets for reusable materials in e-waste are involved. The figure 4.2 shows the downstream pathways of e-waste in China.

The domestic e-waste mainly comes from individuals, large-scale corporations, educational institutions, government and original electronic equipment manufacturers. But the detailed data of the quantity and the ratio of each source in this e-waste stream are not available. Domestic e-wastes collected from individuals after minor repair or refurbishment, are always resold to low-income customers, such as migrant labourers in big cities and university students, or resold to customers in rural areas as well as donated or directly reused by large-scale corporations, educational institutions and government. This measure has extended the lifespan of electronic products and was thought to be an effective way to postpone the critical peak levels of e-waste. Another
downstream pathway of e-waste is temporary storage. Individuals or corporations all tend to store old electronic products for a couple of years before thinking about recycling. This will also reduce the seriousness of e-waste short-term. But not only the e-wastes resold to low-income or rural areas but also those temporarily stored will be a potentially large waste stream before long. They will enter into the e-waste stream after reuse and be collected as showed in Figure 5.1. Small electrical and electronic equipment, components and accessories are always thrown with municipal solid waste into landfills or incinerators without separation, unlike large electronic appliances, such as televisions, washing machines, air-conditions, refrigerators, computers, as well as mobile phones which in China are separated and will not be thrown directly.

After domestic e-waste has been collected it will be dismantled together with some illegal imported e-waste. It will be dismantled and sorted into three main types.

- First, after simple tests some components in e-waste are still useable and will be sold on the secondhand market for reuse in the repairing process or in manufacturing new products. Those usable components, as well as the secondhand electronic products, will enter into the consumption stream to low-income customers or customers in rural areas.

- Second, after the reusable parts of e-waste are removed, a large variety of metals, plastics, and glass remain. To recover additional value, e-waste will be segregated into material type. It will be treated through physical or chemical methods to extract the valuable materials such as iron, aluminum, and copper. After separation those valuable materials will be sold to the regenerative resource market. Once a clean, high-quality stream of material has been produced and consolidated and the customers identified, the valuable material will be used to manufacture new products. Until this step has been completed the recycling of e-waste has not truly occurred.

- Third, in the dismantling process those useless materials and components will be separated. Parts of them will be disposed in landfills or incinerators. But actually
most of them will be treated in an environmentally unsound manner and cause serious pollution.

If e-waste was recycled properly many of the valuable materials could be reused in new products to circle the material flow which is the basic pattern of the circular economy. But in fact this part in the present e-waste management system of China is very limited. Most e-waste is recovered by individual brokers or street hawkers and then resold to small-scale dismantling plants or family work-sheds for environmentally unsound recycling. Only small parts enter into the material recycling chains. The environment has been polluted in the dismantling process and in the final process of disposing of those materials and components which cannot be used.

The formal recycling companies have met many difficulties in this system. For example, it was reported that in Zhejiang province and Qingdao City, two experimental sites, the formal e-waste recycling companies could not run properly because there was not enough e-waste to treat and dispose. The plants were always empty while the private work-sheds and plants were operated very well. In the first fieldwork a formal e-waste recycling plant was visited in Beijing. The staffs introduced that the e-waste in this plant mainly came from large-scale corporations or government, and the quantity of e-waste to be treated was very limited. This can also be reflected from Figure 5.2 which shows the main e-waste collected in this formal e-waste recycling plant, including obsolete (a) printers, (b) laptops, (c) adaptors, (d) printed circuit boards, (e) monitors (after dismantled), and (f) fax machines.
The collected e-waste could be treated in a very short time using very basic techniques shown in Figure 5.3, which would not satisfy the designed treatment capacity. Workers use simple instruments to dismantle e-waste. Figure 5.4 shows the separated (a) circuit boards, (b) plastics, (c) iron and (d) precious metals after...
dismantling to be recycled by special metal and plastic recycling companies.

Figure 5.3 Workers using manual methods to dismantle e-waste

Figure 5.4 The separated circuit boards, plastics, iron and precious metals after dismantling to be recycled by special metal and plastic recycling companies.

To survive this plant had to treat other industrial solid wastes such as metal waste
from the manufacturing industry. This situation can also be compared with what had happened in Guiyu and Taizhou cities where e-waste recycling and disposal even became a special economic supporting industry. To explain the difference the recovery system is outlined below.

5.4.2.2 The recovery system of e-waste

The recovery system is the primary and basic component of the whole e-waste recycling system. Domestic e-waste was always recovered by individual brokers or street hawkers, shown in Figure 5.5, and then resold to small-scaled dismantling plants or family work-sheds for recycling.

Figure 5.5 The street hawkers recovered e-wastes from individual consumers (recovering old or obsolete washing machines, monitors, air conditioners, TV sets, refrigerators, printer and copy machines, fax machines, toners, computers and any other accessories as well as other wastes such as furniture, which were written on the board at the front of the tricycle or on the advertisement poster near the rear wheels)
A very small proportion of the e-waste was collected from individuals by electronic product retailers through an exchange method when buying new ones, which was found in five of seven observed electronic appliance shops or supermarkets during the second fieldwork. The main purpose of these retailers is actually to promote sales of the same brand new products rather than to be responsible for the recovery of e-waste they have produced. So the recovery of e-waste through this method was very limited.

During the interviews with concerned authorities in both fieldworks all of the 23 interviewees mentioned the importance of the recovery system in the whole management system of e-waste. But on the existing e-waste recovery system they gave different opinions which are listed in Table 5.5.

Table 5.5 The key points of view from the informants about the e-waste recovery system

<table>
<thead>
<tr>
<th>Key informants</th>
<th>Key points of view</th>
</tr>
</thead>
</table>
| 14 interviewees | • The individual brokers, street hawkers, retailers and small-scale e-waste recovery factories as well as unlicensed worksheds should be prohibited through legislation.  
• Constructing a regulated recovery system should be the main topic in the drafted regulations on e-waste management.  
• The former regulated recovery system and public infrastructures constructed before the late 70s should be reconstructed in order to recover e-waste effectively. |
| 9 interviewees | • The existing non-governmental recovery system works very well now and it is adapted to the present situation of China. But it really has serious limitations due to the lack of related regulations for control and inspection.  
• Instead of eliminating this kind of recovery system, government should support and control it through legislation, finding the loopholes in this system and changing the negative parts in it.  
• Instead of reconstructing the former regulated recovery system it is more important to reformulate feasible economic preferential policies to improve the present recovery system, such as tax reduction or tax exemption or financial encouragement which were proved to be effective to develop the resource recycle system before the 70s.  
• It is also necessary to regulate the qualification of those individuals or companies that recover e-waste. |
All the 23 informants agreed that the present existing system is not operated under legislation and regulations but adjusted totally by the market economy. This has allowed the small private operators to undercut formal companies and made this recovery system one of the indirect factors which has caused environmental pollution and health hazards to the workers. Street hawkers and workers in private recovery work-sheds and even in some illegal family small plants have existed for a long time. They make their living by recovery of e-waste. It has also solved part of the employment problems of the migrant labourers in big cities. It has proved that they could get profit from this kind of system, so the secondhand markets for electronic products were automatically formulated and material recycling chains were set up although at the cost of environmental pollution. It even broke the old formal recovery system which was constructed by government and formed a special kind of industry. The original regulated recovery system was constructed before the late 70s economic reform in China, which was supported by government through many economic preferential policies such as tax reduction and financial encouragement and consisted of government-employed skilled workers; such a system could not compete with the informal or individual e-waste collection system now and shrank gradually. As a result, only private brokers, some retailers and small-scale e-waste dismantling factories or unlicensed family work-sheds became the main operators of e-waste. As with the developing process of other industries, economic profit was considered first while ignoring the environmental cost.

5.4.2.3 The secondhand market and the regenerative resources market for reusable materials in e-waste

Besides environmental pollution another problem in the e-waste recycling system is that after simple repair or refurbishment by individual brokers, parts of obsolete electronic products will be sold to low-income customers or in rural areas where consumers cannot afford the money to buy new ones. In China economic development in different areas is very unbalanced. The income of consumers and their
consumption behaviours are totally different which has offered a very big market for secondhand products.

In the first fieldwork one secondhand market was observed in Shanghai and in the second fieldwork three secondhand markets in Beijing, Shanghai and Guangzhou were observed respectively. All the situations in these four secondhand electronic product markets were the same. Most of the secondhand electronic products sold in these four markets are mobile phones, computers, copiers, printers, CD/DVD players, MP3 players and other communication equipment as well as the accessories and components including monitors, memory, disk drives, circuit boards, and microprocessor chips. Other large household appliances were sold separately. In Figure 5.6, picture (a) and (b) show two private secondhand shops for large household appliances and computers (including accessories and components) in Beijing. Almost all the individual retailers acted as repair workers as well as simply testing, dismantling, refurbishing, or reassembling the collected obsolete electronic products or those bought from street hawkers. In the backyard of these shops the obsolete toners (picture c) and wires after dismantling (picture d) were found. Some of the operators in these secondhand markets sold new electronic products or components as well as the secondhand ones. The price difference is very large. At the same time this kind of market for used electronic equipment is very price-sensitive and in constant competition with declining prices and increasing performance of new electronic equipment. After they have been dismantled or reconditioned some accessories and components are sold by the retailers and customers may not be able to distinguish them from new as there are no identifying labels. Through talking with some retailers the researcher found that it is very easy for them to get the operation licences to run such business. There are no special qualification standards to confirm that they have the ability to guarantee the quality of the secondhand electronic products.
5.4.2.4 The registration of recycling and disposal enterprises

The main operators that recycle and dispose of e-waste are currently private brokers, small-scale e-waste dismantling factories or unlicensed family work-sheds in China. The dismantling process is mainly to separate the e-waste into different components according to material type. Traditionally this process has involved a high degree of manual labour for dismantling and sorting, then using physical or chemical methods to extract the valuable materials and finally disposing of the economically non-valuable materials and components in landfills or incinerators. Technically dismantling of electronic equipment to recover working components requires desoldering or use of simple hand tools. But actually most of them were treated in an environmentally unsound way and have caused serious pollution in China. The ability of these private recycling and disposing enterprises is totally different.
In the observation process of the fieldworks it was found that the private e-waste recycling and disposal companies or work-sheds were always registered by the local administrative department as metal or plastic recovery enterprises not as e-waste recycling ones. But all kinds of obsolete electronic products are their main raw waste resources. This mixed up the concept of metal or plastic recovery with e-waste recycling which involves both hazardous and valuable materials. Some of them collected obsolete electronic products from customers directly as well as repairing, dismantling, sorting and recovering metals or plastics as a whole. The tools and recycling methods used in these plants were very basic. Most processes were operated manually. The hazardous components, such as batteries which they could not treat, were thrown away directly into landfills or added to the municipal solid wastes. More professional private plants bought dismantled components in e-waste as raw materials, such as circuit boards, cables containing copper and aluminum housings separately. Then through mechanical shredding or grinding and further segregating and sorting by means of magnets, eddy currents, wind sifting, or similar techniques they were able to obtain useful metals or plastics. Some of the small-scale plants and family works-sheds refused to be observed in order to find if they had the operation licences to run such business. The qualification of these businesses is in doubt.

5.4.3 The pilot projects to get the feedback

In January 2004, Zhejiang province and Qingdao City were selected by the Development and Reform Commission (NDRC) as experimental province and city to implement pilot e-waste management projects and to explore different models for e-waste recycling and treatment. From then on many similar pilot projects were planned and e-waste dismantling and disposal centres were constructed or will be constructed in several economically developed cities which are listed in Table 5.6. The information in this table was all given by the following informants. In the second fieldwork two authorities working in the environmental engineering design
institutions which are institutions affiliated to the local environmental protection bureaux were interviewed. One is an engineer in Environmental Engineering Design Institution of Tsinghua University, Beijing. Another is an engineer working in Guangzhou Environmental Engineering Design Institution affiliated to Guangzhou EPB. Both of them gave information about the pilot projects planned and conducted recently, especially in Beijing and Guangdong province.

Table 5.6 The planned pilot projects and e-waste dismantling and disposal centres (constructed or will be constructed)

<table>
<thead>
<tr>
<th>City</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanjing</td>
<td>Jinze Nanjing company invested about 10 million RMB to construct an E-waste dismantling and disposal centre in 2004 which has been completed and run in October, 2005.</td>
</tr>
<tr>
<td>Hangzhou</td>
<td>Dadi Hangzhou company will invest about 100 million RMB to construct an E-waste dismantling and disposal centre.</td>
</tr>
<tr>
<td>Tianjin</td>
<td>Jinyiding Taiwan company invested about 100 million RMB in recovery and remanufacture of electronic circuit boards and other electronic wastes.</td>
</tr>
<tr>
<td>Guangdong Province</td>
<td>In the whole province about 580 million RMB have been invested to construct seven environmentally sound e-waste dismantling and disposal centres which are hoped to be finished before 2010.</td>
</tr>
<tr>
<td>Beijing</td>
<td>Huaxing Group, as the main undertaker of the pilot project on the recovery and disposal of obsolete electronic appliances, has begun to invite public bidding according to related regulations.</td>
</tr>
<tr>
<td>Qingdao</td>
<td>An e-waste recovery and disposal centre has been constructed by Haier Group in September 2005.</td>
</tr>
<tr>
<td>Shanghai</td>
<td>Renxin Group has begun to construct the first domestic professional E-waste disposal plant which can dispose of about 500,000 PCs per year</td>
</tr>
<tr>
<td>Wuxi</td>
<td>Weicheng environmental protection company invested 65 million dollars to construct an e-waste disposal plant to achieve no environmental pollution in all procedures.</td>
</tr>
<tr>
<td>Chengdu</td>
<td>Renxin Group invested 100 million RMB to construct a comprehensive resource utilization plant specially to treat e-waste in Sichuan province. The project began in December, 2005. It is hoped to dispose of 30 thousand tons of e-waste per year through six disposal lines.</td>
</tr>
</tbody>
</table>

*¥ 100.00 (RMB, China Yuan) = £ 7.39904 (GBP) (24th June, 2008)

The two informants mentioned that:

- The purposes of these pilot projects were: (1) to supply valuable experiences in
making interrelated policies and criteria to promote e-waste management as well as sustainable economic development; (2) to get the feedback on the effects of the enforcement of related regulations; (3) to find suitable technologies and processes to recycle and dispose of e-waste in China’s current circumstances and to develop relevant technical standards.

- Both in Beijing and Guangdong province, the formal e-waste recycle companies met difficulties in collecting e-waste as with the pilot programmes in Zhejiang province and Qingdao City. There was not enough e-waste to be recycled and disposed, then they could not get profit from recycling e-waste and cover the costs of environmentally sound processing. The constructed plants were always empty while the other private work-sheds or small-scale enterprises operated very well.

- The charges for treating e-waste were paid by recycling companies themselves at that time. As a result the total charges including the fares for collection and treatment were usually higher than the income gained from selling the reusable secondhand products and valuable recovered materials to a qualified e-waste recycling company. For example, the actual situation of Hangzhou Dadi Environmental Protection Company showed that the average fare for collection and treatment of TV sets is about 120 RMB per unit, while the income gained from selling corresponding valuable reclaimed materials is about 50 RMB per unit.

- The formal e-waste recycling and disposal enterprises introduced advanced technologies and equipment from industrialized countries to treat e-waste which increased the costs greatly. This was thought to be an easy and effective way to resolve the technology problems in e-waste management.

- There was very limited financial support from government and the lack of relevant regulations and standards made most investors take a negative attitude to environmentally sound recycling and disposal of e-waste.
5.4.4 The public attitudes on e-waste legislation

The public attitudes to the management of e-waste are important factors to be considered when developing and improving related regulations in e-waste management. In this part the attitudes of both electronic appliance producers and consumers to e-waste legislation were investigated in fieldworks.

5.4.4.1 Producers’ attitudes to e-waste legislation

To investigate the effects of the electronic appliance producers’ attitudes on e-waste legislation, the interviews were conducted in the second time fieldwork. The interviewed producers in Shanghai are listed in section 5.4.1.2. They worked for eight multinational electronic manufacturers respectively and were available at that time. The questions asked in the interviews are listed in Appendix 6.

When asked about their knowledge of the above domestic laws or drafted regulations on e-waste management (section 4.2.3) as well as foreign ones, all of them had the basic information about them. They got such information mainly from two ways. One was from the parent corporations overseas which focused mainly on foreign countries’ environmental regulations and standards. The other was from their own EHS department where they can obtain all domestic-related environmental protection regulations. The informants of these eight companies had all attended related national or local level conferences or forums of which the main purposes were always to gather information and suggestions from producers on e-waste management in China or to find the countermeasures to deal with the effects caused by EU’s WEEE and RoHS. They were all aware of the seriousness and importance of the e-waste issue in China. To the domestic regulations on e-waste management they all showed positive attitudes. If all the above drafted regulations passed examination and came into force in the future, they would strictly enforce them although there would be many difficulties in the enforcement process. They all agreed that at present the lack of
related laws and regulations has become the most serious obstacle to e-waste management in China. Effective laws and regulations will guarantee fair competition in the electronics industry, improving economic benefits as well as protecting the environment.

When asked for current ways to deal with the e-waste generated both in the production process and after consumption, these eight companies said that they sent the e-waste generated in the production process to the special solid waste treatment centre appointed by the local management department. The amount of this part of e-waste is not very large and because it belongs to the industrial solid waste it is strictly controlled and managed. But all of them bear no responsibility for the e-waste produced after consumption. And at present level none of them have any e-waste recovery or recycle plans focusing on their own products. There are simple symbols printed on their products or packages to indicate that parts of the products have hazardous or toxic materials but no detailed information on the feasibility of separate collection or recycling. All of them indicated that if they should be responsible for the recycling and disposal of e-waste they did not have such ability at present.

These multinational corporations showed much interest in the e-waste management at the present level. Although the increasing cost was indicated by all eight of these producers they still support the constitution of strict regulations to manage the rapid acceleration of e-waste in China. Further research into substitute materials and on advanced technologies was thought to be very necessary. These regulations would give the whole electronics industry an opportunity to compete fairly. Those corporations which cannot meet the related environmental regulations and standards will be eliminated through competition. But at the same time they all doubted the enforceability of these domestic regulations.

In contrast with these multinational corporations the domestic household electrical appliance enterprises and small scale companies showed very negative attitudes to e-
waste management. In the first fieldwork four such companies were contacted by phone or email. In the second fieldwork such producers were contacted as much as possible through email or via staff who work in such companies, both in Shanghai and Guangdong province where electronic products manufacturers are concentrated. A total of 19 producers, including the former eight available interviewed ones in Shanghai, and 16 electronic appliance producers in Guangdong province, were contacted. But, except for the eight interviewed ones in Shanghai, all the other producers, especially all in Guangdong province, did not reply or refused the interviews or replied that they were reluctant to talk about this topic. The reasons will be analyzed in the next chapter and compared with the attitudes of multinational corporations to e-waste management in China.

5.4.4.2 Consumers' attitudes to e-waste

The interviewed consumers came from four cities, Beijing, Shanghai, Guangzhou and Lanzhou. The former three cities have the top three fastest growing economies in China while the fourth one is an economically underdeveloped city in the backland of China. Consumers were chosen from visited universities, companies, customers in supermarkets and ordinary living neighbourhoods. Because the purpose of the interviews with consumers was to identify the present situation of e-waste management and to investigate the effects of public attitudes on e-waste legislation the gender, age, education level and vocation of the interviewees were not taken into account. They were selected at random just according to availability. In the first fieldwork fourteen consumers were interviewed and in the second, twenty-five. The total number of interviewed consumers was not very large so the result will be combined with secondhand data sources (section 2.5.8), such as other researchers’ interview reports, and information obtained from interviews with concerned authorities and even street hawkers who collect obsolete electronic products. The questions asked in the interviews are listed in Appendix 6.
Of the total 39 interviewed consumers, all of them knew about e-waste. Most of these thought that obsolete electronic products refer to obsolete or old computers, televisions and mobile phones. 22 interviewees had at least one or more such obsolete electronic product at that time. When asked about their knowledge of hazardous materials or components in electronic products 31 interviewees mentioned the batteries in these products. 16 interviewees knew other hazards such as mercury and lead in electronic products. They got such information from the package or instructions. Three interviewees were not very clear as to whether there were hazards in electronic products. Three main ways to deal with e-waste were mentioned in interviews; sending to friends or relatives, selling to street hawkers who collect obsolete electronic products or retailers, and storing in homes. Two interviewees said they had directly thrown away the components in computers with the municipal solid waste.

Most consumers preferred to get some money back from e-waste rather than paying for them, even though it would not be much. Computers and mobile phones particularly, which are updated very quickly, are not broken or useless anymore when they are resold out by consumers. They are just out of fashion or the owners are reluctant to update them as the cost of new ones will not be much higher than updating them and at the same time it will save trouble. But consumers knew that these old electronic products were still valuable and it was a pity to throw them away. If they did not send them to friends or relatives some of them would choose to sell out again to get some money back. And the existing secondhand market and private recycling companies can satisfy this kind of demand. Figure 5.7, which was taken in Lanzhou during observations in fieldwork, and Table 5.7 show the general prices of some obsolete electronic products (TV sets, VCDs and washing machines) when they were sold to the street hawkers or retailers. The prices of secondhand computers and mobile phones vary according to brand and quality. Some consumers will of course put them in store for some time hoping that they will be useful some day. All the interviewed consumers thought that at present it was impossible to regulate
consumers to pay for the recovery and disposal fees directly. Maybe government or e-waste recycling companies will have to pay for consumers in order to encourage them to recover e-waste.

Figure 5.7 The prices of obsolete electronic products

Table 5.7 The prices of obsolete electronic products (from Figure 5.7)

<table>
<thead>
<tr>
<th>Obsolete Electronic Product</th>
<th>Brand</th>
<th>Style</th>
<th>Price (RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV sets</td>
<td>Chang Chun or Chun Feng</td>
<td>18 inch</td>
<td>80~100</td>
</tr>
<tr>
<td></td>
<td>Hitachi or Sanyo</td>
<td>18 inch</td>
<td>100~120</td>
</tr>
<tr>
<td></td>
<td>Konka</td>
<td>25 inch</td>
<td>150~250</td>
</tr>
<tr>
<td></td>
<td>Hisense</td>
<td>21 inch</td>
<td>100~150</td>
</tr>
<tr>
<td></td>
<td>Chang Hong</td>
<td>29 inch</td>
<td>200~250</td>
</tr>
<tr>
<td></td>
<td>TCL</td>
<td>29 inch</td>
<td>300~400</td>
</tr>
<tr>
<td>VCD</td>
<td>Any brand</td>
<td>Twin tub</td>
<td>50~80</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>Chang Feng</td>
<td>Single tub</td>
<td>30~40</td>
</tr>
</tbody>
</table>

*¥ 100.00 (RMB, China Yuan) = £ 7.39904 (GBP) (24th June, 2008)

In the interviews most consumers mentioned batteries. The labels on the batteries to inform about the hazardous materials in the products made consumers clearly aware of the potential danger of the hazards. A special regulation on controlling the environmental pollution caused by batteries entered into force four years ago, 9th October, 2003 which made consumers aware of the seriousness of batteries and to actively participate in the take-back programmes. The regulation will promote the environmental protection awareness of the public step-by-step and will guide the
consumers' habit. Limited by economic development and traditional lifestyle, throwing e-waste with municipal solid waste is not very popular in China now. Five consumers showed interest in how to deal with their obsolete electronic products in an environmentally sound way and asked if there were regulations to guide them to deal with e-waste. How to effectively collect those e-wastes from consumers will become an important topic when improving regulations for integrated e-waste management.

5.4.5 Other influences on e-waste management mentioned by informants during the fieldworks

In the interviews with concerned authorities in universities both in Shanghai and Beijing they all talked about the research on the technologies of how to recycle and reuse the e-waste at present in China. These interviewees included: two professors and a lecturer of Environmental Science and Engineering Department of Tongji University, an associate professor of Environmental Science & Technology Department of East China Normal University, two professors and a research student in Environmental Science and Engineering Department of Tsinghua University, and an associate professor in Department on Environmental Sciences, College of Environmental Sciences and Environmental & Resources Law Institute in School of Law of Peking University.

At present most universities focus research on the technologies of how to recycle and reuse e-waste, such as how to effectively dismantle the printed circuit boards to get precious metals. Technologies are one of the most important things in e-waste management. E-wastes aroused people's attention not only because they brought negative impacts to the environment but also because the materials, most of which can be reused, can bring economic profit which is meaningful to the whole country as it lacks all kinds of resources except for cheap labour. But besides the technical policy of Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products drafted by SEPA, there are no related series of standards or
regulations to guide and inspect the recycling and disposal process of e-waste.

6 of the eight interviewees thought that the legislation on the e-waste management is more important at present. They did not worry about the technologies too much although the domestic e-waste recycling and disposal technologies are not very sophisticated now. But they thought that if advanced technologies cannot be developed in a short time they can be bought from industrialized countries as has happened for equipment in the developing processes of other industries in China. Learning from industrialized countries at the same time as improving our own technologies or renovating new equipment is an easy and effective way to resolve the technology problems in e-waste management. The industrialized countries have already done some very useful research on how to dismantle e-waste, how to recover precious metals from e-waste, and have also tried to develop new materials to reduce or substitute the hazardous materials in electronic products. Importing these technologies and equipment are not impossible, but their management system cannot be copied. The social situation of China is totally different from industrialized countries. For example according to the present situation of China, the best way to dismantle and sort e-waste is to use manual labour and not mechanical equipment due to the large migrant labour forces. At present it is more important to formulate regulated management systems by using the experiences of industrialized countries on e-waste management for reference. This will depend on the systematic and practical research works which are very limited and just beginning. They all agreed that enacting feasible laws and regulations would be the most direct and effective method to solve the e-waste problems and the research works were also an indispensable part of the formulation process in the management system.

5.5 Effects of e-waste management regulations

Although there are just five main national laws and regulations related to prevention
of pollution from e-waste (section 4.2.3) and relevant regulations to control importing e-waste to China (section 4.2.5), besides the Environmental Protection Law, each law or regulation focuses on the different points in e-waste management and plays a different role in the whole legislation system (Table 4.1). During the fieldworks the effects of these existing e-waste management regulations were investigated through interviews. The informants questioned on this point are listed in Table 5.2. The specific research question is: What effects do the regulations have on e-waste management?

The summaries of the findings from the interviews are:

1. At present the e-waste management in China is just at the beginning stage and the legislation system is still imperfect. The lack of related laws and regulations has become the most serious obstacle in the whole management system. The existing regulations cannot satisfy the environmentally sound e-waste management although the long term effects of these regulations cannot be assessed easily.

2. The regulations on e-waste management in industrialized countries cannot be duplicated in developing countries. The existing regulations were formulated by relevant administrative department to comply with the international regulations which has caused some articles in the regulations to be too general to be enforced. The process of e-waste control in China should be divided into several steps according to the current social and economic situation.

3. The implementation of these regulations would bring negative impacts to the electronics industry and e-waste management. The increased cost is the most serious impact factor for e-waste management.

4. Except for the negative effect, these regulations could motivate the government to improve the existing e-waste management system. They have also encouraged producers to improve their product design and utilize environmentally-friendly materials in electrical and electronic products.
5.6 Summary

In this chapter from the overview of the legislation system on e-waste management, the related administrative departments or institutions and the interviews with concerned authorities, electronic appliance producers and consumers it can be concluded that at present the e-waste management in China is just at the beginning stage and the lack of related laws and regulations has become the most serious obstacle in the whole management system. Lack of systematic and enforceable national laws and regulations has also limited the formation of corresponding provincial or city regulations. The formation procedure of the regulations was prior to any systematic and practical research which has decreased the enforceability of these regulations and there have been no subsequent regulations and standards to assist the enforcement of these laws and regulations. For example, there are no laws or regulations to control and inspect the secondhand market for obsolete electronic products and the regenerative resource market. The licensing, registration system and qualification standards are too deficient to guarantee the quality of secondhand electronic products and the recycling and disposal enterprises. The definition of e-waste in different laws or regulations issued by different administration departments is inexplicit or even contradictory which allows exemptions from rules to control some of the small household electronic appliances and to import e-waste.

Legislation of other countries, especially the WEEE and RoHS, will bring negative impacts to the electronics industry in China. The increased cost is the most serious impact factor to e-waste management. But these regulations will also motivate producers to improve their product design and utilize environmentally-friendly materials. These regulations have urged the government to enact corresponding regulations to improve e-waste management as well, which is a positive impact.

E-waste management producers of multinational or large scale corporations showed a totally different attitude to middle- and small-scale enterprises. The increased cost is
the key point in domestic regulations as well. It is a huge burden to all producers especially to small-scale enterprises. All producers have no ability to recycle and dispose of e-waste by themselves in the present economic conditions and social background. So it is necessary for related administrative departments to make an economic analysis about e-waste recycling and disposal costs, such as the cost for the recovery process, energy consumption in the treatment process and economic profits which can be made from e-waste reuse and recycling, and then offer financial and technical support to both e-waste recycling enterprises and producers.

The recovery system is the key point in the recycling system and is the important topic when developing and improving the regulations for the integrated management of e-waste. Effectively recovering e-waste from consumers will have a definite effect on the downstream pathways of e-waste. The existing e-waste recovery system adapts to the current social situation in China although it has not been operated and controlled under strict laws and regulations. So enacting feasible regulations for control and monitoring is vital. Developing a secondhand market for obsolete or old electronic products is important in the recycling system especially in the hinterland provinces and in rural areas in China according to the consumption abilities in these areas. Producers as well as government and even consumers should be responsible for e-waste together and not the producers or government alone.
Chapter 6 Discussions of the Results and Implications

6.1 Introduction

Chapter 4 presented the results from documents/literature and chapter 5 presented the results from the interviews and observations in the fieldworks. This chapter presents the discussions of the results based on the former two chapters. The primary data of this research comes from the interviews with officers or experts from key relevant government departments/institutions in China involved in e-waste management, from electronic appliance producers, from customers at different levels of the value chain, as well as direct and non-participant observations carried out in six cities during the fieldworks, i.e. Beijing, Shanghai, Tianjin, Lanzhou in Gansu Province, Guangzhou and Shenzhen in Guangdong Province (Map 3.1). The key informants included officers in SEPA and in local environmental protection departments, authorities in environmental science or engineering departments of universities, and engineers in environmental engineering design institutions which can all be tracked in chapter 5 with details. Another source of data comes from the government documents (sections 4.2 and 4.3) and published literature (section 4.4) both in Chinese and English. The main analysis methods include both vertical and horizontal comparison to develop explanations and then draw conclusions. The following sections discuss the deficiencies in the law and regulations on prevention of pollution from e-waste, the loopholes in the regulations to control importing e-waste, the deficiencies in the enforcement process, the other influences on e-waste legislation and the producers’ and consumers’ responses to the enforcement of e-waste management regulations and the pilot projects. Then the findings are refined into a discussion of implications.
6.2 The deficiencies in the regulations on prevention of pollution from e-waste and to control e-waste import

To identify the present situation of e-waste management in China and to find the existing problems during the enacting and implementing process of legislation on e-waste management, four key informants, who were mentioned in section 5.2, were interviewed with the following specific research question: What deficiencies exist in the legislation for effective e-waste management in China? They mentioned the hidden weakness in the present legislation system and gave examples to illustrate the unreasonable points in the legislation formation process in e-waste management as well as the negative results of these deficiencies (Table S.1).

6.2.1 The deficiencies in the regulations on prevention of pollution from e-waste

From the interviews (section 5.2) and literature review (section 2.6) the main deficiencies in the law and regulations on prevention of pollution from e-waste are indicated:

1. Lack of systematic and practical research on e-waste which has weakened the enforceability of the regulations

The pressures of e-waste issues on the administrative government made it urgent to enact regulations to control these situations while systematic research was ignored or behind schedule. The main regulations were drafted on the basis of insufficient research work. For example there is no economic analysis about e-waste recycling and disposal costs such as the cost involved in the recovery process, energy consumption in the treatment process and economic profits which can be obtained from e-waste reuse and recycling. The financial support and the payment system are the key points in the whole e-waste management system. No matter whether recycling or disposing of e-waste, the cost is always the first consideration for the government.

In the Ordinance on the Management of Waste Household Electrical and Electronic
Products Recycling and Disposal (4.2.3.2) although it regulates that the government shall establish a special fund to assist the financing of e-waste recycling and disposal, the detailed function of this fund, the sources, and the governing unit in charge of this fund were not explained in the regulation which made the establishment of this fund an empty promise. Another example is that the data on e-waste including the quantity, downstream pathway monitoring and material flow are too limited to support the regulations. Until the end of 2006, during which the data collection for this research was completed, there was still no official data on produced e-waste in China or in different provinces. The situation of e-waste in some areas such as Guiyu, Guangdong province and Taizhou, Zhejiang province (section 2.5.3) was reportedly exaggerated or the facts were hidden. To comply with the international regulations three national regulations were drafted prior to any systematic or practical research work (Table 4.1). As a result the articles in these regulations are too general to be accurately implemented.

2. Lack of systematic and enforceable national laws and regulations limited the formation of local corresponding regulations

The regulations drafted by NDRC and SEPA have been discussed and commented on for a very long period but they are still not passed by State Council, which, as a result, has directly affected the formation of local regulations to control e-waste. However those regulations which have been implemented always lack subsidiary regulations and detailed standards to complete the implementation of these laws or regulations. For example, due to the difficulty of finding suitable materials to substitute the six hazardous materials in e-waste, the catalogue listing such substitutes is empty now. In addition the licensing system for monitoring and screening obsolete electronic appliance recycling and disposal enterprises does not yet exist although such an e-waste registration system is required by the regulations. Local government cannot find national support to develop their own regulations. At present, very few provinces and cities have drafted related regulations to manage e-waste.
3. The definition of e-waste in different laws or regulations issued by different administration departments is inexplicit. Some of the small household electronic appliances are not covered. Through comparing and analyzing the main regulations (section 4.2.3) on e-waste management it was found that the definition of e-waste is indistinct in different regulations. First, there are no standards to classify e-waste separately from municipal solid waste (MSW) and which will require special technologies for disposal and recycling. Second, the categories of e-waste in different regulations are not identical. For example in the Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products (4.2.3.5) e-waste refers to all wastes of electrical and electronic equipment as a single category. In the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (4.2.3.2) there are just five main household electronic appliances mentioned, obsolete TV sets, refrigerators, washing machines, air conditioners and computers, but not including other small household appliances such as CD/DVD players and even mobile phones which are one of the main solid waste streams in e-waste. In another regulation Management Methods on Pollution Prevention in Electronic Industry (4.2.3.3) refrigerators, washing machines and air conditioners are excluded. Third, e-waste is a new problem in the last one or two decades; with the rapid development of information and electronics industries, there are no special standards to define e-waste and to evaluate the hazards in e-waste and no licensing system to control the treatment enterprises, all of which has made it difficult to interpret the existing laws or regulations. The enforceability of these laws and regulations is weakened.

6.2.2 The loopholes in the regulations to control the import of e-waste

1. Some detailed articles in the regulations to control the import of e-waste, which have the same legal effects but are issued by different administrative departments, are contradictory which provides opportunities for exemption to import e-waste. Although government has made great efforts to control the e-waste import, some laws
or regulations are contradictory and there exist some loopholes in them, which all make the import activities more serious. For example, under existing regulations, according to the lists issued by Customs Administration in July 2002 (section 4.2.5.2) which include wastes prohibited for import, printed circuits, electronic integrated circuits and micro assemblies are absolutely prohibited from import. But in another directive, also approved by Customs Administration and enforced from 1st January 2002, Measures on the Management of Automatic Import Products' Permit (Ministry of Commerce, 2001), hardware and electronic equipment which have recoverable metals, such as copper and aluminum, can be automatically imported and do not belong to hazardous waste. These recoverable metals are the main materials used in the components of circuit boards of computers. This means that there exist loopholes in these two regulations. E-waste can also be imported and it seems reasonable as they contain metals which can be imported under the name of recoverable products. This contradiction of some regulations has allowed the enforcement institutions to provide exemption from rules.

2. The legislation gaps between China mainland and Hong Kong have made Hong Kong and its neighbouring Guangdong Province weak points in the e-waste importing control system.

From analyzing the national regulations on e-waste import (section 4.2.5.2), it was found that there are gaps between China mainland and Hong Kong in waste legislation, which have made Hong Kong an e-waste transfer station and made Guangdong Province become the most serious area for e-waste issues. For example, in Hong Kong, China Inspection Company Limited (CIC) is the sole representative of General Administration of Quality Supervision, Inspection and Quarantine of China (AQSIQ). All the imported used mechanical and electrical products and recyclable materials should be inspected by CIC first and then be declared to the Customs. All the products listed on the Fifth list of Prohibited Goods for Import will not pass the inspection (CIC, 2003). But actually importers have declared to the Customs that they just import hardware which has recoverable copper and aluminum (Greenpeace China,
2003). So the products have no need to be inspected by CIC and can be imported directly as automatic import products. CIC seems no longer effective to prohibit import.

Additionally, in the Waste Disposal Ordinance, which is the main regulation on waste management in Hong Kong, there is a most important concept - prior informed consent (PIC) - which is also the most important aspect of the Basel Convention (UNEP, 2007). PIC ensures that countries exporting hazardous waste receive prior consent from the government receiving the waste including the transfer countries. But the Import and Export (Registration) Regulations in Hong Kong permit that exporters and importers can also declare to the Customs within 14 days of the products departure or arrival from Hong Kong (Department of Justice, 2003). This almost equates to an abrogation of the PIC because when e-waste is shipped from Hong Kong to Guangdong Province in China mainland, it only needs one day. So in these 14 days, there will be enough time for exporters and importers to finish transportation, resell, dismantle and even carry out all other disposal processes. This has made it easy to import e-waste to China.

Moreover, in Hong Kong only destroyed CRTs and other electronic applications are regarded as e-waste. Secondhand electronic products do not belong to e-waste (Environment Protection Department, 2003) so they will not be controlled by the Waste Disposal Ordinance. And only this ordinance controls the import and export of e-waste in Hong Kong, while under the Import and Export (Registration) Regulations there are no rules to limit the import and export of e-waste. This is an exemption for secondhand electronic products to be exported to the China mainland. As a result, it is not illegal in Hong Kong to import and export parts of obsolete electronic products such as circuit boards, although it is illegal in China.
6.2.3 Implications

Findings through the interviews and documents/literature show that:

- Developing subsidiary regulations in the form of statutory instruments and standards could support the enforcement of the main national laws and regulations on e-waste management and it could further encourage the development of local regulations.

- The categories of e-waste and the contents of the e-waste management regulations formulated by different administration departments should be consistent to avoid exemption or contradiction of the rules. Although due to the large and continually increasing quantity of some e-wastes, such as large house appliances, computers and mobiles, priority attention was paid to such obsolete items in some regulations, small electrical and electronic equipment, components and accessories should also be regulated and controlled.

- There is a need to survey the quantity of e-waste, to monitor the downstream pathways and impacts of e-waste and to do the research on the e-waste material flow before the administrative department can make the plans on e-waste control and finalise the regulations.

- There is a need to provide economic analysis on the e-waste recycling and disposal before the drafted regulations are finalized and issued by the administrative departments. Then the establishment of special funds to support the financing of e-waste recycling and disposal to the e-waste recovery enterprises and producers will become feasible.

6.3 The deficiencies in the enforcement process

In an e-waste management system, many administrative departments and institutions are involved (section 4.3.1 and Table 4.2). Different institutions and administrative department collaborate to implement the regulations to control e-waste. To survey the implementation, review and feedback processes of the laws and regulations on e-
waste management and to evaluate the linkages and relationships of legislation with these administrative departments, the following specific research question was raised:

How are regulations on e-waste in China enforced and monitored?

Six key informants from SEPA and local environmental protection bureaux were interviewed (Table 5.2). From the interviews (Tables 5.3 and 5.4) and the analysis of Table 4.2 the deficiencies in the enforcement process are discussed in turn below.

- The administrative function of SEPA
- The responsibilities of each relevant administrative department
- The localization of the national legislations
- The monitoring system
- The collaboration of different administrative departments at local level.

6.3.1. The administrative function of SEPA

The administrative function of SEPA is undermined by NDRC and parts of the responsibilities of these two administrative departments overlap.

From the national level SEPA and NDRC theoretically have the same administrative power. NDRC (section 4.3.1.2) focuses on the macro-control to balance the economic development and environment protection, while SEPA (section 4.3.1.1) mainly manages environmental protection. But actually all the projects and enforceable plans related to the environmental protection industry have first to be examined and approved by NDRC, which is the Chinese style of organizational structure for government administrative departments. NDRC is also responsible for adjusting and controlling the relationship of the environmental protection industry with other industries such as the electronics industry. The general e-waste management strategies and financial supports are also included in its administrative responsibilities. When the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (4.2.3.2) was drafted, NDRC wanted to be the principal administrative unit leading the management of e-waste, because this
involves the conservation and comprehensive utilization of resources which are important concepts for sustainable development in China. But NDRC do not have corresponding personnel or workgroups to implement these regulations and do not detail the enforcement process of these regulations (Table 5.3), which has caused SEPA to be in an embarrassing situation over e-waste management. As a result the function of NDRC was questioned and it is not now in the leading position to manage e-waste. Actually SEPA acts as the principal administrative unit to manage e-waste and has drafted another law as well (4.2.3.5). Most articles in these two regulations are repeated. SEPA is the main administrative department to implement e-waste management laws and regulations but some strategies and detailed activities have to be approved by NDRC first. The administrative power of SEPA is undermined and it is located in a passive position on e-waste management. As shown in Table 4.2, parts of the responsibilities of SEPA and NDRC overlap which has made it difficult for SEPA to regulate and implement related legislations effectively.

6.3.2. The responsibilities of each relevant administrative department

The responsibilities of each administrative department involved in e-waste management are not explicit.

The activities to manage e-waste always involve more than one administrative department as shown in Figure 6.1, which illustrates the involved administrative departments and their main responsibilities in the e-waste management system. The overlap of responsibilities made it very easy to shirk their duty. For example (Table 5.3), MII focuses on the management of new electrical and electronic product research and development, and in principle it is also responsible for the reduction of e-waste through recycling as well as minimizing the environmental pollution caused by e-waste, both of which are regulated by its own laws (4.2.3.3). But in fact MII just controls the e-waste produced in the electronic product manufacture process not including e-waste collected after consumption and e-waste recycling, which is
considered to be mainly dealt with by SEPA. At the same time SEPA does not have enough ability to adjust the relationship with MII which is thought of as the responsibility of NDRC. Without the support from MII to make the producers responsible for their products after consumption, it is difficult for SEPA to collect, transport, sort, recycle and dispose of all e-waste. Then as the result, the regulations of e-waste management are not implemented practically and effectively. The management of e-waste is not integrated. On the surface several departments collaborate to participate in the management of e-waste. But in fact, different units managing e-waste separately cause the effective enforcement of laws and regulations to be undermined.

Figure 6.1 The involved administrative departments and their main responsibilities in the e-waste management system

6.3.3. The localization of the national legislation

The localization of the national legislation has become the weak link in e-waste management.

After the national law has been issued and entered into force, local related
administrative departments will develop corresponding detailed enforceable regulations and rules consistent with the national laws or regulations (Figure 4.3). This is the most important step in the whole enforcement process. But from the interviews with the informants, who work at the city level or district level in environmental protection bureaux (Table 5.4), it was found that at the local level, the administrative institutions such as provincial or city development and reform commission and environmental protection bureaux met the same problems as SEPA and NDRC. Local EPBs do not always have the real administrative power to regulate e-waste management. At the same time the imperfect national laws and regulations on e-waste management make the local administrative department lack support to develop their own regulations.

There is also another important reason why the existing laws and regulations cannot be effectively transformed from national level to local level. The concept of economic development priority still applies in some areas especially in the economically backward areas (Table 5.4). Local government will consider the economic development first. If the government can gain profit from a special industry, even though it is environmentally unsound, such as the existing e-waste recovery system in Guangdong and Zhejiang province (Map 2.1), the environmental protection will always be ignored. Then the enforcement of the regulations to control e-waste is put aside which has caused a commonly observed phenomenon in China; although there are related regulations to manage e-waste, actually at local level there are no practical activities to implement these regulations. This also indicates another deficiency in the whole enforcement process.

6.3.4. The monitoring system

There is no systematic monitoring system to supervise the enforcement of the regulations to control e-waste.
As stated in 4.3.1.1 the Bureau of Environmental Supervision in SEPA organizes the national inspection and supervision of environmental law enforcement. Local environmental protection bureaux also set the same department to inspect and supervise the enforcement of related regulations. But due to the shortage of personnel it is difficult to exercise this supervisory authority (Table 5.4). At the same time these supervision units in the environmental protection department have no rights of administrative punishment and as there are no standards to regulate the punishment system the monitoring system becomes ineffective.

6.3.5. The collaboration of different administrative departments at local level

The collaboration of different administrative departments at local level is not effective.

For example (Table 5.4), the collection of solid waste is the responsibility of the urban environmental sanitation institution which belongs to the city construction bureau, another administrative department at the same level as the environmental protection bureau. The local EPB is only responsible for the recycling and disposal of e-waste after it has been collected from all kinds of consumers. The two departments are responsible for the recovery of e-waste from consumers and the disposal of e-waste respectively. The current reality is that there is no regulated recovery system organized or supervised by the administrative department which has caused environmentally unsound enterprises to become the main operators to recycle and dispose of e-waste. The urban environmental sanitation institution cannot recover e-waste through a regulated system. Then the local EPB cannot recycle or dispose of e-waste in an environmentally sound manner. The effective management of e-waste needs the collaboration of different administrative departments at local level.
6.3.6 Implications

Findings from the documents and interviews show that:

- Identifying the administrative function of each department to implement e-waste management laws and regulations is the key to effective management of e-waste.
- One principal administrative department should be responsible for e-waste management and coordinate the cooperation of various departments which could avoid the duplication of administrative functions among government departments.
- At local level, the effective management of e-waste also needs the collaboration of different administrative departments. Developing local e-waste management regulations could improve the enforceability of the national law and regulations.
- Establishing the correct awareness that economic development and environmental protection should be taken into account simultaneously is a long term task for the local governments. The potential benefits of recycling e-waste are not perceived by the local government.
- Constructing a monitoring system to supervise the enforcement of the regulations could be an effective way to control e-waste.

6.4 The other influences on e-waste legislation

Besides the analysis of the deficiencies in the existing law and regulations and in the enforcement process, there are other influences that will also directly affect the e-waste legislation in China. The specific research question in this section is:

What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?

The main factors, which were identified during the interviews, focus on:

- the other countries’ or international legislation
- the recovery system of e-waste
- the secondhand market for e-waste and the regenerative resources market for
reusable materials in e-waste
• the registration of recycling and disposal enterprises
• public (producers' and consumers') attitudes to e-waste management regulations
• the pilot projects on e-waste recycling and disposal
All of these factors will also affect the development and improvement of regulations on this e-waste issue.

6.4.1 The impact of other countries' legislation or policies

6.4.1.1 Summaries of the findings from interviews and literature

The data from the interviews (section 5.4.1) and literature (section 4.4) indicate:

1. Other countries' or international legislation, especially the WEEE and RoHS, have brought negative impacts to the electronics industry and e-waste management in China. The increased cost (a) to recycle e-waste, (b) to develop more advanced techniques and equipment and (c) to invest in the study and exploration of substitute materials, are the most serious impact factors on e-waste management.

2. These regulations have motivated the Chinese government to enact corresponding laws or regulations to deal with the increasingly serious issue of e-waste and improve the existing e-waste management system. They have also urged producers in China to improve their product design and utilize environmentally-friendly materials in electrical and electronic products.

3. These regulations have given the producers of multinational or large scale corporations in the electronics industry an opportunity for environmentally sound competition and better management of e-waste through improved technology and advanced raw materials. But they have brought negative impacts to middle- or small-scale electronic product manufacturing enterprises. To solve the problems caused by the increased cost and to compete in the international electronic product market they
need more support from government through legislation.

6.4.1.2 The improvement processes to counter the negative impacts

In the process of data collection, apart from eight producers who accepted the interviews (section 5.4.1.2) there were no direct replies from other contacted middle- or small- scale electronic product manufactures to this question: What kind of effect does other countries' legislation, such as WEEE and RoHS, have on e-waste management in China?

But from secondary data, it has been found that the economic loss caused by the extra charges has made it unacceptable for most of the household electrical appliance enterprises in China (Wu, 2004). To compete with large corporations in the world market these enterprises need more support from government through legislation. To find countermeasures to deal with these negative impacts brought by other countries legislation, and to improve electronic product manufacture in China the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (4.2.3.2) and the Management Methods on Pollution Prevention in Electronic Industry (4.2.3.3) were drafted. The former one was to comply with WEEE while the latter one was to correspond to RoHS. But unlike WEEE and RoHS these domestic regulations will take several steps to manage e-waste. For example in the latter, the six hazardous materials in e-waste are difficult to be substituted at current levels of technology. Then the related regulation is divided into two steps; the first step is to label the hazards on electronic products and the second one will be to phase out the use of these hazards. This gives producers a period of time to develop suitable strategies to deal with the e-waste issue. Besides technical support, financial support is also important and needs to be reflected through the regulations.
6.4.2 The recovery system of e-waste

From the interviews (section 5.4.2.2) and observations (Figure 5.5), the conclusion can be drawn that the recovery system is the key to the whole recycling system although there are different opinions about the pattern of it (Table 5.5). The current existing recovery system, which is not operated under legislation but adjusted totally by the market economy, is adapted to the current situation in China. Improvements have to be made from the legislation perspective by reducing the limitations caused by the lack of related regulations to control and inspect.

According to consumers’ consumption habits most consumers will not pay for the recycling of e-waste but resell obsolete electronic products to individual brokers or retailers for some money back. If the government or other professional recycling companies want to recover e-waste, they must buy it from those brokers or retailers, which increases the disposal cost of e-waste. At the same time because the environmentally sound recycling and disposal of e-waste also needs money and there are no preferential policies from government to support the recycling of e-waste, most producers, as well as large recycling companies, are reluctant to recover e-waste themselves. They meet difficulties in making economic profit from this business. The original regulated recovery system, constructed before the late 70s economic reform in China, was supported by government through many economic preferential policies such as tax reduction and financial encouragement and consisted of government-employed skilled workers. This cannot compete with the informal or individual e-waste collection system now and gradually shrank. As a result, only private brokers, some retailers and small-scale e-waste dismantling factories or unlicensed family work-sheds become the main operators of e-waste.

Constructing a regulated recovery system combined with the reality of the current informal recovery system needs relevant policies for support. The existing recovery system cannot be ignored entirely and cannot be swiftly eliminated. It is also
impossible to reconstruct the former regulated recovery system which was totally controlled and managed by government. Instead of prohibiting the current e-waste recovery by small-scale enterprises or individuals, it should be possible to control and monitor them by enacting more appropriate regulations. It is feasible to reformulate preferential economic policies to improve the current recovery system, such as tax reduction or tax exemption or financial encouragements which were proved to be very effective when developing the resource recycle system before the 70s. These preferential policies from government can not only regulate the existing e-waste recovery system but also encourage the electronic appliance producers to take part in the recovery programme of e-waste and to stimulate more professional recycling enterprises to deal with e-waste in an environmentally sound manner. This will be the most proper method to improve the recycling system of e-waste in China.

6.4.3 The secondhand market and the regenerative resources market for reusable materials in e-waste

6.4.3.1 The secondhand market for obsolete electronic products

In China economic development in different areas is very unbalanced. The income of consumers and their consumption behaviours are totally different. Table 6.1 shows the household consumption expenditure level in 2006 in the three visited municipal cities Beijing, Shanghai and Tianjin and two provinces Guangdong and Gansu where the visited provincial capital cities of Guangzhou and Lanzhou are located respectively. Another province Zhejiang was also listed because it is the only nationally appointed experimental province in the e-waste management programme. The location of these cities and provinces is showed in Map 3.1.
## Table 6.1 Household Consumption Expenditure Level in 2006

<table>
<thead>
<tr>
<th>Region</th>
<th>Value (RMB)</th>
<th>Urban/rural Consumption Ratio (Rural household =1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Households</td>
<td>Urban Households</td>
</tr>
<tr>
<td>Beijing</td>
<td>16,770</td>
<td>18,508</td>
</tr>
<tr>
<td>Shanghai</td>
<td>20,944</td>
<td>22,294</td>
</tr>
<tr>
<td>Tianjin</td>
<td>10,564</td>
<td>12,554</td>
</tr>
<tr>
<td>Guangdong</td>
<td>10,829</td>
<td>14,913</td>
</tr>
<tr>
<td>Gansu</td>
<td>3,810</td>
<td>8,190</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>11,161</td>
<td>15,877</td>
</tr>
</tbody>
</table>

1. The effect of price differentials between urban and rural areas has not been considered in the calculation of the urban/rural consumption ratio.
2. Absolute figures in this table are calculated at current prices.

* ¥100.00 (RMB, China Yuan) = £7.39904 (GBP) (24th June, 2008)

This table shows that the consumption expenditure in these cities and provinces is totally unbalanced. The consumption expenditure of all households in Shanghai is about 5.5 times that in Gansu province which is one of the poorest provinces in China. The same consumption expenditure in Tianjin, which is the second lowest in these listed figures, is also about 2.8 times that in Gansu province. The consumption expenditure of urban households in Shanghai and Tianjin is about 2.7 times and 1.5 times respectively higher than the one in Gansu province. In rural areas this difference is more obvious. The consumption expenditure of rural households in Shanghai is about 5.4 times the one in Gansu province and about double that of both Tianjin and Guangdong province. This unbalanced situation has caused the secondhand electronic products to flow away from the coastal cities to the economically backward hinterlands such as western provinces in order to satisfy the demand of those low-income consumers. This trend was also observed during the fieldworks of this research.

And from the above Table 6.1 the urban/rural consumption ratios are all higher than 2.2. This tremendous difference between the urban and rural areas can also be reflected from Table 6.2 which shows the number of major durable electronic
appliances owned per 100 households in urban, rural and 12 western provinces (autonomous regions, municipality) households at the end of 2006.

Table 6.2 Number of major durable electronic appliances owned per 100 households in urban, rural and 12 western provinces (autonomous regions and municipalities) at the end of 2006

<table>
<thead>
<tr>
<th>Item</th>
<th>All China</th>
<th>12 Western Provinces (Autonomous Regions, Municipality)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Washing Machine (set)</td>
<td>96.77</td>
<td>42.98</td>
</tr>
<tr>
<td>Refrigerator (set)</td>
<td>91.75</td>
<td>22.48</td>
</tr>
<tr>
<td>Colour TV set (set)</td>
<td>137.43</td>
<td>89.43</td>
</tr>
<tr>
<td>Black and White TV set (unit)</td>
<td>17.45</td>
<td></td>
</tr>
<tr>
<td>Air Conditioner (unit)</td>
<td>87.79</td>
<td>7.28</td>
</tr>
<tr>
<td>Electric Fan</td>
<td>152.08</td>
<td></td>
</tr>
<tr>
<td>Smoker Absorber (Exhaust Fan) (unit)</td>
<td>69.78</td>
<td>7.03</td>
</tr>
<tr>
<td>Hi-Fi Stereo Component system (unit)</td>
<td>29.05</td>
<td>14.29</td>
</tr>
<tr>
<td>Video-recorder (set)</td>
<td>15.08</td>
<td>2.97</td>
</tr>
<tr>
<td>Video Disc Player (set)</td>
<td>70.15</td>
<td></td>
</tr>
<tr>
<td>Radio Cassette Player (unit)</td>
<td>10.28</td>
<td>32.66</td>
</tr>
<tr>
<td>Computer (set)</td>
<td>47.20</td>
<td>2.73</td>
</tr>
<tr>
<td>Mobile Phone (unit)</td>
<td>152.88</td>
<td>62.05</td>
</tr>
</tbody>
</table>

(1). 12 Western Provinces (Autonomous Regions and Municipality) refer to Xinjiang Autonomous Region, Xizang Autonomous Region, Neimenggu Autonomous Region, Gansu Province, Qinghai Province, Sichuan Province, Ningxia Autonomous Region, Shanxi Province, Chongqing Municipality, Guizhou Province, Guangxi Autonomous Region and Yunnan Province.


The table shows that black and white TV sets, electric fans and radio cassette players are still very popularly used in rural areas and have become almost obsolete in urban areas. The large household electrical appliances, such as washing machines, refrigerators and colour TV sets, are widely used in both urban and rural areas, but the possession of these electronic appliances owned by rural households is much lower than in urban areas. For computers and mobile phones, two of the most popularly used...
communication products, the gaps between urban and rural areas are most obvious. Nationally the number of computers owned per 100 urban households is almost 17 times that of rural households. The number of mobile phones owned per 100 urban households is about 2.5 times higher than that in rural areas. In 12 western provinces (autonomous regions and municipality), including Gansu province visited during this research, the number of computers owned per 100 urban households is even as much as 68 times the number in rural households. The number of mobile phone owned per 100 urban households is 2.7 times higher than the number in rural households. So these obsolete electronic products such as computers and mobile phones from urban households are always sold to rural consumers after simple testing and repair without considering if these products will shortly reach the end of their safe lifespan. Except for the computers and mobile phones, the possession of the other electronic products such as colour TV sets, washing machines, refrigerators, air conditioners and video disc players per 100 households in rural areas is also very low in the 12 western provinces which are the economically poorest areas in China. This means there is a very big market for secondhand products in those rural areas.

From a positive perspective the existence of the secondhand electronic product market gives an opportunity to prolong the lifespan of those obsolete electronic products which are thrown away or resold, not because they are broken or unusable but because they have become old-fashioned in urban areas. But at the same time because there are no detailed regulations and standards for inspection of this secondhand market, this has given some private brokers or retailers a chance to sell obsolete electronic products which have already reached their maximal lifespan (section 5.4.2.3). They will sometimes be potentially dangerous to users and of course will reach the end of their lives very quickly. Most consumers lack knowledge on the hazards of e-waste and do not realize the seriousness of environmental and potential safety issues posed by e-waste (section 5.4.4.2). Some brokers or retailers dismantle obsolete electronic products to get the still usable components and then resell or reuse them in the secondhand market. Some old style components are even reused in new
products in unlabelled form to cheat the customers (section 5.4.2.3), which also destroys the rules of fair market competition. To protect the rights and interests of consumers it is also necessary to develop relevant regulations to manage e-waste. Formulating regulations to manage the secondhand market for electronic products is another important part in e-waste management which is not reflected in the existing e-waste management system.

6.4.3.2 The regenerative resources market of reusable materials in e-waste

As shown in the literature review (section 2.2.2), although e-waste is hazardous, if recycled properly the materials in it can be used as replacement of raw materials required in the growing information and electronics industry and other manufacturing fields. Circling the material flow is the basic pattern of a circular economy (Zhou, 2006). China is a resource poor country (SEPA, 2004). With the rapid economic development the resource exploitation rate has increased greatly as well as in intensity and extent. Now it is in the second place for resource and energy consumption in the world just below America (EIA, 2007). If this condition lasts, the resources will not be able to support the long-term economic development. The shortage of resources will become the most important factor restricting the development of the economy in the future. At present the per capita resource in China is very low and the resources have been depleted seriously due to the traditional unsustainable economic model which is the linear economic development model illustrated in Figure 6.2 (CCICED, 2003 and Zhu, 2004). The social economy system is composed of a production system and a consumption system. The natural resources are turned into products through the production system and then the products become wastes by consumption. Compared with the concept of sustainable development (section 2.3.1), in this whole process many raw materials have been wasted and plenty of wastes produced. E-waste is also an outcome of this unsustainable economic development model.
But according to the characters of e-waste it can play a very important role in comprehensive resource utilization through proper recycling. There are many valuable materials in e-waste such as plastics, copper, iron, aluminum and other precious metals, gold, platinum, cadmium, and barium etc (section 2.2.2). If all these materials were recycled and reused properly the rate of resource depletion could decrease, the stress from the shortage of resources could be alleviated and the circular economy and sustainable development could be realized. Reusing the valuable materials in e-waste is one of the basic material flow patterns of the circular economy development model which overcomes the shortages of the linear economic model. The circular economic development model is shown in Figure 6.3 (CCICED, 2003; Zhu, 2004 and Zhou, 2006). In this model the wastes are reused as resources and returned to the material flow by the recycle system.

At present in the unregulated recycling and disposal process of e-waste in China, owing to the backward technologies, only the most precious and easily extracted materials are recovered such as gold plating, copper wiring and lead solder (section 2.6). Many valuable materials, such as other precious metals, are discarded thereby not only polluting the environment but also wasting useful material resources (section 2.5.3 and Figure 5.6). These materials in e-waste actually have a high economic value which makes material recovery desirable. Selling these valuable materials to the
Chapter 6 Discussions of the Results and Implications

regenerative resources market is one of the main income sources of the whole recycle system (section 5.4.2.1). To get the maximal commercial value from e-waste, those private disposal and recycling companies or family work-sheds have even imported e-waste illegally. The regenerative resource market links the wastes and material resources in the recycle system. It also needs government or related administrative institutions to control and inspect this upstream generation of e-waste. But the lack of such regulations has become another point of weakness in the recycle system.

6.4.4 The registration of recycling and disposal enterprises

From the observations in the fieldworks (Figure 5.5) and the interviews with street hawkers or workers (section 5.4.2.4), the main operators who recycle and dispose of e-waste in China now are private brokers, small-scale e-waste dismantling factories or family work-sheds, which use environmentally unsound methods to deal with e-waste and cause a serious environmental pollution problem in China. Some of these private e-waste recycling and disposal enterprises have registered in the local administrative department as metal or plastic recovery enterprises rather than e-waste recycling ones. But actually e-waste is their main raw waste resource. This has mixed up the concept of metal or plastic recovery with e-waste recycling which involves both hazardous and valuable materials. During the fieldwork some of the small-scale plants and family work-sheds refused to be observed in order to find if they had the operation licences to run such business. The qualification of these businesses is in doubt. It is the same result as another survey conducted in Beijing, 2005 (section 2.5.2). From the literature review (sections 2.5.1 and 2.5.2), in Guiyu and Taizhou areas, individuals and companies that dispose and recycle e-waste disposed of all kind of electronic wastes which were collected from all over the country as well as from foreign countries, including imported parts and smuggled goods. From the buying of e-waste, to transporting, dismantling, sorting, disposing to reselling an unofficial e-waste industry has been formed. They gain enormous profit from this local industry and the people working there are now rich. They do not need to cultivate the land anymore.
Most of them have their own family recycle work-sheds and they have divided the dismantling and disposing processes into detailed segments. It is very clear as to who will be responsible for dismantling circuit boards and who will work on getting metals from wires. It is impossible to force all of them to close their work-sheds in a short time. If controlled and monitored properly these individuals and enterprises could be able to develop on an effective economic basis as well as an environmentally sound one. The ability of these private recycling and disposal enterprises is totally different. The deficiency of the regulations to judge and screen the qualification of recycling and disposal enterprises has given them the opportunities to shirk their responsibility of pollution control in the e-waste treatment process.

The Announcement on Reinforcing the Environmental Management of Waste of Electrical and Electronic Equipment promulgated in 2003 (4.2.3.1) regulated that provincial level environmental protection administrations should issue hazardous waste processing licences to enterprises that can meet the environmental requirements for e-waste recycling. But until now this specific licensing system for obsolete electronic appliance recycling and disposal has not been constructed. Because e-waste is not thought of as hazardous waste the existing hazardous wastes licensing system has not been used to qualify those e-waste recycle and disposal enterprises. The draft of Management Methods for the Prevention of Pollution from Waste Electrical and Electronic Products (4.2.3.5) regulates that the enterprises which will recycle and dispose of e-waste have to be registered by the local environmental protection department. But the interviews show that which unit in the local environmental protection department should be responsible for the registration and the decision on whether the enterprise has the ability to recycle and dispose e-waste are all not regulated. The feasibility of this qualification system is limited.

6.4.5 Summaries of discussions

The data from interviews and observation in the fieldworks of this research indicate
that:

1. Obsolete electronic products, which are sold to low-income or rural areas and which are temporarily stored will finally enter into the e-waste stream making the e-waste issue more serious. It needs related regulations to prepare for dealing with this situation (section 5.4.2.1).

2. The recovery system is the key point in the recycle system. Effectively recovering e-waste from consumers will have a marked effect on the downstream pathways of e-waste (sections 5.4.2.2 and 6.4.2).

3. More than half of the interviewed authorities thought that private, small-scale e-waste recovery companies and unlicensed work-sheds should be prohibited through legislation and that it was necessary to reconstruct a regulated system and public infrastructures to recover e-waste. But other interviewees thought that the existing e-waste recovery system was adapted to the current social situation in China although it was not operated and controlled under strict laws and regulations. So enacting enforceable regulations to control and monitor them would be ideal (sections 5.4.2.2 and 6.4.2).

4. Developing a secondhand market for obsolete or old electronic products is important in the recycle system especially in the economically backward provinces and rural areas of China, based on the consumption abilities in these areas. It has a huge potential ability to deal with old electronic products. To comprehensively utilize valuable materials in e-waste the regenerative resources market also needs to be strictly regulated (sections 5.4.2.3 and 6.4.3).

5. There are no laws or regulations to control and inspect the secondhand market for obsolete electronic products or the regenerative resource market. The licensing, register system and qualification standards are too deficient to guarantee the quality of either the secondhand electronic products or the recycling and disposal enterprises (sections 5.4.2.4 and 6.4.4).
6.4.6 Implications

Related to other countries' regulations or policies the case study findings have the following implications:

- Private sector recovery and recycling has limitations and therefore the involvement of the public sectors is needed in addition.
- With the reference of the financial flow shown in figure 2.7, the financial support from the government is important to electrical and electronic equipment producers to recycle e-waste, especially for middle- or small-scale electronic product manufacturers and for final disposal of materials which cannot be recycled.
- The financial support to the formal e-waste recycling or disposal companies would be beneficial to effective e-waste management. It is feasible to reformulate preferential economic policies to improve the current recovery system, such as tax reduction or tax exemption or financial encouragements. Financial incentives are justified by the importance of e-waste management for the environment and public health.
- The regulations on e-waste management in industrialized countries cannot be duplicated in developing countries. The process of e-waste control should be divided into several steps according to the current social and economic situation.
- Improving the current recycle system in e-waste management through enhancing the legislation system would be an important step. From the perspective of developing a circular economy and constructing a sustainable society, proper recycling of e-waste appears to be very important. It is necessary to regulate the existing e-waste recovery system not to prohibit it.
- The subsidiary regulations at national level should include the standards and registration system to qualify the e-waste recycling and disposal enterprises which will guarantee the quality of secondhand electronic products and ensure environmentally sound e-waste management. Those existing individuals and companies that dispose and recycle e-waste need to be strictly registered and also
need support from government not prohibition.

- Economic differences across China have made it possible to sell secondhand electronic products to economically backward provinces or rural areas and to low-income customers in urban areas, but this market also needs strict control and monitoring through developing local regulations. There is a need for different special regulations for economically backward areas compared to the more advanced areas within such a big country. These special regulations would be developed at local level, but provision needs to be made for this in national regulations.

6.5 The pilot projects to get the feedback

The National Development and Reform Commission of China (NDRC) commissioned a pilot research project in 2004 whose main objective was to research the reuse of obsolete electronic appliances (section 2.5.6). Qingdao, Shandong province and Zhejiang province were commissioned as demonstration city and provinces for cutting-edge technological methods of promoting environmentally and economically sustainable e-waste management. This development may be a starting point for the government to work towards providing a more enabling environment, in terms of capacity building, financial and technical support, to the formal e-waste recycle and disposal entrepreneurs. From then on many similar pilot projects were planned and e-waste dismantling and disposal centres were constructed or will be constructed in several economically developed cities (Table 5.3).

From the interviews of this research (section 5.4.3) and related literature (section 2.6) it was found that in Zhejiang province and Qingdao, the two experimental points, the formal e-waste recycle companies could not run properly because there was not enough e-waste to be recycled and disposed. The constructed plants were always empty while the other private work-sheds or small-scale enterprises operated very
well. In the fieldwork a professional e-waste recycling plant was visited in Beijing which met the same problem. The e-waste mainly came from large-scale corporations and government which meant that the quantity of e-waste was very limited shown in Figure 5.2. The collected e-waste could be treated in very short time using very basic techniques (Figures 5.3 and 5.4) which could not satisfy the designed treatment capacity. To survive this plant had to treat other industrial solid wastes such as metal wastes from manufacturing industry. This situation can also be compared with what happened in Guiyu and Taizhou cities where e-waste recycling and disposal have even become a special economic supporting industry. To explain the differences focus was placed on the recovery system. Technically some of the formal e-waste recycling and disposal enterprises introduced advanced technologies and equipment from industrialized countries which increased the costs greatly. Both the pilot programmes have experienced difficulties in collecting e-waste and in covering the costs of environmentally sound processing (section 2.6). The problems exposed from these pilot projects provided the references for the relevant administrative department to pay more attention to the regulated e-waste recovery system and to the practical financial support.

Introduction of advanced technologies and equipment could be an easy and effective way to resolve the technology problems of e-waste management in China, but the e-waste management system in industrialized countries cannot be copied. The development of an effective way of managing e-waste should comply with the current social situation of China. For example according to the present situation of China, the best way to dismantle and sort e-waste is to use manual labour not mechanical equipment due to the large and cheap migrant labour forces. More systematic and practical research works still have to be done through these pilot projects.

Implications:
The above discussions show that:

- Importing advanced technologies and equipment would increase the operation
costs for formal e-waste recycling and disposal enterprises. Sufficient and cheap labour resources could be utilized to effectively recycle and dispose of e-waste under the present conditions.

- The pilot programmes have experienced difficulties in collecting e-waste from consumers. The current e-waste recovery system cannot meet the regulated market demand.

6.6 The producers' and consumers' response to the enforcement of e-waste management regulations

6.6.1 The reasons of the producers who refused the interviews

To investigate the effects of the electronic appliance producers' attitudes to e-waste legislation the interviews were conducted in fieldworks. The informants are listed in section 5.4.1.2 and they worked for eight multinational electronic manufacturers respectively. In contrast with these multinational corporations the domestic household electrical appliance enterprises and small-scale companies showed very negative attitudes to e-waste management during the fieldworks. Some of the contacted producers did not reply or refused the interviews or replied that they were reluctant to talk about this topic.

The main reason given by the respondents was that the e-waste issue is too sensitive at present. It is a 'hot' topic in China now. Several conferences have been held in the last two years, such as the International Conference on Electronic Waste and Extended Producer Responsibility in China, Beijing, April, 2004 and A National Forum on New Partnership for the Environmentally Sound Management of Hazardous and Other Wastes with Partnership Initiatives, Qingdao, August, 2004 (section 2.5.6), but so far there have been no substantial results. From analyzing the interviews (section 5.4.4.1) and related literature (section 2.5.7) the key point of discussion is about the extended
producer responsibility, which is listed in the draft of Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (4.2.3.2). But how to enforce this is difficult as there are no detailed or subsidiary regulations. The responsibility for recovery and dealing with e-waste was taken by the government in the past although the governmental practices were very limited and many private companies, individuals or illegal family work-sheds become involved. But the drafted regulations are trying to shift all the responsibilities from government to the producers. In the past producers have just played the role of manufacturing customer-satisfying products but have not been involved in the recycle system for end-of-life products. They have been responsible for the wastes generated from the production process but not for the products after sale or when they become obsolete although they are the originators of the e-waste. The interviews (section 5.4.4.1) show that these e-waste management regulations will mean a really big change in the whole industry which is almost impossible under the present conditions in China. For small-scale companies the increased cost will be a huge burden and not every company has such ability. It will bring negative effects to their business. Then it is important for them to get the financial or technical support from government and not to have to solve the problems all by themselves. Producers as well as government and even consumers should together be responsible for e-waste. But the current regulations cannot provide such information and the deficiencies of the national laws and regulations have made it difficult to transform them from national level into local executable level. As a result there are still no enforceable regulations to follow locally. They can do nothing to deal with e-waste without the support from government regulations and at present there are no changes to the ways to deal with the e-waste issue.

This situation is the same as what happened in some conferences (section 2.5.6) held in Beijing and Qingdao, the city which was nominated as an experimental city to construct a recycling and treatment system for e-waste. The key informants of this research described the detailed situation in these conferences which can be traced in
Appendix 8. In these conferences most electronic product manufacturers who said they would attend the conferences did not come at all. However, there were many delegates from the material recovery companies or private waste recovery enterprises. They showed much more interest in this field than electronic appliance producers.

Most of the domestic producers in the electronics industry were waiting for the further regulations on legislation by government. If they are to be responsible for e-waste it means that they will spend a great deal of money on recovery and disposal of their products and make less profit from their products in a highly competitive market. They hope to gain more concrete and enforceable polices and financial support from government rather than have endless discussions on paper. By contrast the material recovery corporations or private recovery waste work plants thought that they could only get profit from recovery materials if there were adequate e-wastes to deal with. So they were more concerned about the recovery system and how to recover e-waste from consumers using the lowest cost and gaining the highest profit.

Another reason that producers refused the interviews was mentioned by three producers who replied to the enquiry. It was that they had been interviewed by the media several times before and felt that it would affect their companies' good reputation. The recycling and disposal of e-waste are the responsibility of the whole society not just single producer. At the same time their attitudes to e-waste management would be very important information to other companies and to keep their business secrets they were reluctant to be interviewed any more.

6.6.2 Summaries of discussions

From the investigation of the producers’ as well as consumers’ attitudes (section 5.4.4.2) to e-waste legislation, the following conclusions can be drawn:

1. All producers agreed that at present the e-waste management in China is just at the beginning stage and the lack of related laws and regulations has become the most serious obstacle in the whole management system.
2. There are almost no producers responsible for the e-waste produced after consumption and no feasible recovery or recycle plans for their products. Producers have no ability to recycle and dispose of e-waste all by themselves under the present economic conditions and social background.

3. Large or multinational corporations showed more interest in e-waste management and were more supportive of the making of strict regulations to manage e-waste than middle- and small-scale enterprises.

4. The increased cost is also a key point in domestic regulations. It is a huge burden to all producers especially to small-scale enterprises. They need more financial and technical support from government.

5. Middle or small-scale enterprises lack the confidence on e-waste management due to the deficiencies of detailed and enforceable regulations and corresponding countermeasures.

6. Producers as well as government and even consumers should be responsible for e-waste together, not producers or government alone.

7. Enacting related regulations will promote awareness of environmental protection amongst the public step-by-step and will guide the consumers' habit. But at present it is impossible to regulate consumers to pay for the recovery and disposal fees directly. Government or e-waste recycling companies have to pay consumers in order to encourage them to recover e-waste.

8. How to effectively collect e-waste from consumers has become an important topic when improving the regulations for integrated e-waste management.

6.6.3 Implications

The producers' and consumers' responses in the case study to the enforcement of e-waste management regulations have the following implications:

- Producers have no ability to recycle and dispose of e-waste all by themselves under current economic conditions and social background. It is impossible to shift all the responsibilities of e-waste recycling and disposal from government to
 producers. Producers as well as government and even consumers should be responsible for e-waste together.

- There is a need for the government to offer detailed financial and technical support for middle- or small-scale enterprises, private companies or even individuals who are involved in the recycling and disposal of e-waste.

- Encouraging the consumers to participate in the e-waste recovery system could mean that they take an appropriate share in the responsibilities of e-waste management. Enacting related regulations could promote awareness of environmental protection amongst the public in a gradual way and guide the consumers' habits.

- The deficiencies of the national laws and regulations in China have made it difficult to transform them from national level into locally executable level. Actually as a result there are still no enforceable regulations to follow locally. Regulating the payment system for e-waste recycling and disposal according to the local economic conditions could improve the integrated management of e-waste.

6.7 The implications for other developing countries

6.7.1 The findings and lessons for other developing countries

As stated in the literature review (section 2.4) the issue of e-waste in developing countries has become more serious than in industrialized countries due to the inadequate professional capacity and lack of environmentally sound technologies to dispose of or recycle e-waste. The exporting of e-waste from industrialized countries has aggravated the e-waste problem in developing countries as well. The environmentally unsound e-waste recycling and disposal operations exposed in China can also be found in other developing countries, such as India, Bangladesh and Pakistan (Table 2.5). Compared with the industrialized countries, the e-waste management in developing countries is unsophisticated and only in its infancy. The
following findings and lessons can be summarized through analyzing the difficulties and problems on e-waste management in developing countries (section 2.4.4.2) as well as the case of China:

- Developing countries display the fastest growing markets for electrical and electronic products and, accompanying this growth, is the rapid increase in the quantity of domestic e-waste. Some developing countries are illegally importing considerable quantities of e-waste which has aggravated the problem.

- In developing countries e-waste is mainly recovered by informal individual brokers or street hawkers and then resold to small-scale dismantling plants or household work-sheds for environmentally unsound recycling or disposal, which has provided employment to many labourers. But most of the participants in this e-waste management system, motivated by the economic profits from e-waste recycling and disposal, are not aware of the environmental pollution and health hazards to residents and workers caused by e-waste.

- Besides general regulating the e-waste management, the public sectors in e-waste management in developing countries focus mainly on the final disposal and treatment of e-waste, but due to the lack of public infrastructures and supporting services the public sectors cannot meet the requirement for effective e-waste control. The private sectors play the important role in e-waste management although there are limitations. The private sectors involve in e-waste dismantling, sorting, transportation, recycling and final treatment, that is in all operations in e-waste recycling and disposal processes.

- The relevant governments in some developing countries have been aware of how serious the issue caused by e-waste is and have begun to develop relevant laws or regulations for improving and perfecting the existing e-waste management system. But the lack of reliable data and systematic research poses a challenge to the administrative departments to develop enforceable laws or regulations to
effectively manage e-waste. On the other hand, the lack of subsidiary laws and standards, as well as local e-waste management regulations, has obstructed the enforcement of the main national laws and regulations on e-waste management.

- E-waste in the existing or drafted regulations is defined as a single category covering a broad range of wastes of electrical and electronic equipment. Due to the large and continually increasing quantity of some e-wastes in developing countries, such as large house appliances (televisions, washing machines, air-conditions, refrigerators), as well as most widely used computers and mobiles, priority attention needs to be paid to such obsolete items in subsidiary regulations. Computers were mostly found in illegal imported e-waste in developing countries, which may need special regulation to control.

- The responsibilities of each administrative department involved in e-waste management are not explicit. The overlap of administrative functions among government departments has given them the opportunity to shirk their duty. The contradiction of some regulations formulated by different administration departments has caused exemptions to the rules. The lack of cooperation between various departments and a lack of a systematic monitoring system to supervise the enforcement of the regulations have limited the effective implementation of relevant laws and regulations in developing countries to control e-waste.

- The international regulations mainly developed under the Basel Convention seem to face difficulties in effective implementation and the lack of corresponding standards for simple but efficient e-waste management system delays their implementation. Much of the e-waste imported from industrialized countries to developing ones is in the name of donations, reuse or recycling, but in practice, it becomes an indirect way to dump hazardous e-waste onto these countries.

- The introduction of the comprehensive legal framework by industrialized
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countries, and especially by the EU, has affected the e-waste management in
developing countries. To comply with other countries’ regulations, some
developing countries have formulated their own regulations to manage e-waste.
The concept of Extended Producer Responsibility (EPR) has been proposed to
solve the problems caused by e-waste. But the regulations on e-waste
management in industrialized countries cannot be duplicated in developing
countries. Most of the electrical and electronic equipment producers in
developing countries do not have the ability to be responsible for e-waste
recycling and disposal without the financial and policy support from government.

- In contrast to the industrialized countries, the consumers are reluctant to pay the
  recycling fees for e-waste management. On the contrary, the e-waste collectors
  always have to pay the consumers to recover e-waste. The e-waste recovery
  system has become the weakness in the current recycling system of e-waste
  management. The cost for recycling and disposal of e-waste is the most
  highlighted point from the interviews for the administrative departments when
drafting regulations to manage e-waste.

- According to the economic and social conditions in most developing countries
  there are broad markets for secondhand electrical and electronic products. The
  economic differences between areas have made it possible to sell secondhand
  electronic products to economically backward provinces or rural areas and to
  low-income customers in urban areas. But the lack of standards and registration
  system to qualify the e-waste recycling and disposal enterprises means that there
  is no guarantee of the quality of secondhand electronic products or
  environmentally sound e-waste recycling and disposal. Those existing individuals
  and companies that dispose and recycle e-waste have not been strictly registered
  and cannot recycle and dispose of e-waste in an environmentally sound manner.

- In short term the stricter regulations on e-waste management may cause closing
down of small-scale e-waste dismantling factories or informal family work-sheds and the unemployment of migrant workers working for these stakeholders, and may bring negative impacts to local economy. Preventing private sectors from pursing their economic activities, such as informal e-waste recovery and recycling may result in them losing status, incomes, and assets and can deepen the economic disparities in developing countries. For the changes to be effective, some alternative opportunities for people currently working in these informal sectors will be important. Otherwise there will be political resistance at local level as well as negative impacts on the workers. For examples of changes to alternative and improved livelihoods see WEDC’s project on livelihood substitution - involving the poor in urban infrastructure and services development (Rouse, 2004).

6.7.2 The implications for the other developing countries

From the case of China the research has found the following implications for the other developing countries which meet the same e-waste issues and have similar economic characteristics.

- Developing subsidiary regulations and standards could support the enforcement of the main national laws and regulations on e-waste management and could further encourage the development of local regulations to improve the enforceability of the national laws and regulations.

- It is necessary to survey the quantity of e-waste, to monitor the downstream pathways of e-waste and to do research on the e-waste material flow before the administrative department makes the plans on e-waste control and formulates the regulations.

- Priority attention should be paid to the obsolete large house appliances (televisions, washing machines, air-conditions, refrigerators), as well as computers and mobiles, when developing subsidiary regulations to effectively recycle or dispose e-waste and to control the illegal e-waste import.
• Identifying one principal administrative department which is responsible for the e-waste management, clarifying the administrative function of each department and coordinating the cooperation of various departments could avoid the duplication of administrative functions among government departments.

• Constructing a monitoring system to supervise the enforcement of the regulations could be an effective way to control e-waste. And the monitoring system should also include the standards and registration system to qualify the e-waste recycling and disposal enterprises, the secondhand market of electronic products and the regenerative resources market of reusable materials in e-waste.

• Improving the current recycling system on e-waste management through enhancing the legislation system is important. The existing e-waste recovery system constructed mainly by individual brokers, street hawkers, informal small-scale dismantling plants or household work-sheds cannot be prohibited but should be guided by government regulations. Sufficient and cheap labour resources could be utilized to effectively recycle and dispose of e-waste under the present conditions.

• The economic differences make it possible to formulate special regulations for economically backward areas compared to the more advanced areas, even within one country. This can be done using local regulations.

• Producers have no ability to recycle and dispose of e-waste all by themselves under the current economic conditions in developing countries. The consumers cannot pay the recycling fees for e-waste management at the moment. It is impossible to shift all the responsibilities for e-waste recycling and disposal from government to producers and consumers. Regulating the payment system according to the local economic conditions for e-waste recycling and disposal could improve the integrated management of e-waste. Producers as well as government and even consumers should be responsible for e-waste together.
6.8 Summaries

This chapter has discussed the deficiencies in the laws and regulations on prevention of pollution from e-waste, the loopholes in the regulations to control importing e-waste, the deficiencies in the enforcement process, the other influences on e-waste legislation, and the producers' and consumers' response to the enforcement of e-waste management regulations and the pilot project to get the feedback. Then from the case of China the findings have been refined into a discussion of implications for other developing countries which meet the same e-waste problem. The regulations on e-waste management in industrialized countries cannot be completely duplicated in developing countries. The process of e-waste management should be divided into several steps according to the social and economic situation. Strengthening the legislation system to effectively manage e-waste is the most important step to control e-waste in developing countries. Although the developing countries have begun to develop regulations to manage e-waste, there are still shortcomings and deficiencies which have weakened the feasibility of the regulations. From the above discussions, the conclusions can be drawn that it is significant to improve management of e-waste in developing countries through developing subsidiary regulations and standards to support the enforcement of the main national law and regulations, surveying the quantity of e-waste, identifying one principal administrative department, constructing a monitoring system to supervise the enforcement of the regulations, improving the current recycling system, formulating special regulations for economic backward areas, and sharing the responsibility among the producers, government and consumers. These implications cannot only be effective for managing e-waste in China but will also give useful suggestions to other developing countries.
Chapter 7 Conclusions

7.1 Introduction

Chapter 6 discussed the key findings and summarized the implications of the thesis. This chapter concludes the thesis by highlighting the most important findings that have arisen from the case study in relation to the overall research process and outcome.

7.2 Conclusions

7.2.1 The research question

The research was guided by the research question “How can legislation and regulations be used to improve management of e-waste?” The main purpose of this research is to find how legislation and regulations can be effectively used to improve the management of e-waste in developing countries and especially in the case of China. In order to achieve the objective of this research, specific research questions leading towards answering the primary research question were developed from four main perspectives: (1) policy formation and the framework of legislation and the administrative institutions; (2) implementation, review and feedback processes of the laws or regulations on e-waste management; (3) other influences on e-waste legislation and (4) the effects of these regulations on e-waste management. This research has focused on the legislation framework of e-waste management and the implementation of legislation. The main specific research questions are:

- What deficiencies exist in the legislation for effective e-waste management in China?
Chapter 7 Conclusions

- How are regulations on e-waste enforced and monitored in China?
- What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?
- What effects do the regulations have on e-waste management?

This research is based on the case study of China. Data were collected through review of Chinese language documents and fieldworks comprising semi-structured interviews and observations. One shortcoming was reluctance of some stakeholders to be interviewed according to the fieldwork plan. But it was overcome by triangulating all possible data collection methods and combining other secondhand sources - documents and literature. The research lead to specific conclusions from the China case study (section 7.2.2) and more general conclusions on e-waste management in developing countries for each specific research question (sections 7.2.3-7.2.6).

7.2.2 Conclusions from the China case study

Through the literature review the current situation of e-waste management in developing countries and the existing problems were identified which enabled the formulation of the research questions. The review indicated that regulating for e-waste calls for clear policies, regulations, systems and institutions for effective management, monitoring and control, which are the weakest points in the e-waste management systems of developing countries. From analysis of the legislation and management system on e-waste in both industrialized and developing countries, and according to industrialized countries' experiences, it is a priority to ameliorate the existing legislation system on e-waste management in developing countries before the e-waste problem becomes worse. Most of the research on e-waste management in developing countries has focused on the survey of environmental pollution and health hazards caused by e-waste and the treatment measures to recycle and dispose of e-waste. This research however contributes new knowledge on the effective management of e-waste in developing countries through legislation and regulations, including the findings of
the existing problems during the enacting and implementing process of the laws and regulations on e-waste management. From the case of China the following conclusions were drawn.

- Lack of systematic and enforceable laws and regulations has become the most serious obstacle in the e-waste management system and limited the effective control of e-waste in developing countries.

- Developing subsidiary regulations and standards could support the enforcement of the main national law and regulations on e-waste management and it could further encourage the development of local regulations to improve the enforceability of the national law and regulations.

- Identifying the principal administrative department and coordinating the cooperation of various departments could avoid the duplication of administrative functions among government departments.

- A significant advance would be to construct a monitoring system to supervise the enforcement of the regulations and a standards and registration system to qualify the e-waste recycling and disposal enterprises, the secondhand market for electronic products and the regenerative resources market of reusable materials in e-waste.

- The economic differences would make it possible to formulate special regulations for economically backward areas compared to the more advanced areas even within one country.

- Improving the existing e-waste recovery system and regulating the payment system according to the local economic conditions for e-waste recycling and disposal could improve the integrated management of e-waste. Producers as well as government and even consumers should be responsible for e-waste together.

- Integrated management of e-waste would ensure Chinese-made products continue to have access to global markets and bring improved sustainability in particular through:
  - Benefits to the environment and public health, reduced pollution and waste disposal problems
• Through recycling, improving the efficiency of use of materials (comprehensive utilization).

• Changing the existing system however faces potential resistance from existing small-scale and informal enterprises which could lose business and face increased costs, and from local governments concerned about local economic impacts.

7.2.3 The framework of legislation and regulations on prevention of pollution from e-waste

• Developing subsidiary laws in the form of statutory instruments and standards could support the enforcement of the main national laws and regulations on e-waste management and this could further encourage the development of local regulations.

• The categories of e-waste and the contents of the e-waste management regulations formulated by different administration departments should be consistent to avoid exemption or contradiction of the rules.

• There is a need to survey the quantity of e-waste, to monitor the downstream pathways and impacts of e-waste and to do research on the e-waste material flow before the administrative department makes plans on e-waste control and finalises the regulations.

• There is a need to provide economic analysis on the e-waste recycling and disposal before the drafted regulations are passed and implemented by the administrative departments. Then the establishment of special funds to support the financing of e-waste recycling and disposal for the e-waste recovery enterprises and producers will become feasible.

7.2.4 Enforcement and monitoring of regulations

• Identifying the administrative function of each department to implement e-waste
management laws and regulations is key to the effective management of e-waste.

- Clearing one principal administrative department to be responsible for e-waste management and coordinating the cooperation of various departments could avoid the duplication of administrative functions among government departments.

- At local level, effective management of e-waste also needs the collaboration of different administrative departments. Developing local e-waste management regulations could improve the enforceability of the national laws and regulations.

- Establishing the correct awareness that economic development and environment protection should be taken into account simultaneously is a long term task for the local governments. The potential benefits of recycling e-waste are not perceived by the local government.

- Constructing a monitoring system to supervise the enforcement of the regulations could be an effective way to control e-waste.

7.2.5 The other influences on e-waste legislation

As well as the framework of legislation and the enforcement and monitoring of regulations, conclusions were drawn on other influences on e-waste legislation as follows:

- Financial support from the government needs to be included effectively in legislation to enable electrical and electronic equipment producers to recycle e-waste, to improve the techniques and to utilize environmentally-friendly materials, especially for middle- or small-scale electronic product manufacturers.

- By perfecting the legislation system the current recycle system in e-waste management can be significantly improved. From the perspective of developing the circular economy and constructing a sustainable society, proper recycling of e-waste appears to be very important. It is necessary to regulate the existing e-waste recovery system and not to prohibit it.

- The subsidiary regulations at national level should include the standards and registration system to qualify the e-waste recycling and disposal enterprises
which will guarantee the quality of secondhand electronic products and ensure environmentally sound e-waste recycling and disposal. Those existing individuals and companies that dispose and recycle e-waste need to be strictly registered and also need support from government not prohibition.

- The economic differences across the country have made it possible to sell secondhand electronic products to economically backward provinces or rural areas and to low-income customers in urban areas, but this market also needs strict control and monitoring through legislation. There is a need for different special regulations for economically backward areas compared to the more advanced areas within such a big country.

7.2.6 The effects of regulations on e-waste management

- The regulations on e-waste management in industrialized countries cannot be duplicated in developing countries. The process of e-waste control should be divided into several steps according to the current social and economic situation.

- The implementation of the regulations used in industrialized countries would bring negative impacts to the electronics industry and e-waste management in developing countries. The increased cost is the most serious impact factor for e-waste management.

- The new regulations for exports to industrialized countries have given the producers of multinational or large scale corporations in the electronics industry an opportunity for environmentally sound competition and improving the management of e-waste through improved technology and advanced raw materials. But they have brought negative impacts to middle- or small- scale electronic product manufacture enterprises. To solve the problems caused by the increased cost and to compete in the international electronic product market they need more support from government through legislation.

- The regulations could motivate the government to improve and perfect the existing e-waste management system. They have also encouraged producers to
improve their product design and utilize environmentally-friendly materials in electrical and electronic products.

### 7.3 Recommendations for further research

- This research found that the lack of systematic and practical research on e-waste has weakened the feasibility of the regulations. Further research is required to survey the quantity of e-waste, to monitor the downstream pathways and impacts of e-waste and to do research on the e-waste material flow, which can provide the basic data for the administrative department to make plans on e-waste control and formulate the subsidiary regulations.

- There is no detailed financial analysis on the e-waste recycling and disposal in developing countries. The cost of the e-waste recovery is a burden for both the e-waste recovery enterprises and the electrical and electronic equipment producers. Producers as well as government and even consumers should be responsible for e-waste together. There is a need for the government administrative department to establish special funds or give financial support such as tax reduction to support the implementation of the regulations on e-waste management. Further research is required to provide detailed economic analysis on the e-waste recycling and disposal in developing countries.

- This research found that the regulations gave the producers of multinational or large scale corporations in the electronics industry an opportunity for environmentally sound competition and improving the management of e-waste through improved technology and advanced raw materials. But they brought negative impacts to middle- or small-scale electronic product manufacture enterprises. Further research is required to develop different policies to support both these types of enterprise.

- The study found that the localization of the national legislation became the weak link in e-waste management. Further research is required to establish what factors
will assist the local administrative department or institutions to establish the correct awareness and take feasible activities to balance the local economic development with environment protection.

- The study found that the pilot programmes in China have experienced difficulties in collecting e-waste from consumers. The current e-waste recovery system cannot meet the regulated market demand. Further research is required to establish the most suitable recovery system based on the current informal and environmentally unsound system, effectively utilizing the sufficient and cheap labour resources in developing countries.

- In short term the stricter regulations on e-waste management may adversely affect the small-scale e-waste dismantling factories or informal family work-sheds and cause the unemployment of migrant workers working for these stakeholders, may bring negative impacts to local economy and set political resistance at local level. Further research is required to integrate livelihood considerations into e-waste management plans and find alternative measures for both protecting livelihoods as well as promoting more sustainable development.
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Appendix 1

The journals used in literature review process
Appendix 1 The journals used in literature review process

The journals, both English ones and Chinese, listed below were found to be very useful in providing published academic articles in e-waste management. Some of the secondary sources of data in this research comes from these journals. These journals included, but not exclusively:

English Journals:
- *Environmental Impact Assessment Review*
- *Journal of Hazardous Materials*
- *Journal of Environmental Management*
- *Journal of Cleaner Production*
- *Resources, Conservation and Recycling*
- *Waste Management*

Chinese Journals:
- *Appliance Technology*
- *China Environmental Management*
- *Electric Machine and Electric Apparatus Technologies*
- *Environmental Protection*
- *Guangzhou Environmental Sciences*
- *Journal of Comprehensive Utilization of Resource*
- *Pollution Prevention Technology*
- *Recycling Research*
- *Shanghai Environmental Sciences*
- *Techniques and Equipment for Environmental Pollution Control*
Appendix 2

The websites visited for government documents and literature
Appendix 2 The websites visited for government documents and literature

The web pages visited regularly for literature review included, but not exclusively:

The worldwide web pages of some international organizations:
- Basel Action Network: http://www.ban.org/
- European Recycling Platform: http://www.erp-recycling.org/
- Greenpeace China (English): http://www.greenpeace.org/china/en/
- Silicon Valley Toxics Coalition: http://svtc.ige.org/cleancc/index.html
- Toxics Link: www.toxicslink.org
- WEEE Forum: http://www.weee-forum.org/

Chinese government websites relevant to e-waste management (Both in Chinese and English):
- State Environmental Protection Administration of China (SEPA): www.sepa.gov.cn
- General Administration of Customs of the P.R China (CGA): http://www.customs.gov.cn/YWStaticPage/default.htm
- General Administration of Quality Supervision, Inspection and Quarantine of the P.R China (AQSIQ) : http://www.aqsiq.gov.cn/
- State Administration for Industry and Commerce of the P.R China (SAIC): http://www.saic.gov.cn/
- Ministry of Commerce of the P.R China (MOFCOM): http://www.mofcom.gov.cn/
- China Inspection Company Limited (CIC): http://www.cichk.com/index-e.htm
- Ministry of Science and Technology of China (MST): http://www.863.org.cn/

Chinese e-journal publisher and provider (Chinese journal papers):

http://www.cnki.net/index.htm
http://www.cqvip.com/
http://www.lib.tsinghua.edu.cn/
http://lib.tongji.edu.cn/
Appendix 3

Hazardous materials and their effects on humans and environment
Appendix 3 Hazardous materials and their effects on humans and environment

Hazardous materials and their effects on humans and environment, as well as the use or location of these materials in e-waste (Puckett and Smith, 2002 and Computer Takeback Campaign and Californians against Waste, 2004):

<table>
<thead>
<tr>
<th>Materials</th>
<th>Effects on humans and environment</th>
<th>Use or location</th>
</tr>
</thead>
</table>
| Lead               | ● Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive system in humans (European Union, 1999).  
                   ● Effects on the endocrine system have been observed and its serious negative effects on children's brain development are well documented.  
                   ● Lead accumulates in the environment and has high acute and chronic effects on plants, animals and micro-organisms (OECD, 1993).  
                   ● The presence of lead in landfills has the potential for the lead to leach and contaminate drinking water supplies.                                                                                                                                                                                                                                                                   | Soldering of printed circuit boards and other electronic components  
                   Glass panels and gasket (frit) in computer monitors (3-8 pounds per monitor) and TV's cathode ray tubes |
| Cadmium            | ● Cadmium and cadmium compounds are toxic with a possible risk of irreversible effects on human health and accumulate in the human body, in particular in kidneys (US Department of Labour, 2002).  
                   ● Cadmium can easily be accumulated in amounts that cause symptoms of poisoning due to the long half-life (30 years) (European Union, 1999).  
                   ● Cadmium shows a danger of cumulative effects in the environment due to its acute and chronic toxicity (OECD, 1997).                                                                                                                                                                                                                          | In certain components such as SMD chip resistors, infra-red detectors, and semiconductor chips  
                   Used as a plastic stabilizer  
                   Some older cathode ray tubes |
| Mercury (European Union, 1999) | ● Mercury can cause chronic damage to various organs including the brain and kidneys, as well as foetus. And the developing foetus is highly susceptible through maternal exposure to mercury.  
                   ● Methylated mercury easily accumulates in living organisms and concentrates through the food chain, particularly via fish.  
                   ● Inorganic mercury is transformed into methylated mercury in the bottom sediments when it spread out into the water                                                                                                                                                                                                                                         | Thermostats, position sensors, relays, switches (e.g. on printed circuit boards and in measuring equipment)/housing, lamps medical equipment, data transmission, telecommunications, mobile phones and batteries |
<table>
<thead>
<tr>
<th>Hexavalent Chromium/Chromium (VI) (European Union, 1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chromium (VI) easily passes through cell membranes and is then absorbed – producing various toxic effects in contaminated cells. It causes strong allergic reactions in even small concentration.</td>
</tr>
<tr>
<td>- Asthmatic bronchitis is a typical allergic reaction linked to Chromium (VI).</td>
</tr>
<tr>
<td>- Chromium (VI) can cause DNA damage.</td>
</tr>
<tr>
<td>- Hexavalent chromium compounds are toxic in the environment and contaminated wastes can leach from landfills.</td>
</tr>
<tr>
<td>- There is widespread agreement among scientists that wastes containing chromium should not be incinerated.</td>
</tr>
<tr>
<td>Used as corrosion protection of untreated and galvanized steel plates and as a decorative or hardener for steel housings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastics including PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The largest volume of plastics (26%) used in electronics has been poly-vinyl-chloride (PVC), which creates more environmental and health hazards than most other types of plastic.</td>
</tr>
<tr>
<td>- PVC is a difficult plastic to recycle and contaminates other plastics in the recycling process (van der Naald and Thorpe, 1998).</td>
</tr>
<tr>
<td>- The production and burning of PVC products generates dioxins and furans.</td>
</tr>
<tr>
<td>Plastics make up 13.8 pounds of an average computer (Puckett and Smith, 2002). Cabling and computer housing Packaging and household products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brominated flame retardants (BFRs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- More than 50% of BFRs usage in the electronics industry consists of tetra-bromo-bis-phenol-(TBBPA), 10% is polybrominated diphenyl ethers (PBDEs) and less than 1% is polybrominated biphenyls (PBB) (Greenpeace, 1999).</td>
</tr>
<tr>
<td>- Exposure to PBDEs in early life could induce neurotoxic effects similar to those caused by other toxic substances such as PCBs and some pesticides (Silicon Valley Toxics Coalition, 1999).</td>
</tr>
<tr>
<td>- PBDE, like many halogenated organics, reduces levels of the hormone thyroxin in exposed animals and is shown to cross the blood brain barrier in the developing fetus (Silicon Valley Toxics Coalition, 1999).</td>
</tr>
<tr>
<td>The plastic housings of electronic equipment, components such as connectors, cables and printed circuit boards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Barium</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Short-term exposure to barium has caused brain swelling, muscle weakness, damage to the heart, liver, and spleen (ATSDR, 1995). But there is still a lack of data on the effects of chronic barium exposures to humans.</td>
</tr>
<tr>
<td>- Animal studies reveal increased blood pressure and changes in the heart from ingesting barium over a long period of time (Puckett and Smith, 2002).</td>
</tr>
<tr>
<td>In the front panel of a CRT</td>
</tr>
</tbody>
</table>
| **Beryllium** | Beryllium has recently been classified as a human carcinogen as exposure to it and inhalation of beryllium dust, fume or mist can cause lung cancer (Occupational Safety and Health Administration, 1999).  
- Workers who are constantly exposed to beryllium, even in small amounts, and who become sensitized to it can develop what is known as Chronic Beryllium Disease (beryllicosis), a disease which primarily affects the lungs (US Department of Labour, 2004).  
- Exposure to beryllium also causes a form of skin disease that is characterized by poor wound healing and wart-like bumps (ATSDR, 2002).  
- Studies have shown that people can still develop beryllium disease even many years following the last exposure (ATSDR, 2002). |
| **Toners** | A pigment commonly called carbon black, the general term used to describe the commercial powder form of carbon, is the main ingredient of the black toner which may lead to respiratory tract irritation through inhalation and acute exposure (Ohio State University College of Biological Sciences, 1998).  
- The International Agency for Research on Cancer has classified carbon black as a class 2B carcinogen, possibly carcinogenic to humans (Puckett and Smith, 2002).  
- Little information exists on the hazards of colored toners, but some reports indicate that such toners (cyan, yellow and magenta) contain heavy metals. |
| **Phosphor and additives** | The hazards of phosphor in CRTs are not well known or reported, but the phosphor coating contains heavy metals, such as cadmium, and other rare metals, e.g. zinc, vanadium, etc. as additives. These metals and their compounds are very toxic (Puckett and Smith, 2002). |

On mother-boards and used as alloys to increase flexibility and strength in components that need to be capable of flexing, such as contacts and springs.
The plastic printer cartridge (one of the ubiquitous computer peripheral scraps and post consumer e-waste) containing black and color toners.
Applied as a coat on the interior of the CRT faceplate.
Appendix 4

The detailed information about the legislations on e-waste management in selected industrialized countries or area
### Appendix 4 The detailed information about the legislations on e-waste management in selected industrialized countries or area

<table>
<thead>
<tr>
<th>Status</th>
<th>European Union</th>
<th>Japan</th>
<th>Belgium</th>
<th>Netherlands</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>Taiwan (China)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Scope</td>
<td>Electrical and electronic products</td>
<td>Air conditioners, TVs, refrigerators, washing machines</td>
<td>Electric and electronic products</td>
<td>Electric and electronic products</td>
<td>Electrical and electronic products. Refrigerators and freezers are excluded</td>
<td>Electrical and electronic products</td>
<td>Computers, household appliances and air conditioners</td>
</tr>
<tr>
<td>What does programme do?</td>
<td>WEEE establishes that manufacturers are required to set up treatment centres that will recycle and handle e-waste in an environmentally sound way. Manufacturers must collect products from non-household entities. The RoHS Directive restricts the use of hazardous materials including lead, cadmium, mercury, hexavalent chromium/chromium (VI), brominated flame retardants (BFRs) which include polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBB).</td>
<td>National programme requiring manufacturers and importers to arrange designated take-back sites, provide transportation from retailers and local governments; take back products which the manufacturers or importers themselves have manufactured or imported; recycle products and reuse components. Local governments will collect and recycle products not covered by retailers. Under the law each manufacturer has to utilize five to six recycling plants.</td>
<td>Agreement between Belgium's three regional environment ministers and manufacturers of electronic products. Under the agreement, consumers may take back their end-of-life electronic products for free when buying a similar product, or they may take their e-waste to a collection centre for no cost. Manufacturers and importers wholesalers are responsible for having the used equipment collected from the retailers or collection centres, and treated in the most environmentally sound manner.</td>
<td>National legislation which mandates manufacturers to: take back old equipment when customers buy new equipment free of charge; educate the public about the law; handle the e-waste in an environmentally sound manner. The law further states that the e-waste must be treated at a certified establishment before land filling, shredding or incineration.</td>
<td>National legislation requires manufacturers to take back their products. Consumers can bring their end-of-life products to any retailer free of charge. The retailers send the products back to the manufacturers or importers to dispose according to the law (disposal of these products requires a special license from SAFEL). The take-back requirement applies to all products. The e-waste is banned from landfills. The government will allow the exporting of materials only on a case-by-case basis; manufacturers must prove that the products will be handled in an environmentally sound manner by the import country.</td>
<td>The legislation establishes that manufacturers, importers, and retailers of e-waste are financially responsible for the collection, transportation, and disposal of the end-of-life products. Consumers can return their products to take-back stations operated around the province, or to a recycling company of municipal recycling facility, where the hardware is disassembled and separated for reuse or recycling.</td>
<td></td>
</tr>
<tr>
<td>Administration entity</td>
<td>Different for member states</td>
<td>Multiple Ministries</td>
<td>Belgium's three regional ministers (Flanders, Brussels, Wallonia)</td>
<td>The Ministry for Housing, Regional Development</td>
<td>Swedish Environmental Protection Agency</td>
<td>The Swiss Agency for the Environment, Forests, and Landscapes (SAFEL)</td>
<td>Taiwan Province Environmental Protection Agency</td>
</tr>
</tbody>
</table>

246
<table>
<thead>
<tr>
<th></th>
<th>European Union</th>
<th>Japan</th>
<th>Belgium</th>
<th>Netherlands</th>
<th>Sweden</th>
<th>Switzerland</th>
<th>Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fee system?</td>
<td>Manufacturers are responsible for collecting and recycling their own products. The fee was estimated equivalent to the total cost of collecting and recycling electronics. No costs to the consumer. Currently, the cost is estimated to be only an additional 1% to 3% of retail prices.</td>
<td>Retailers, local governments, and designated take-back sites collect fees, which range from US$18 to US$35 (Fees are announced in advance by the manufacturers, importers or retailers and are based on market mechanisms)</td>
<td>An environmental tax will be levied on each electric and electronic product sold.</td>
<td>Manufacturers and retailers collect fees, which are based on market mechanisms. Currently, they are between US$0.83 (for very small household appliances) and US$6.69</td>
<td>Manufacturers, retailers, and local governments collect fees. CRT's cost between US$3-8 to recycle.</td>
<td>Fees are collected at the point of purchase. The recycling fee ranges from US$1.22 to US$18.24. The fee is approximately US$6-7 for a PC &amp; Monitor.</td>
<td>Manufacturers pay recycling cost to local governments. Costs vary depending on the type of appliance.</td>
</tr>
<tr>
<td>Who pays fee?</td>
<td>Manufacturers</td>
<td>Consumers pay fees for collection, take-back and recycling at the time of disposal.</td>
<td>Consumers pay the tax at the point of purchase.</td>
<td>Consumers pay a visible fee at the time of purchase.</td>
<td>Manufacturers</td>
<td>Consumers pay a recycling fee at the point of purchase.</td>
<td>Manufacturer pays fees to local governments based on sales.</td>
</tr>
<tr>
<td>Rates, Dates &amp; Accountability Mechanisms</td>
<td>Lead, mercury, cadmium, hexavalent chromium and two brominated flame retardants may not be used in the manufacturing of products as of July 2006. WEEE Directive must be in force in members states by August 13th, 2005.</td>
<td>Recovery goals are as follows: more than 60% of air conditioners; more than 55% of TV sets; more than 50% of refrigerators and washing machines.</td>
<td>Large household electric equipment (i.e. refrigerators) will need to be &quot;depolluted&quot; from hazardous substances, then recycled or reused at 90%; all other equipment (i.e. TVs, computers) have a 70% recycle or reuse target.</td>
<td>Target goals for 2000 included a 69% recycling rate for TVs, a 73% recycling rate for large white goods, a 75% recycling rate for cooking and freezing units, and a 53% recycling rate for other/small appliances.</td>
<td>No recycling rate required by Swedish law.</td>
<td>No numerical targets required by Swiss law.</td>
<td>No recycling rate required.</td>
</tr>
</tbody>
</table>

The schedule of the data collection activities in the fieldworks
Appendix 5 The schedule of the data collection activities in the fieldworks

1. The schedule of the data collection activities in first fieldwork

- From 17th January, 2005 to 24th January, 2005
  
  Location: Shanghai

1. Semi-structured interview and a small group discussion with four concerned authorities in Environmental Science and Engineering Department of Tongji University

2. Semi-structured interview and discussion with two concerned authorities in Environmental Science & Technology Department of East China Normal University

3. Searching information and published articles about e-waste management in China from the website http://www.enki.net/index.htm and http://lib.tongji.edu.cn/ to get the full text

4. Getting information from earlier research in laws or policy of e-waste management in China from Tongji University Library

5. Getting information from earlier research in international laws or policy of solid waste management from Resource Centre in Environmental Science and Engineering Department of Tongji University

6. Direct and non-participant observation in a secondhand electronic production market

7. Direct observation in consumers' everyday life and unstructured interviews with three consumers

- From 25th January, 2005 to 5th February, 2005
  
  Location: Beijing

1. Semi-structured interview and discussion with two officers in related e-waste management department

2. Semi-structured interview with three concerned authorities in Environmental Science and Engineering Department of Tsinghua University
3. Searching information and published articles about e-waste management in China from the website http://www.lib.tsinghua.edu.cn/ to get the full text

4. Searching published thesis about e-waste management and disposal research in China from the website http://www.cnki.net/index.htm to get the full text

5. Getting information from earlier research on laws or policy about e-waste management, government documents and other published literatures from Resource Center in Environmental Science and Engineering Department of Tsinghua University

6. Searching and reading published books about e-waste management in Beijing Xidan Books Building

7. Direct observation in consumers' everyday life and unstructured interviews with seven consumers

8. Direct and non-participant observation in an electronic production recovery market (collection point), Shuang Qing Road, Hai Dian District

9. Unstructured interviews with two street hawkers who collect obsolete electronic products and two workers in the recovery market and secondhand electronic production trade shops, Shuang Qing Road, Hai Dian District

- 22nd February, 2005

  Location: Lanzhou

1. Direct and non-participant observation in an electronic production recovery market, Xi Gu District

2. Unstructured interviews with four consumers
2. The schedule of the data collection activities in second fieldwork

- From 3rd January, 2006 to 14th January, 2006 and from 22nd February, 2006 to 4th March, 2006
  Location: Beijing

1. Semi-structured interviews with three concerned authorities in Policy Research Centre for Environment and Economic (PRCEE) of State Environmental Protection Administration and in Sino-Japan Friendship for Environmental Protection Centre
2. Semi-structured interview with a concerned authority in Environmental & Resources Law Institute in School of Law of Peking University
3. Semi-structured interview with four concerned authority in Environmental Science and Engineering Department and in Environmental Engineering Design Institution of Tsinghua University
5. Searching and reading published books about e-waste management in Beijing Xidan Books Building and Wangfujing Books Building
6. Direct and non-participant observation in a secondhand electronic production market and two electronic appliance shops
7. Unstructured interviews with two street hawkers who collect obsolete electronic products
8. Direct observation in consumers’ everyday life and unstructured interviews with six consumers

- From 15th January, 2006 to 24th January, 2006
  Location: Shanghai
1. Semi-structured interview with six EHS specialists and two managers in electronic appliance corporations
2. Semi-structured with a concerned authority in Department of Planning &
Construction in Shanghai Waigaoqiao Free Trade Zone Administration

3. Semi-structured interview with two concerned authorities in Shanghai Academy of Environmental Science and in Jingan District Environmental Protection Department

4. Semi-structured interview with two concerned authorities in Environmental Science and Engineering Department of Tongji University

5. Searching information and published articles about e-waste management in China from the website http://lib.tongji.edu.cn/ get the full text

6. Getting information from earlier research in laws or policy of e-waste management in China from Resource Centre in Environmental Science and Engineering Department of Tongji University and Tongji University Library

7. Direct and non-participant observation in a secondhand electronic production market and an electronic appliance shop

8. Unstructured interviews with a street hawker who collect obsolete electronic products

9. Direct observation in consumers' everyday life and unstructured interviews with nine consumers

• From 8th February, 2006 to 10th February, 2006

  Location: Lanzhou

1. Unstructured interviews with eight consumers

2. Searching information and published articles about e-waste management in China from the website http://www.cnki.net/index.htm to get the full text

3. Unstructured interviews with two street hawkers who collect obsolete electronic products

4. Direct and non-participant observation in an electronic production recovery market and two electronic appliance shops

• From 16th February, 2006 to 21st February, 2006
Location: Guangzhou and Shenzhen

1. Semi-structured interview with a concerned authority in Guangzhou Environmental Engineering Design Institution
2. Semi-structured interview with a concerned authority in Nanshan District Environmental Protection Department in Shenzhen
3. Direct and non-participant observation in a secondhand electronic production market and two electronic appliance shops
4. Unstructured interviews with four street hawkers who collect obsolete electronic products
5. Unstructured interviews with two consumers

- From 27th February, 2006 and 28th February, 2006

Location: Tianjin

1. Discussion with a concerned authority in Environmental Science and Engineering Department of Tianjin University
2. Direct and non-participant observation in an electronic production recovery market
The main questions to be asked in the interviews
Appendix 6 The main questions to be asked in the interviews

1. The list of questions to be asked in the interviews with officers in administrative department or concerned authorities in relevant institutions

- Block 1: Policy formation and the framework of legislation and the administrative institutions

Main specific research question:
What deficiencies exist in the legislation for effective e-waste management in China?

The main questions:
1. What is the main character of each policy or regulation, which also means different regulations focus on what kind of stage in e-waste management and what the aim is in these regulations?
2. What is the purpose and content of these policies or regulations? It will include the background (triggers) of these policies.
3. How are the articles or the ordinances in policies or regulations described?
4. How are the key words in these regulations defined?

Questions to be asked during the interviews:
Q: What is the purpose of the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal which was drafted by NDRC (National Development and Reform Commission) and discussed in 2004?
Q: Was it approved by the State Council in early of this year and enforced?
Q: If it was approved by the State Council when will it be enforced? If not why was it not be approved?
Q: What is the main point in this Ordinance? Is there any special Articles?
Q: Which stage is this Ordinance on in the legislation level on e-waste management?
Q: What is the purpose of the Management Measure for the Prevention of Pollution from Electronic Products being drafted by MII (Ministry of Information Industry)?
Q: How is it going on? Has it been finished or passed yet?
Q: What is the main point in this Management Measure? Is there any special Articles?
Q: Which stage is this Management Measure on in the legislation level on e-waste management?

Q: How is the Technical Policy for the Prevention of Pollution from Waste Electrical and Electronic Products drafted by SEPA (State Environmental Protection Agency) going on? Has it been finished yet?
Q: I knew SEPA revised the Law on the Prevention of Environmental Pollution from Solid Waste and the second version came into force in 2004. Are there any changes or improvement or articles on this e-waste issue?
Q: What is the relationship this Technical Policy with the Law on the Prevention of Environmental Pollution from Solid Waste (SEPA)?

The main questions:
5. With the accelerative development of electronics industry in China how do the administrative institutions amend the existing laws and regulations?

Questions to be asked in the interviews:
Q: In your opinion what deficiencies are there in the present legislation system on e-waste management?
Q: If the law on e-waste appears to be poorly enforced, which process in management system is deficient or wrong?
Q: The second version of the Law on the Prevention of Environmental Pollution from Solid Waste came into force in 2004. How does it affect the current e-waste management?
Q: What is your department going to do next in this field?
• Block 2 Implementation, review and feedback processes of the laws or regulations on e-waste management

Main specific research question:

How are regulations on e-waste in China enforced and monitored?

The main questions:

1. How do the regulations be implemented in China?
2. Which institutions will implement these policies or regulations?
3. How do different institutions or department, which is responsible for e-waste management, work with each other and what kind of relationship do they have?

Questions to be asked during the interviews:

Q: The three major, national-level legislations mentioned before in response to the problem of e-waste management were drafted by three different government institutions. What kind of relationship do they have?
Q: If different institution is responsible for different part in e-waste management, how do they cooperate?
Q: If the duty of each institution is not explicit, is it possible that the management department will shirk its responsibility?

The main questions:

4. How do the administrative institutions get the feedback information of the implementation of these laws and regulations?

Questions to be asked in the interviews:

Q: Who will inspect and supervise the implementation of these regulations?
Q: How do they inspect and supervise the implementation of these regulations?
Q: Are there any regulations or standards to inspect and supervise the implementation of these regulations?
Q: Is there any information system about e-waste such as the quantity of e-waste, the downstream pathways of e-waste and the ultimate disposal methods of e-waste?
Q: Has anybody who illegally imported or dispose e-waste been punished in the past? How did they be punished?

The main questions:
5. How does district, province or different local government implement its own regulations on e-waste management which will be consistent with the national regulations?
6. Is it necessary to design a pilot project to prove the effectiveness and get the feedback of e-waste management system and then it can be used nationwide?

Questions to be asked in the interviews:
Q: Are there any finished pilot projects which were constructed with the goal of addressing the e-waste problem in the draft legislation and are there difficulties in establishing a e-waste recycling system?
Q: How do these projects going on?
Q: Where does the investment come from, government or private companies?
Q: What problems do they meet in the operation process of this project?
Q: What do you think the main reason is to these problems? How to solve these problems?
Q: What kind of experiences have you got from this project?
Q: Did government offer some supportive policies to these programmes?

- Block 3: Other influences on e-waste legislation

Main specific research question:
What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?
The main questions:

1. What effects does other countries’ legislation, such as WEEE and RoHS, have on e-waste management in China?

Questions to be asked in the interviews:
Q: What is your opinion about the two directives of EU?
Q: Some experts or relevant producers are worrying about these two directives will bring negative effects to electronic product trade with EU countries. What do you think to this thought?
Q: If other countries’ legislations bring negative effect to e-waste management in China, how does government eliminate it through legislation?
Q: In WEEE Extended Producer Responsibility (EPR) was required to be used in e-waste management. It requires producers of electronics to take responsibility — financial and otherwise — for the recovery and recycling of e-waste. Do you think EPR can be used in China on e-waste management?
Q: In environmental management of China is EPR principle used in any other field? Is it suitable for current situation in China?
Q: From the perspective of government do you know how the producers’ responses to EPR are?

The main questions:

2. Is it appropriate for government to enforce payment system imperatively through legislation or through market control?

Questions to be asked in the interviews:
Q: In the draft of the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal producers, importers, distributors and consumers are all have the responsibility to pay for the fees involved in e-waste recovery and recycle system. But there are no details about the rate of how much each of these different parts will pay for. Do you think why there are no such details?
Q: What difficulties did government meet in this payment system?
Q: Does government have any economic policies to support the recovery and recycle system of e-waste?
Q: Do you think which kind of payment system is appropriate in China now?

The main questions:
3. In the e-waste disposal process, can all the existing technologies meet the environmental protection regulations?

Questions to be asked in the interviews:
Q: Besides the Technical Policy for the Prevention of Pollution from Waste Electrical and Electronic Products drafted by SEPA, are there relevant series standards or regulations to inspect the disposal process?

The main questions:
4. From the legislation perspective how to improve present collection system in e-waste management?

Questions to be asked in the interviews:
Q: What problems are there in the current e-waste collection system?

The main questions:
5. What kind of relationship is there between recovery system or recycling technology and legislation in China (developing countries)?

- Block 4: Effects of e-waste management regulations

Main specific research question:
What effects do the regulations have on e-waste management?
The main questions:
1. What effects do these existing laws or regulations have on e-waste management?
2. Will these regulations affect electronic product trade with developed countries?
3. How will these regulations affect public's attitude to environmental protection?
2 The list of questions to be asked in the interviews with producers in electronics industry:

- Block 3: Other influences on e-waste legislation

Main specific research question:
What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?

Questions to be asked in the interviews:
1. Do you know the regulations on e-waste management in China, such as the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal drafted by NDRC?
2. If you knew the regulations on e-waste management, how do you response to the enforcement of these management regulations?
3. In your opinion what kind of roles will produces act in e-waste management?
4. What do you hope government does on e-waste management?
5. What are you going to do to the increasing e-waste? Do you have take back plan?
6. How do you deal with the solid e-waste produced in the producing process?
7. Do you have symbols printed on your products that indicate this product has hazardous materials and can be collected separately and recycled?
8. Do you have e-waste recovery or recycle plan focus on your own products?
9. Is it possible for you to phase out the hazardous materials used in electronic products in the time limit required in these regulations?
10. In you opinion what effects do these laws or regulations have on e-waste management in China?
11. What is your opinion to the Extended Producer Responsibility (EPR)?
12. Do you think if EPR can be used in e-waste management in China? How is it used under the current situations in e-waste management system?
13. What do you think who will pay for the e-waste management fees?
14. What do you think which kind of payment system in e-waste management will be
suitable for China?

15. Do you know WEEE and RoHS?

16. After the implement of the two directives WEEE and RoHS, what kind of impact do they have to your company? Are there any changes to your company’s export trade?

17. Will these regulations affect electronic product trade with developed countries?

18. If there are negative impacts to your company, what do you want to do to eliminate these negative effects?

19. If there are no obvious impacts to your company, what kind of impact do you estimate to the whole electronics industry in China after the implement of the two directives?

20. Do you have discussed or communicated with other electronic producers about e-waste problems in China?
3. The list of questions to be asked in the interviews with operators or managers in solid waste treatment plants or companies

- Block 3: Other influences on e-waste legislation

Main specific research question:

What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?

The main questions:

1. Is it necessary to design a pilot project to prove the effectiveness and get the feedback of e-waste management system and then it can be used nationwide?

Questions to be asked in the interviews:

Q: How is this project going on?
Q: Did government invest to this project?
Q: What problems do you meet in the operation process of this project?
Q: What do you think the main reason is to these problems? How to solve these problems?
Q: Did government offer some supportive policies to these programmes?
Q: How can you get profit from this project?
Q: What do you want to do next?
Q: What kind of experiences have you got from this project?
4. The list of questions to be asked in the interviews with consumers

- Block 3: Other influences on e-waste legislation

Main specific research question:
What factors affect e-waste legislation in China other than the framework of legislation and the enforcement and monitoring of regulations?

Questions to be asked in the interviews:
1. Do you know e-waste?
2. Do you know the hazardous materials in electronic products?
3. Do you have e-waste in your home? What kind of e-waste do you have?
4. How do you deal with the obsolete e-waste in your home?
5. Do you know the regulations on e-waste management?
6. Do you think who should pay for the recycling and disposal of e-waste, consumers, producers or government, or all of them?
7. How do you think the take-back or exchange programs of e-waste sponsored by some producers?
Appendix 7

The detailed timetable and contents of fieldworks (including all detailed information about interviewees)
Appendix 7 The detailed timetable and contents of fieldworks (including all detailed information about interviewees)

1. First fieldwork timetable and contents:

From 17th January, 2005 to 24th January, 2005
Location: Shanghai

18th January
1. Searching information and published articles about e-waste management in China from the website http://www.cnki.net/index.htm to get the full text
2. Getting information from earlier research in laws or policy of e-waste management in China from Resource Centre in Environmental Science and Engineering Department of Tongji University

19th January
1. Searching information and published articles about e-waste management in China from the website http://lib.tongji.edu.cn/ to get the full text
2. Getting information from earlier research in laws or policy of e-waste management in China from Tongji University Library

20th January
1. Semi-structured interview and a small group discussion with concerned authorities in Environmental Science and Engineering Department of Tongji University
   1). Prof. Li Guangming: Vice dean of Environmental Science and Engineering Department of Tongji University
   3:00-3:30 pm
   2). Dr. Wanghua: Lecturer of Environmental Science and Engineering Department of Tongji University
   3:30-5:30 pm
   3). Dr. Xu Min: First Year Research Student (PhD) in Environmental Science and Engineering Department of Tongji University
   3:30-6:30 pm

21st January
1. Semi-structured interview and discussion with concerned authorities in Environmental Science & Technology Department of East China Normal University
   1). Associate Prof. Lin Fengchun: Lecturer of Environmental Science & Technology Department of East China Normal University
   1:30-4:00 pm
   2). Teng Jiyan: First Year Research Student (Master) in Environmental Science &
Technology Department of East China Normal University  
1:30~4:00 pm

22nd January  
1. Direct and non-participant observation in a secondhand electronic production market in Shanghai

23rd January  
1. Direct observation in consumers’ every day life and unstructured interviews with three consumers

24th January  
1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tongji University  
   1). Prof. Zhou Qi: Dean of Environmental Science and Engineering Department of Tongji University  
   2:30~3:00 pm

From 25th January, 2005 to 5th February, 2005  
Location: Beijing

25th January  
1. Discussion with a concerned research student in Environmental Science and Engineering Department of Tsinghua University  
   1). Zhu Fenfen: Third year Research Student (Master) in Environmnetal Science and Engineering Department of Tsinghua University  
   9:30~11:00 am

26th January  
1. Searching information and published articles about e-waste management in China from the website http://www.cnki.net/index.htm to get the full text  
2. Searching information and published articles about e-waste management in China from the website http://www.lib.tsinghua.edu.cn/ to get the full text  
3. Getting information from earlier research on laws or policy about e-waste management, government documents and other published literatures from Resource Center in Environmental Science and Engineering Department of Tsinghua University

27th January  
1. Semi-structured interview and discussion with two officers in related E-waste management department  
   1). Xu Yunhai: Dean of China Urban Construction Design & Research Academy Environmental Sanitation Engineering Technology Research Centre of Ministry of Construction  
   3:30~5:00 pm
2). Zhao Shuqing: Director of Consultant Department in China Urban Construction Design & Research Academy Environmental Sanitation Engineering Technology Research Centre of Ministry of Construction
3:30~5:00 pm

28th January
1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tsinghua University
   1). Associate Prof. Li Jinhui: Office director of SEPA and Basel Convention Asia-Pacific Regional Centre for Hazardous Waste Management Training and Technology Transfer
   11:00 am ~12:30 pm

29th January
1. Direct observation in consumers’ every day life and unstructured interviews with three consumers

30th January
1. Direct observation in consumers’ every day life and unstructured interviews with two consumers
2. Direct and non-participant observation in an electronic production recovery market (collection point), Shuang Qing Road, Hai Dian District

31st January
1. Searching and reading published books about e-waste management in Beijing Xidan Books Building

1st February
1. Direct and non-participant observation in the electronic production recovery market (collection point), Shuang Qing Road, Hai Dian District
2. Unstructured interviews with two street hawkers who collect obsolete electronic products and two workers in the recovery market and secondhand electronic production trade shops, Shuang Qing Road, Hai Dian District

2nd February
1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tsinghua University
   1). Prof. Bai Qingzhong: Training director of SEPA and Basel Convention Asia-Pacific Regional Centre for Hazardous Waste Management Training and Technology Transfer
   5:00~7:00 pm

3rd February
1. Searching published thesis about e-waste management and disposal research in
China from the website http://www.cnki.net/index.htm to get the full text

4th February
1. Direct observation in consumers' every day life and unstructured interviews with two consumers

22nd February, 2005
Location: Lanzhou
1. Direct and non-participant observation in an electronic production recovery market, Xi Gu District
2. Unstructured interviews with four consumers
2. Second fieldwork timetable and contents:

From 3\textsuperscript{rd} January to 14\textsuperscript{th} January and from 22\textsuperscript{nd} February to 4\textsuperscript{th} March
Location: Beijing

6\textsuperscript{th} January
1. Searching information and published articles about e-waste management in China from the website http://www.cnki.net/index.htm and http://www.cqvip.com/ to get the full text
2. Searching information, published articles and thesis about e-waste management in China from the website http://www.lib.tsinghua.edu.cn/ to get the full text

9\textsuperscript{th} January
1. Semi-structured interviews with two officers in Policy Research Centre for Environment and Economic (PRCEE) of State Environmental Protection Administration
   1). Dr. Chen Sai: Researcher in Environmental Law
   2:30~3:00 pm
   2). Dr. Guo Dongmei: Manager on Policy Advisory Service
   3:00~5:00 pm

10\textsuperscript{th} January
1. Searching and reading published books about e-waste management in Beijing Xidan Books Building

11\textsuperscript{th} January
1. Semi-structured interview with an Adjunct Professor in Environmental & Resources Law Institute in School of Law of Peking University
   1). Dr. Mei Fengqiao: Associate Professor in Department on Environmental Sciences, College of Environmental Sciences and Environmental & Resources Law Institute in School of Law of Peking University
   1:00~3:00 pm

12\textsuperscript{th} January
1. Discussion with a concerned research student in Environmental Science and Engineering Department of Tsinghua University through internet
   1). Zhu Fenfen: Third year Research Student (Master) in Environmental Science and Engineering Department of Tsinghua University (Now a research student (PhD) in Kyoto University)
   10:30~11:00 am
2. Direct observation in consumers' every day life and unstructured interviews with two consumers
3. Direct and non-participant observation in a secondhand electronic production market and two electronic appliance shops

13th January
1. Searching and reading published books about e-waste management in Beijing Xidan Books Building
2. Direct and non-participant observation in the secondhand electronic production market (same as the above)
3. Unstructured interviews with four consumers and two street hawkers who collect obsolete electronic products

23rd February
1. Searching and reading published books about e-waste management in Beijing Wangfujing Books Building

24th February
1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tsinghua University
   1). Prof. Bai Qingzhong: Training director of SEPA and Basel Convention Asia-Pacific Regional Centre for Hazardous Waste Management Training and Technology Transfer
   11:00~11:30 am

25th February
1. Semi-structured interview with a concerned authority in Environmental Engineering Design Institution of Tsinghua University
   1). Zhou Yugang: An engineer in Environmental Engineering Design Institution of Tsinghua University
   2:00~2:30 pm

1st March
1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tsinghua University
   1). Associate Prof. Li Jinhui: Office director of SEPA and Basel Convention Asia-Pacific Regional Centre for Hazardous Waste Management Training and Technology Transfer
   16:45 am ~17:10 pm

2nd March
1. Semi-structured interview with a concerned authority in Sino-Japan Friendship for Environmental Protection Centre
   1). Zhu Chunlin: Manager in Service Department in Sino-Japan Friendship for Environmental Protection Centre
   1:00~1:30 pm
From 15th January to 24th January

Location: Shanghai

16th January
1. Semi-structured interview with four EHS Specialists in electronic appliance corporation
1). Li Hao: EHS Specialist in General Electric Company
1:30–2:00 pm
2). Ou Yang: EHS Specialist in General Electric Company
2:00–2:40 pm
3). Tang Ruowang: EHS Specialist in Samsung Investment Ltd. Shanghai Subsidiary Company
4:30–4:50 pm
4). Wang Yinping: EHS Specialist in Royal Philip Electronics
5:50–6:10 pm

17th January
1. Semi-structured interview with two EHS Specialists in electronic appliance corporation
1). Xu Binbin: EHS Specialist in Sharp Corporation
11:00–11:45 am
2). Annie Zhou: EHS Specialist in Asia Pacific of Husky Injection Molding Systems (Shanghai) Ltd.
2:00–3:00 pm

18th January
1. Semi-structured interview with two managers in EHS department in electronic appliance corporation
1). Honda Gao: Manager in EHS Department in Amokor Assembly & Test (Shanghai) Co., Ltd.
1:30–2:50 pm
2). Cao Xiaoliang: Manager in General Affairs Department in J.S.T. Mfg. (Shanghai) Co., Ltd.
3:30–3:45 pm
2. Semi-structured with a concerned authority in Department of Planning & Construction in Shanghai Waigaoqiao Free Trade Zone Administration
1). Wei Wen: Vice-Director in Department of Planning & Construction in Shanghai Waigaoqiao Free Trade Zone Administration

19th January
1. Semi-structured interview with a concerned authority in Shanghai Academy of Environmental Science
1). Xing Shaowen: Manager in Department of Environmental Engineering Design in Shanghai Academy of Environmental Science
11:00~11:25 am
2. Direct and non-participant observation in a secondhand electronic production market
3. Direct observation in consumers’ every day life and unstructured interviews with two consumers
4. Unstructured interviews with a street hawker who collect obsolete electronic products

20th January
1. Searching information and published articles about e-waste management in China from the website http://lib.tongji.edu.cn/ to get the full text
2. Getting information from earlier research in laws or policy of e-waste management in China from Tongji University Library
3. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tongji University
1). Prof. Zhou Qi: Dean of Environmental Science and Engineering Department of Tongji University
16:45~17:20 pm

21st January
1. Direct and non-participant observation in an electronic appliance shop
2. Direct observation in consumers’ every day life and unstructured interviews with seven consumers
3. Semi-structured interview with a concerned authority in Jingan District Environmental Protection Department
1). Wu Zhengyu: Engineer in Jingan District Environmental Protection Department
4:30~5:00 pm

23rd January
1. Getting information from earlier research in laws or policy of e-waste management in China from Resource Centre in Environmental Science and Engineering Department of Tongji University
2. Semi-structured interview with a concerned research student in Environmental Science and Engineering Department of Tongji University
1). Dr. Zhang Hua: Third Year Research Student (PhD) in Environmental Science and Engineering Department of Tongji University
11:30~12:00 am

From 8th February to 10th February
Location: Lanzhou
8th February
1. Unstructured interviews with two street hawkers who collect obsolete electronic products
2. Direct and non-participant observation in two electronic appliance shops
9th February
1. Searching information and published articles about e-waste management in China from the website http://www.cnki.net/index.htm and http://www.cqvip.com/ to get the full text
2. Unstructured interviews with three consumers

10th February
1. Direct and non-participant observation in an electronic production recovery market
2. Unstructured interviews with five consumers

From 16th February to 21st February
Location: Guangzhou and Shenzhen
17th February
1. Semi-structured interview with a concerned authority in Guangzhou Environmental Engineering Design Institution
2. Unstructured interviews with two consumers

18th February
1. Direct and non-participant observation in a secondhand electronic production market

19th February
1. Unstructured interviews with two street hawkers who collect obsolete electronic products
2. Direct and non-participant observation in two electronic appliance shops

20th February
1. Semi-structured interview with a concerned authority in Nanshan District Environmental Protection Department in Shenzhen
2. Unstructured interviews with two street hawkers who collect obsolete electronic products in Shenzhen

From 27th February and 28th February
Location: Tianjin
28th February
1. Discussion with a concerned research student in Environmental Science and Engineering Department of Tianjin University
1. Yan Li: Third Year Research Student (PhD) in Environmental Science and Engineering Department of Tianjin University
10:00~11:30 am
1:00~4:00 pm
2. Direct and non-participant observation in an electronic production recovery market
Appendix 8

Samples of key informant interview transcripts
Appendix 8 Samples of key informant interview transcripts

1. Semi-structured interview with a concerned authority in Environmental Science and Engineering Department of Tongji University

1). Prof. Li Guangming: Vice Dean of Environmental Science and Engineering Department of Tongji University
3:00-3:30 pm 20th January 2005

Q: Can you introduce the research work on e-waste that has been done in your research group?

Li: Recently the issue about e-waste became a hot topic in China after the media reported that a large volume of e-waste was imported to China and some areas became dismantling and recycling centres of e-waste, where the private e-waste plants or family work-sheds earned a lot of money through dealing with e-waste but destroyed local environment and harmed the workers' residents' health as a cost. Another reason is the two directives implemented in European countries which will bring negative impacts to our electronics industry. Producers which export their products to European countries will be affected by these two directives. The government has become to realize the importance and emergency of this issue, while some investors also found this would be a good opportunity for them to get benefit from this field. There are several conferences held continuously in this one year. Both relevant government and research institutions are beginning to do or want to do something to deal with the e-waste issue. The universities in Shanghai and Beijing are all doing research on e-waste. In Shanghai our university and East China University of Science & Technology are cooperating to carry out a research programme and want to complete an experimental project to effectively dispose part of the e-waste in Shanghai. This research programme is mainly divided into two parts. One is about the technology. The other is about the integrated e-waste management which will focus on the management system of e-waste. Actually most universities and research institutions now focus on how to dismantle e-waste to get the precious metals and
plastics, how to recycle the materials in e-waste in a environmentally sound way, how
to dispose the remained wastes after dismantling and how to make the whole
recycling process industrialization. In East China University of Science & Technology,
our co-operators, they have better experimental conditions in this field. So they
mainly focus on the dismantling and disposal technologies. Now our research group is
mainly responsible for the latter one. From the management perspective, how to
improve and ameliorate the management system is our concerned topic. Then we have
an idea to construct an experimental project to put the theory into practice which can
link the technology and management to prove the effectiveness. Of course this will
include different kinds of cooperation such as local government, investor and other
research institutions, which will spent a long time to plan and implement.

Q: How is this programme going?
Li: This programme is just beginning. It is too early to get some conclusions. Now
our first step is to gather information about the present situation of e-waste. In fact
there are no particular surveys about how much e-waste in Shanghai or the whole
country. And how serious the environment pollution problems caused by e-waste are
is not very clear. The media and some non-governmental organizations (NGOs) are
always pleased to magnify the problems to make people recognize the issue. So it is
necessary to do some practical fieldworks to investigate the relevant areas or cities to
get the data.

Q: Do you think the existing laws or regulations or the ones drafted recently on e-
waste management in China are consistent with international directives?
Li: There are no special laws on e-waste management except for the directive (draft)
proclaimed on the government website in October, 2004. This directive (draft) is tried
to be consistent with international directives and with industrialized countries. But
this directive is unrealistic at present. It is just a framework to regulate the e-waste
management. It will be the first special regulation in this field and very important, but
the implementation will meet many problems and it will spend a long time to be
effectively implemented, maybe one year or several years longer. Because it is too
general and some key points are very indistinct. For example it said that we will carry
out extended producer responsibility (EPR). That means producers will finally be
responsible for their products after obsolete. At the same time consumers and
government will also pay for part of the recycling and disposal fees. How much rate
each other will pay for it is not mentioned because it is a very complicated problem
including the basic key point: the profits. In China most producers have not realized
that they should be responsible for the environmental impact their products brought.
Some producers do not have the capacity to deal with e-waste although they want to.
Because the high cost prohibited them to recycle or dispose e-waste. This is also one
of the purposes of most research institutions being doing to renovate or improve the
recycle and disposal technologies. Some producers are hoping that government will
support them through financial policy and revenue. If they can not get profit from it of
course they are reluctant to do it. On the other hand consumers will not pay for it. It is
impossible to let most people pay for the obsolete electronic produces instead of
getting money from street hawkers, retailers or secondhand market when they resell
their unusable products. This is also the awareness of consumers which needs a long
time to change. So in the drafted regulation it just said the extended producer
responsibility but no details about how to implement.

Q: What kind of work does the local government do in this field?
Li: In fact government is trying to solve this problem. In our programme we will
cooperate with local government to survey the recovery system of e-waste and
construct an experimental project to dispose part of e-waste in Shanghai. We found an
investor who has realized recycling and disposal of e-waste can be a very promising
commercial business in the future because of the valuable materials in e-waste. If
dealing with properly and getting the support from the government it will not only be
environmentally sound but also can get high profit from it. We hope this project can
give some useful information to the e-waste management system.
2. Semi-structured interview and a small group discussion with concerned authorities in Environmental Science and Engineering Department of Tongji University

1). Dr. Wanghua: Lecturer of Environmental Science and Engineering Department of Tongji University
3:30~5:30 pm 20th January 2005

2). Dr. Xu Min: Frist Year Research Student (PhD) in Environmental Science and Engineering Department of Tongji University
3:30~6:30 pm 20th January 2005

Q: Did you attend the conference held several months ago in Beijing about e-waste?

Wang: No, I did not attend the conference held in Beijing. I attended the conference held in Qingdao 2004, the city which you know is nominated as experimental city to construct the recycling and disposal system of e-waste. The main topic of this conference was also about e-waste in China and the two directives, WEEE and RoHS, which will bring what impacts to electronics industry in China as well as the countermeasures. Most electronic product manufacturers who said they would attend the conference did not come, while there were many delegates from the material recovery enterprises or private waste recovery work plants. They showed more interests in this field. Most of the producers in electronics industry are waiting for the further laws and regulations by government. If they will be responsible for e-waste it means that they will spent a lot of money on recovery and disposal of their products under the actual circumstance that they got less and less profits from their products when competitions are more drastically. They hope gaining more concrete and feasible policies and financial support from government than endless discussions on paper. On the contrary for the material recovery enterprises or private waste recovery work plants, they can get profit from recovery materials if there are adequate e-waste to deal with. So they are more concerned about the recovery system and how to recovery e-waste from consumers using lowest cost and then getting highest profit.

Q: You mentioned the recovery system is the most concerned problem in the
conference. Does it mean there is no such kind of recovery system at all or the existing system can not meet the requirement?

Wang: It is the latter one. There are waste recovery systems but it is not controlled by government and it cannot meet the requirement. The street hawkers collected e-waste from consumers, then sending them to private dismantling work-sheds. They have already formulated their long term even fixed market chains. Most of the obsolete computers and other electronic equipment which come from individuals and small businesses will enter into this unregulated recovery system. Some large-scale corporations, educational institutions or government will sent their obsolete computers to some rural areas as donations to help education or low income consumers. It extended the lifespan of these electronic products. But these products will also end in this unregulated recovery system or will directly be thrown into the landfills to pollute the environment. It is reported that some formal recovery enterprises have constructed plants which can use environmentally sound manners to dismantle and recycle e-waste. But they cannot run properly and get profit at all. Because there are no e-wastes sent there to be disposed and the income cannot balance the payout for the process of environmentally sound recycling and disposal of e-waste. For these kinds of formal recovery enterprises only when the quantity of recycled e-waste reached a certain amount they can bring profits. While for those family work-sheds their operating cost is very low because they are never worried about investing on environmental protection. If they cannot get enough e-waste to dispose they will import, even smuggling e-waste. So if this report reflected the reality of such kind of formal enterprises, the existing e-waste recovery system cannot meet the present requirement and have many shortages. The recovery system should be one of the most important parts of e-waste management. At present most e-waste is not collected and recycled. Now we began to classified municipal solid wastes. Maybe the government can put e-waste into this MSW classification programme to collect e-waste or construct special collecting points for e-waste.

Q: Do you think how consumer’s attitude to e-waste will affect legislation in China?
Wang: Almost all consumers will resale their obsolete electronic products to street hawkers or private waste recovery work-sheds. Actually I myself also sold my old television to a street hawker to get about one hundred Yuan several days ago. Consumers are preferred to getting some money back from e-waste other than paying for them although it will not be too much. Especially the computers and mobile phones which are updated very quickly are not broken or useless when they are resold by consumers. They just are out of fashion or the owners are reluctant to update for the cost of new one will not be much higher than updating it and at the same time it will save a lot of trouble. Consumers know these obsolete products are still valuable and it is a pity to throw them away directly. If they do not send them to friends or relatives some of them will choose to resell to get some money back. And the existing secondhand market and private recovery work-sheds can satisfy this kind of request. Of course some consumers will put them in store for some time wish they will be useful in some days. So when the governments consider the regulations they cannot let consumers pay for the recovery and disposal fees directly. Maybe they have to pay for consumers in order to encourage them to recovery e-waste.

Xu: One of the programmes in our department is about collecting batteries. We put several collecting boxes in front of the accommodations to hope students put their obsolete batteries into these boxes. We advertised and posted the information on the bulletin boards such as the potential hazards in batteries when thrown with general municipal solid wastes. But when we collected these boxes we found other waste such as paper even gum in stead of batteries. Very few batteries were collected at last. At first it really attracted many people’s attention but with time flying it was forgotten. Consumers do not have such habits to sort wastes even batteries are the easiest classified wastes. On the contrary in our university there was an activity that some producers in order to sale their new batteries exchanged obsolete batteries with new ones. Then students are all preferred to this exchange. Other e-waste will also meet the same situation but it is more complicated.

Q: Did local government or research institutions such as your research group do
something to deal with the e-waste issue?

Wang: We planned to do some fieldworks to investigate some areas such as Guiyu, Guangdong province and Taizhou, Zhejiang province which were reported by all kinds of media because where the issues are most serious. Actually in these areas they have fabulous capacity to recycle and dispose e-waste which was collected from all over the country as well as from foreign countries including imported part and smuggled. It has already formed an unregulated e-waste industry. They have their own e-waste sources, transportation network, division of dismantling processes and distribution system of recycled materials. They got enormous profit from this local industry. At the same time owing to the rudimental and even primitive methods they used to dismantle e-waste to get precious metals, the water, soil and air are all seriously polluted. Water can not be drunk. Soil can not be planted. The working conditions are very harmful to workers and their healths are unconsciously damaged. It is reported that almost every worker in these areas has different chronics. After reported by media it was said that the situation changed much. Local government began to close the most polluted family recovery work-sheds and prohibit using open burning and acid baths to recover metals. The remnants which cannot be recycled are forbidden to throw straight into rivers or landfills. Those who already got benefits from some kind of unregulated or illegal operations are always good at find their own ways to deal with government policies.

Xu: It was also reported that in these areas when there are investigators or correspondents these work-sheds will be concealed or closed during the special period. They even moved their acid baths indoors to escape spot. Actually things were not changed. This countermeasure will make the matter worse and more dangerous. We have already interviewed some street hawkers and observed some work-sheds and secondhand market for obsolete electrical and electronic products around Shanghai. Some workers are reluctant to be interviewed now because they said they were too much interrupted by investigators and correspondents. The owners of such kind of family work-sheds said the operations became little bit difficult including getting e-
waste to treat and reselling of the recovered metals or plastics because government began to set foot in the management of e-waste. And when they have to consider the environmental protection the cost of recovery and disposal of e-waste will increase. For small family work-sheds or private recycling plants they do not have the ability to invest more. It will be a heavy burden for them.

Q: How do you think about the two directives, WEEE and RoHS? In your opinion what impacts will they bring to our electronics industry as well as to the e-waste management in China?

Wang: It will bring some negative impacts to our electronics industry. These two directives heighten the threshold of import electronic products from China to European countries. For China European countries are exactly the most important market of electronic products. When electronic products are exported to European countries, the producers have to pay extra costs for the recovery and recycling of e-waste. These costs will depend on the recovery and recycling costs in European countries, which are much higher than those in China and even higher than the production cost of same products. So these costs will increase the whole production cost of electronic products and if producers can not find proper ways to deal with this problem, it will be difficult for them to compete with producers in other countries. And if the electronic products can not conform to the European countries’ environmental protection standards, they will not be imported and producers will suffer heavy losses in the market. I think it will be a green barrier. According to our present technologies it is really difficult to reach these two directives’ requirement, especially for small- or middle-scale enterprises.

Xu: It will affect not only disposal technologies but also design processes of electronic products. Actually if the products were designed easily dismantled and recycled and there were no or less hazardous materials be used in these products this problem would not be so serious. Producers who will be responsible for recycling of there products should resolve this problem from the very beginning of product design.
Q: One of your articles predicts the amount of obsolete computers in China. According to it, from 2004 China will come into the climax period of e-waste. Are there any official statistics on how much e-waste will be produced in China every year?

Lin: No. It is difficult to get exact statistic data about how much e-waste in China now and how much will be produced in the following years. But the government began to notice this problem. I predicted it based on the annual output of computers, average number of personal computers per 100 households in China and the average lifespan of computers. Although it was only a prediction, the amount of obsolete computers this year in other non-governmental organization's research is almost same. But there is no exact data of the amount of e-waste in the whole country, it should be an important step in e-waste management. On the other hand how much e-waste is environmentally sound disposed or recycled every year is not know either. It will not be a pleasant number.

Q: What kind of relationship is there between recovery system or recycling technology and legislation in China?

Lin: At present most universities focus their research on the technologies of how to recycle and reuse e-waste, such as how to effectively dismantle the printed circuit boards to get precious metals. Technologies are one of the most important things in e-waste management. E-waste aroused people's attention not only because they brought negative impacts to environment but also because the materials most of which can be
reused and can bring economy profit. This is meaningful to our country which lacks all kinds of resources except for cheap labours. But the legislation on the e-waste management is more important at present level. I am not worried about the technologies too much because I think if we cannot develop advanced technologies in short period we can buy them. The same as other industries in China we bought equipment and technologies from industrialized countries. Then we learned from them, meanwhile improving our own technologies or renovate new equipment. I think it will be an easy and effective way to solve the technology problems. The industrialized countries have already done some very useful research on how to dismantle e-waste, how to recover precious metals from e-waste and also have tried to develop new materials to reduce or substitute the hazardous materials in electronic products. We can import this technologies and equipment. But we can not use the same management system. The situation is totally different. We have to formulate our own management system of course using the experiences of industrialized countries on e-waste management as reference. This will depend on our own research work. It will be an effective method to solve the problems.

Q: What roles or responsibilities government play in e-waste management in China?
Lin: Basically SEPA and provincial or local environmental protection department are responsible for the management of e-waste because it belongs to the solid waste management and the disposal of e-waste should be controlled by them. The recovery system is taken charged by local environmental and sanitary department. Recycling and reusing the wastes are the main work of the department of resource comprehensive utilization. The directive Management of WEEE recycling proclaimed on the government website was drafted by the National Development and Reform Commission (NDRC). The manufacture and distribution of electronic products were dealt with the Ministry of Information Industry (MII). On the other hand the import and export of all kinds of waste also are controlled by Customs General Administration and local Customs. But as a matter of fact the duty of each administrative department is not very clear. There are many other departments
involved. The more departments involved the more complicated it is and the easier
shirking the responsibility. Recently government recognized the seriousness and
emergency of the problems caused by e-waste. They began to make some, maybe
useful, efforts to improve the management system of e-waste. For instance the
government will establish regulated recycle companies to recovery e-waste and is
discussing the enforceable methods on the payment system.

Q: Do you think the present laws or regulations on e-waste management in China are
consistent with international directives?

Lin: Yes. It is also the right direction required by economic development. But I do not
think the regulations can be implemented right now. For the drafted ordinance it only
regulates producers will be responsible for the products and that is all. The payment
system, the recovery rate, who recover it and how the e-waste will be recovered, and
so on, all of these details are not mentioned in this drafted regulation. It will take a
long time to review and get feedbacks and then improve. Additionally there are no
systems or regulations to supervise and control the enforcement of the policies or
regulations about e-waste. The following work of government also includes drafting
related regulations to supervise the implement of the regulations.

Q: Which kind of payment system is appropriate in China?

Lin: It is really one of the key points and one of the main reasons that the above
drafted regulation is not finalized and issued. Producers, retailers, consumers and
government all can pay for it. But all of them should pay for it or just one or two of
them pay for it is not decided. If all of them pay for it how the rate of different parts
and according to what kind of standards will be concerned. When producers pay for it,
of course they will add these fees into the producing cost. When retailers pay for it,
they will add these fees into the sale price. Government paid for it from the tax which
also comes from the producers and consumers. Actually in the end all the increased
fees paid for the recycling and disposal of e-waste will be paid by consumers. One
method will be consumers paying it when they buy the new products. The other is
consumers paying it when they send obsolete products to retailers or producers. No matter which method will be used all fees will be paid by consumers finally. But the latter one maybe will not be adapted to consumers' present concept about waste management. It means it is difficult for them to pay for disposal fees while they can get some money back if they send obsolete products to street hawkers or private secondhand stores. It is the habit of consumers in China. I think every one may have the experience of reselling unusable electronic products to street hawkers or private secondhand stores. It is convenient and an easy way to deal with e-waste. You can find on the street that a lot of street hawkers collected obsolete electronic products such as old televisions, washing machines, radios and mobile phones. Especially mobile phones and computers which are updated so quickly will be resold to private secondhand stores. Those which were thrown away just because of old fashioned and still usable will be sold to rural areas and low-income consumers. Those which were broken and cannot be used will have three ends. One is dismantled to find useful accessories to be used for repairing other broken products. One is to be dismantled to get valuable materials and then to be sold to regenerative resources market for reusing as raw materials. Another is for those parts which cannot be used in whatever ways and are really wastes to be thrown away. During these processes, people always ignored the problem of pollution and health impacts. That is the point. The whole process is not operated under legislations and regulations.

Q: What problems are there in the current e-waste collection system?

Lin: Some one said there is no e-waste recovery system in China. But how to explain that there are so many street hawkers and workers in private e-waste recovery workshops and even in some illegal family plants? They exist not for a short time. They make their livings by e-waste recycle. It proved that the existing recovery system worked very well. People can get profit from this system, so the secondhand market for electronic products and material recycle chains are automatically formulated. It even forms a special e-waste recycling industry. But it has serious limitation. It is adjusted totally by market economy itself. It even destroyed the original waste
recovery system which was constructed by the government. There are no government controlled or strictly regulated recovery system of e-waste. The existing systems are not operated under legislations and regulations. As result environment is polluted and the workers'/residents' health are affected by hazardous materials involved. Like other industries’ developing process economic profit is first considered while ignoring the environment cost. Several years ago the white plastic lunch box met the same problem which we called it white pollution at that time. I talked with Professor Qian Yi IN Tsinghua University about this problem. She has the same opinion with me that the informal recovery system works very well and it is suitable for the current situation in China. In stead of prohibiting this recovery system, government should support and control it through legislation, find the loopholes in this system and change the negative parts in it. We can construct pilot projects in some cities first. For instance in Guiyu and Taizhou they disposed all kind of e-waste which were collected domestically as well as from foreign countries including smuggled. From buying e-waste, transporting, dismantling to reselling it has already formed an e-waste recycling industry. They got enormous profits from this local industry. The people working there are rich now. They did not cultivate anymore. Most of them have their own family recovery work-sheds. And they divided the dismantling process into details. It is very clear that who will be responsible for dismantling circuit board and who will work for getting metals from wires. Although they polluted the environment we can not forbid all of them to close their work-sheds.

Teng: It is reported when local government exactly forbid open burning and acid bath to get precious metals some work-sheds even move these operations indoors. The streets are cleaned but the pungent smell still exists. Things are not really changed but concealed.

Lin: So now some experts mentioned that we can use their strong point of large-scale of e-waste recovery participants and their successful as well as unsuccessful experiences to construct a basic e-waste recovery and disposal centre. It will work if the government will participate in management of the operations.
Q: Are there national or industrial regulations to judge which company or private work-sheds can have the qualification to recycle or dispose e-waste?

Lin: There are these kinds of regulations on hazardous solid waste management. E-waste management should belong to these regulations. But e-waste is different from hazardous waste because most of its materials are recyclable if treated properly. So it is necessary to develop special regulations and standards to judge the qualification.

Q: How do you think about the importing and smuggling of e-waste?

Lin: It is because of the economic profit. Why so many people smuggling e-waste? It is also related to the recovery system. The present system can not offer enough e-waste to recycle and dispose. To earn money they smuggled e-waste. Actually the import of e-waste is prohibited by government but they also can import e-waste as the name of import obsolete metals or other wastes which can be imported. The laws and regulations are poorly enforced. The situation can not be change in short time. Smuggle is also involved corrupt. It is a very complicated issue. I think I will not talk about it too much. Additionally the recovery company can get higher profit only when the quantity of disposed e-waste reached a certain amount. If they have no enough e-waste to recycle and dispose they can not earn money. So it is necessary to formulate an effective recovery system.

Q: What effects does other countries' legislation, such as WEEE and RoHS, have on e-waste management in China?

Lin: These two directives really will bring some impacts to our electronics industry. In every conference this problem will be discussed ardently. But I do not think these two directives will bring too much negative impacts to electronics industry and will be a green barrier. For those international companies in electronics industry their strategies on manufacture are localization and buying raw materials internationally. For example Haier, which is the biggest electronic product manufacturer in China, in order to compete with local manufacturers in industrialized countries it constructed several factories overseas, hired local labours, purchased raw material locally, used
foreign technologies and sold their products to these countries directly. It uses the local environmental standards which are the same as other manufacturers in local area. Now they are all facing the two directives. It will change their management and technology with industrialized countries at the same time. It will be responsible for its products and pay for the fees according to local legislations or regulations. For those middle- and small-scale manufacturers their exports of electronic products might be affected if they cannot satisfied the developing countries’ request mentioned in these two directives. It will force them to increase the produce cost paying more to recovery and dispose their products. But I do not think it is a negative impact. On the contrary it will motivate these manufacturers to renovate and improve their products. But how to use these methods or strategies into practice and how to research in depth are also the problems. This maybe one of the reasons that not too many researches have been done about e-waste management in China and most universities involved in this field are preferred to researches on technologies not the legislation and regulations.
4. Semi-structured interviews with an officer in Policy Research Centre for Environment and Economic (PRCEE) of State Environmental Protection Administration

1) Dr. Guo Dongmei: Manager on Policy Advisory Service
3:00~5:00 pm 9th January 2006

Q: What deficiencies exist in the legislation for effective e-waste management in China?

Guo: The process of formulating regulations disobeyed the normal procedure. The pressures on the government made it urgent to enact regulations to control e-waste while systematic and practical research was ignored or behind the schedule. For example there are no the data on how much e-waste produced in the whole country and materials flow of e-waste. The report of Guiyu is too negative. The condition there has been changed. The researches on e-waste are too limited to support the formulation of the regulations. The administrative institutions both national and local level are always drafting laws or regulations first to consist with international regulations or first consider the temporary count measures to deal with the emergency problems, while no considering the subsequence policies or regulations. Another example is that there is no economic analyzing about e-waste until recently. The government really did some work to support the researches on the technologies on how to recover precious metals from all kinds of obsolete electrical and electronic products. But the economic analyzing about e-waste recycling and disposal is very limited. All of these factors can affect the enforceability of the relevant regulations on e-waste management.

Q: How are regulations on e-waste in China enforced and monitored?

Guo: The enforcement of the regulations is the weakest part in waste management. Too many administrative departments are involved in the e-waste management. This situation is not limited to the e-waste management. Almost all the other waste management systems are facing this problem. The main administrative department
which is responsible for e-waste management should be SEPA. But SEPA do not have the ability for adjusting the relationship of the environmental protection industry with other industries such as the electronics industry, and balance the relationship of different administrative institutions. The responsibilities of each administrative department involved in e-waste management are not explicit which caused the difficulties to effective implement the relevant regulations. Bureau of Environmental Supervision in SEPA organizes the national inspection and supervision of environmental law enforcement. But because there are not enough personnel in this bureau and there are no detailed standards to regulate the punishment system, the monitor system is not operated very well.

Q: The three major, national-level legislations mentioned before in response to the problem of e-waste management were drafted by three different government institutions. What kind of relationship do they have? If different institution is responsible for different part in e-waste management, how do they cooperate?

Guo: Different administrative departments lack effective collaboration to manage e-waste. For SEPA only it is difficult to co-operate with other administrative department. For example, SEPA is the main administrative department which is responsible for all the affairs about environmental protection and should be the main unit to implement the relevant regulations. But actually all the programmes and enforceable plans related to the environmental protection industry have to be examined and approved by NDRC first. On the e-waste issue, SEPA met the same situation. Besides environment protection, because NDRC is responsible for the national development and socio-economic reform, it is the participant in almost all industries. Now because the issue of e-waste has brought remarkable influences on the electronics industry, one of the most important industries for economic development of China, NDRC would like to be the principal administrative unit leading the management of e-waste. NDRC drafted a regulation. Some of the articles in it are repeated with the other regulation drafted by SEPA. But NDRC do not have corresponding personnel or workgroups to implement it and do not detail the enforcement process of the regulation. Then all the
problems of e-waste have to be handled by SEPA. As a result the function of NDRC is questioned It is considered to be the leader to manage e-waste because e-waste also plays an important role in resource comprehensive utilization. From developing circular economy and constructing sustainable development society perspective, NDRC wants to integrated manage e-waste. The scope of its responsibilities is too broad to have enough manpower and finance to manage e-waste which is just a small part in its ordinary business.

Q: With the accelerative development of electronics industry in China how do the administrative institutions amend the existing laws and regulations?

Guo: For example, it is necessary to construct the database of e-waste then tracing the upstream and down stream pathways of e-waste first. It is difficult to find suitable materials to substitute the six hazardous materials in e-waste. And then there should be relevant regulations or standards to separate this material control in separate levels. MII regulates that it is responsible for the reduction of e-waste through recycling and minimizing the environmental pollution caused by e-waste and producers should take the responsibility for e-waste control. But in fact MII does not participate in the e-waste collection after consumption. The collection of e-waste from consumers is not the responsibility of SEPA either. Then the most important factor in e-waste recycling and disposal system is also the weakest point. Constructed or regulated the e-waste recovery system should be considered when we are improving the existing or drafted regulations.

Q: What effects do these existing laws or regulations have on e-waste management? Will these regulations affect electronic product trade with developed countries?

Guo: The e-waste management in China is just focused by the government especially after Guiyu and Taizhou areas were reported. The management system is just at the beginning stage and the legislation system is still imperfect. The lack of related laws and regulations has become the most serious obstacle in the whole management system. The existing regulations cannot satisfy the environmentally sound e-waste
management at present. It is difficult to say the domestic regulations will what effects on electronics industry in China as well as on e-waste management. But the regulations in industrialized countries cannot be duplicated according to the current social and economic situation in China. The awareness of environmental protection and waste recycle among publics need to be improved through the government education. The process of e-waste control in China should be divided into several steps according to the current social and economic situation. The increased cost will be the most serious negative impact for e-waste management. But on the other hand, these regulations could motivate the government to improve and perfect the existing e-waste management system. They could also encourage producers to improve their product design and utilize environmentally-friendly materials in electrical and electronic products.
Q: How are regulations on e-waste in China enforced and monitored? Which institutions will implement these policies or regulations? And what kind of relationship do they have?

Mei: The enforcement of the laws and regulations is the key point in the whole e-waste management system. But the existing regulations and the drafted ones are all difficult to be enforced at the present situation. SEPA is responsible for environment pollution control. NDRC is responsible for waste recovery and resource comprehensive utilization. Developing circular economy and clean producing are also its business. But the enforcement is always delivered to SEPA. It is just the reflection of the traditional management system in environmental protection in China. Too many administrative departments involved in waste management but effective cooperation of these departments are questionable.

Q: In your opinion what deficiencies are there in the present legislation system on e-waste management?

Mei: To be in line with the international regulations some articles in the existing and drafted regulations are too general to be enforced. This has caused the two drafts of NDRC and SEPA to be discussed and commented on for a very long period and until now they have not been passed by State Council. The key points in these regulations, such as the special standards to define e-waste and to evaluate the hazards in e-waste, the licensing system to control the treatment enterprises and special funds to support e-waste recycling and disposal by producers, are not regulated yet. And as a result this has directly affected the formation of local regulations to control e-waste. At the same
time, there are no related regulations to manage the secondhand market and the licensing system for obsolete electronic appliance recycling and disposal enterprises does not yet exist although the e-waste registration system is required by the regulations. It is easy to run the business of e-waste dismantling, repairing and resold without government control which caused serious environment pollution and affected the workers even the local residents’ health. Many environmentally unsound treatment companies or even illegal family plants have become the main units to deal with e-waste.

Q: What kind of effect does other countries’ legislation, such as WEEE and RoHS, have on e-waste management in China?

Mei: These two directives would have some negative effects on the electronics industry and e-waste management in China. But they also motive the government to take actions to improve e-waste management gradually. The negative impact would be for a short period only. If these two directives were understood as both an environmental protection and a green trade barrier, this barrier is not only set before China, but also before other developing countries.

The policies of the large-scale companies in the electronics industry are to manufacture locally and buy raw materials internationally. For example Haier Group, which is the biggest electronic appliance manufacturer in China, in order to compete with local manufacturers in industrialized countries, has constructed several factories overseas, hired local labourers, purchased raw material locally, used foreign technologies and sold their products to these countries directly. It uses the local environmental standards which are the same as for other manufacturers in the local area. Now they are all facing the two directives. They will change their management and technology at the same time as the industrialized countries. They will be responsible for their products and pay for the fees according to local legislations or regulations. So it will not affect the export of electronic products too much. For those domestic middle- or small-scale manufacturers it is a good opportunity for them to
renovate and improve their products and it also will urge government to improve e-waste management.

Q: What problems are there in the current e-waste collection system? From the legislation perspective, how to improve present collection system in e-waste management?

Mei: The existing unregulated recovery system works very well and it is adapted to the present situation of China. But it really has serious limitations due to the lack of related regulations for control and inspection. Instead of eliminating this kind of recovery system, government should support and control it through legislation, finding the loopholes in this system and changing the negative parts in it. It is necessary to reformulate feasible economic preferential policies to improve the present recovery system, such as tax reduction or tax exemption or financial encouragement which were proved to be effective to develop the resource recycle system before the 70s.

Q: In the e-waste disposal process, can all the existing technologies meet the environmental protection regulations?

Mei: At present most universities focus researches on the technologies of how to recycle and reuse e-waste, such as how to effectively dismantle the printed circuit boards to get precious metals. Technologies are one of the most important things in e-waste management. E-wastes aroused people’s attention not only because they brought negative impacts to the environment but also because the materials, most of which can be reused, can bring economic profit which is meaningful to the whole country. We have to develop our own advanced technologies to environmentally sound recycle and dispose e-waste. There are no related series of standards or regulations to guide and inspect the recycling and disposal process of e-waste.
6. Semi-structured interview with an EHS Specialist in electronic appliance corporation

1). Xu Binbin: EHS Specialist in Sharp Corporation, Shanghai
11:00–11:45 am 17th January 2006

**Q:** Do you know the regulations on e-waste management in China, such as the Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal drafted by NDRC?

**Xu:** Yes. I myself attended the conference held in Qingdao. And we also get the information from local administrative department. We also have our own special departments to collect such information about environmental protection laws or regulations and to control our own industrial wastes including solid wastes.

**Q:** How do you deal with the solid e-waste produced in the producing process?

**Xu:** We will separate them first by workers and then store them in special places which were located at the corner of this plant. After a period of time we will send them to the appointed professional waste recovery centre in this Waigaoqiao Free Trade Zone. The amount of this part of e-waste is not very large and because it belongs to the industrial solid waste it is strictly controlled and managed. The management of waste control in this special district in Shanghai is comparatively stricter than other districts. So we have to pay for the e-waste recycling or disposal fees by ourselves to deal with it.

**Q:** Do you have symbols printed on your products that indicate this product has hazardous materials and can be collected separately and recycled?

**Xu:** There are simple symbols printed on the products or packages to indicate that parts of the products have hazardous or toxic materials but no detailed information on the feasibility of separate collection or recycling.

**Q:** What are you going to do to the increasing e-waste? Do you have take back plan?
Xu: No. We do not have any take back plan at present. It is so difficult for us to recover obsolete products from consumers directly. And if there are no national or local regulations to support this action has too much risk now.

Q: Is it possible for you to phase out the hazardous materials used in electronic products in the time limit required in these regulations?
Xu: We have our own technical institution to be responsible for the development of more environmentally friend materials and green design. We try to use more environmentally friend materials in our products and have already used some recycled materials. We got some of equipment and advanced technologies from parent corporations in Japan directly.

Q: In you opinion what effects do these existing or drafted laws or regulations have on e-waste management in China?
Xu: If all the above drafted regulations passed examination and came into force in the future, we would strictly enforce them although there would be many difficulties in the enforcement process. At present the lack of related laws and regulations has became the most serious obstacle to e-waste management in China. Effective laws and regulations will guarantee fair competition in the electronics industry, improving economic benefits as well as protecting the environment. Those corporations which cannot meet the related environmental regulations and standards will be eliminated through competition. But when these regulations will be enforced is not known and the enforceability of these regulations should be discussed further by the administrative departments.

Q: After the implement of the two directives WEEE and RoHS, what kind of impact do they have to your company? Are there any changes to your company’s export trade? Will these regulations affect electronic product trade with developed countries?
Xu: This is a Japanese company which also has to comply with the regulations and environmental standards of Japan. The Specified Home Appliance Recycling Law of
Japan and the Law for Promotion and Effective Utilization of Resources were enforced in 2001, two years earlier than the two EU directives and are stricter than the latter ones. So the two directives you mentioned will not bring too much negative impacts on our company's business.

Q: If there are no obvious impacts to your company, what kind of impact do you estimate to the whole electronics industry in China after the implementation of the two directives?

Xu: I think these regulations could motivate the government to improve and perfect the existing e-waste management system and could encourage producers to improve the product design and utilize environmentally-friendly materials in electrical and electronic products. I think it is a good opportunity for domestic electronic product manufacturers to compete in an environmentally sound way as well as improving the management of the whole industry.