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## Present status of e-waste disposal and recycling in China

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### Abstract

Due to rapid economic growth, faster upgrade of electrical and electronic equipment causes the ever-increasing quantity of waste electrical and electronic products (WEEE). At present, China is not only a large consumption nation of electrical products, but also a largest importer of e-waste. Through reviewing the present status of e-waste industry and the legal system in China, this article analyzing several problems and barriers in China's e-waste recycling industry: (a) illegal e-waste import from developed countries; (b) the booming development of China's informal recycling sectors; (c) informal disposal leading to serious environmental problems and human health impacts; (d) formal companies facing with the problems of severe lack of e-waste; (e) the morbidity of China's regulatory and legal system. What's more, compared with several developed countries in e-waste management, this paper also recommends that (a) building up the regulatory system of e-waste management in both central and local government; (b) encouraging the development of formal disposal of WEEE; (c) forcing enterprises to focus on Extended Producer Responsibility (EPR).

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### 1. Main text

With rapid growth of science and technology, there is an unprecedented increase in the consumption of electrical and electronic products worldwide <sup>[1]</sup>. Correspondingly, the pursuit for new functions and designs to some extent shortens the lifespan of electronic products <sup>[2]</sup>, leading to the mass generation of waste electrical and electronic equipment (WEEE, often called e-waste). Global e-waste arising amounts to about 40 million tons per year <sup>[3]</sup>, while China is estimated to produce around 2.3 million tons in 2010, second only to the United States <sup>[4]</sup>. Based on the data in 2003, Yang et al <sup>[5]</sup> also estimated that there

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would be 3.3 million tons of WEEE generated in 2010. Until now, there is no actual official data for the e-waste generation in China. What's more, China still remains one of the largest recipients of e-waste or used electronic products from developed countries, even though it has already taken measures to ban e-waste imports from 2002 [6]. According to a report from the United States Environmental Programme (UNEP), approximately 70% of e-waste was illegally shipped into China annually [7].

E-waste, one of the fastest growing waste fractions, constitutes 8% of all municipal waste [8]. It is estimated to increase at the rate of 13-15% per year in China [9]. However, e-waste contains both toxic and some high market value materials. Driven by the huge economic interests, many people recover metals such as copper, gold and aluminum through incorrect handling and treatment of e-waste, posing several harmful impacts on environment and human health [10, 11]. Consequently, more attention is been given to e-waste issues by the Chinese government, scientists and the public.

From analyzing the current situations of e-waste disposal and treatment in China, this paper reviews the likely environmental and health impacts of e-waste, and aims to explore the challenges and problems of China's e-waste management faced. At the same time, this will also put several recommendations on regulating China's e-waste recycling system.

## **2. Status quo of China's e-waste recycling**

### *2.1. Domestic e-waste flows*

In generation, there are mainly three types of destinations for e-waste generated in China. Firstly, used electrical and electronic products might enter into the second-hand markets. The majority of Chinese people would prefer to store their old home appliances at home or office rather than dispose them. When given a considerable price, people are willing to sell their e-waste [12]. But due to a big urban-rural gap in economic development, these second-hand goods would be probable purchased by rural residents, effectively extending their lifespan [13]. Secondly, they might be donated to poor people in western China. In the past, organizations, companies or individuals donated obsolete electronic appliances to hope schools or poverty-stricken areas. In Regulations on Recovery Processing of Waste Electrical and Electronic Products, such transferring behaviors are explicitly forbidden [14]. Finally, obsolete appliance might be recycled by private companies for raw materials. Such recyclers usually buy WEEE from household users at a relative low price, but they do not have professional disposal facilities; thus, environmental pollutions are mainly caused by this channel of e-waste disposal.

### *2.2. Informal Disposal of E-waste in China*

#### *2.2.1 China's informal recycling sector*

Driven by huge profits, majority of domestic e-waste entered into China's informal recycling sectors, which also include the disposal of imported WEEE. In 2007, there are more than 700,000 people employed in e-waste industry, 98% of which were in the informal recycling sector [12]. Take Guiyu for example. As the largest e-waste recycling site in China even in the world, Guiyu has a population of 150,000, nearly 100,000 of which are migrant laborers engaged in e-waste recycling operations [15]. Moreover, these people are congregating in several places, such as Guiyu, Qingyuan in Guangdong province and Taizhou in Zhejiang province (Figure 1). But workers have very low wages. Usually, these sites have hundreds of individual workshops involved in the WEEE recycling business.



Fig. 1. The Distributions of E-waste Informal Recycling

However, the disposal processes involve lots of primitive techniques, which are crude. These techniques include (1) dismantling electronic equipment; (2) heating and manual removal of components from printed circuit boards; (3) opening burning cables and wires for recovering metals; (4) chipping and melting plastics; (5) toner sweeping; (6) open acid leaching of e-waste to recover precious metals [3, 15-17]. Under such crude recycling methods, any precautionary measures aren't taken to protect workers [18]. Additionally, components of printed circuit boards such as integrated circuits and cathode-ray can be sold to some assembly plants to install "new" products. Extracted metals like copper, aluminum, iron and gold can also be offered to metal refineries at low prices [19]. The huge demands and favorable prices impel the development of informal recycling, shaping a complex trading network.

### 2.2.2 Environmental and health impacts

With crude techniques and inappropriate facilities, the informal sector has released a large quantity of toxic heavy metals and organic pollutants into the workplace and the surrounding environment.

Several studies have reported the higher levels of toxic metals, such as lead (Pb), cadmium (Cd), mercury (Hg), copper (Cu) and so on, and organic pollutants like polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and polybrominated dibenzo-p-dioxins/ dibenzofurans (PCBB/Fs) in the air, water, soil and sediment which are near the individual operations [20, 21]. Through direct inhalation, dermal exposure and oral intake of food and water, workers and local residents might be affected by these toxic contaminants. There is scientific evidence that toxic substances can be stored in certain tissues through bioaccumulation and biomagnifying, leading to the growth of the body burden of these compounds [15]. Chatterjee [22] showed that in Guiyu, levels of human exposure of dioxins are almost 10-15 times higher than the WHO recommended maximum intake. Children in such recycling places have much higher blood Pb and Cd levels. For instance, in Guiyu, 70.8% of children had blood Pb levels over

10 ug/dL and 20.1% of children had blood Cd levels more than 2 ug/L<sup>[23]</sup>. Additionally, residents in Guiyu have a much higher proportion of diseases, such as breathing ailments, skin infections, leukemia and other serious illnesses, than the national average. Attention on China's e-waste recycling industry has been caught by developed countries and international organizations, such as the Greenpeace and the UN<sup>[4, 24]</sup>.

However, up to now, individual workshops are still operating.

### *2.3. Formal disposal of e-waste in China*

Since 2004, the State Development and Reform Commission (SDRC) designated Qingdao Haier, Hangzhou Dadi, Beijing Huaxing, Tianjing Datong as national pilot projects, aiming to establish WEEE recycling system and management methods. However, little progress has been made until now<sup>[25]</sup>. For example, as the world's fourth largest whitegoods manufacturer, Haier was chosen as the pilot enterprise to recover discarded home appliances, trying to build a producer-owner recycling model. Moreover, the Haier Group developed coordination with Tsinghua University to improve recycling technologies<sup>[26]</sup>. But by May 2007, Haier only disposed 8000 home appliances with the capacity of 600 thousand units per year<sup>[27]</sup>. As a result, the production lines for e-waste collection have sunk into shutdown or half shutdown, and so have other pilot projects.

Besides, in 2006, the UNEP launched a WEEE recycling pilot project in Suzhou, which named Suzhou Weixiang E-waste Recycling Ltd. This company also works closely with Tsinghua University to deal with computer motherboard, liquid crystal display (LCD), lithium-ion batteries and Cathode Ray Tubes (CRTs). Yet in less than half a year, this 5000-ton-capacity firm met difficulties with the lack of e-waste<sup>[28]</sup>.

Some companies also launched a series of reclamation campaigns for e-waste in China. Together with China Mobile and Motorola, Nokia launched a take-back program —'Green Box' program—to collect obsolete mobile phones and accessories in December 2005<sup>[29]</sup>. Only in 2009, they all collected almost 20 tons e-waste<sup>[30]</sup>. But Nokia reported that only 1% of phones have been recycled in China. The majority of them are stored in people's home or sold to individual recyclers. Other international corporations like Dell, HP and Sony also launched e-waste recycling project. Usually, they paid a little money to consumers for their old computers or PCs. For instance, Dell paid for 1 RMB per 1kg computers. As a result, Dell collected about 55 thousand kg from 2006 to 2008<sup>[26]</sup>.

China's private environmental protection companies also made effects to improve recovery rate of e-waste. Shenzhen Green Eco-Manufacture (GEM) High-tech Co., Ltd ran his first supermarket for e-waste recycling in Wuhan<sup>[31]</sup>. According to different products, GEM set different prices for used or obsolete EEE. Until now, GEM has already signed a strategic cooperation agreement with Wuhan Zhongbai, Gome and Suning. In this way, GEM hopes to solve the problems of no e-waste and achieve low carbon consumption through market mechanism action. Whatever successful or not, GEM provided a referenced mode for China's e-waste recovery industry.

To stimulate consumption, China carried out a pilot program for replacement of household electrical appliances with a 10% subsidy in 9 cities in June 2009, expanding to 28 cities in June 2010. This old-for-new scheme sold around 45 million home appliances by the end of April 15, 2011, recycling 46.6 million units of old ones<sup>[32, 33]</sup>. Obviously, this practice plays a key role in the foundation of China's e-waste recycling system.

All in all, this is a serious game between formal and informal sector in China. At present, informal recyclers are at a more distinct advantage than formal ones. Although China has already invested more in the e-waste recycling industry, formal recycling businesses find it difficult to collect enough WEEE. So what causes the current situations in e-waste disposal and recycling industry? There are several reasons. First and most important, there is a disparity in waste recycling fees between the two sectors. Generally,

Curbside collectors could pay 150-200RMB for an old computer to consumers, while formal recyclers could only pay around 50 RMB<sup>[28]</sup>. This is mainly because of the lower labor cost in the informal sector. Under such conditions, people are prone to send their used home appliances or electronic products to curbside collectors, which are also around the neighborhood. Even few people know the existence of recycling center. Second, the informal sector has already formed industrial chain of WEEE. This chain consists of large amounts of collectors, intermediates, handlers and buyers. They are increasingly interconnected and interdependent, producing a huge profit. How to take effective measures to deal with this informal system still remains a headache for the government. Third, there are many loopholes in China's legal system. This will be analyzed in Section 3.

### 3. Policy Framework of China's e-waste management

China has long since realized the environmental and health effects of e-waste<sup>[5]</sup>; hence, the Chinese government issued a variety of laws, regulations, policies, standards, and technical guidance to manage and control the EEE Production and WEEE recycling.

**Table 1** lists out the present laws and regulations related to e-waste in China. Based on *Law of the People's Republic of China on Prevention and Control of Environmental Pollution by solid waste* and *Law of the People's Republic of China on Promotion of Cleaner Production*, relevant regulations and policies are issued by various governmental agencies, such as the Ministry of Environmental Protection (MEP), Ministry of Industry and Information Technology (MIIT) and the State Council.

Beginning July 1, 2004, collection, storage and disposal of hazardous wastes including e-waste require business licensing<sup>[34]</sup>. *Measures for the Control of Pollution from Electronic Information Products*, which is the counterpart of the EU RoHS directive, restricted the use of six hazardous substances (i.e. Pb, Hg, Cd, Cr<sup>6+</sup>, PBB or PBDE) during the production, sale, and import of electronic information products in China destined for export<sup>[3, 10, 35]</sup>. However, there are some loopholes in this ordinance. For example, no deadline for the restriction has been fixed. Moreover, this regulation only applies to mainland China, no to Hong Kong or Macao; nevertheless, Hong Kong has already become the main entrance for used electrical and electronic products imported into China.

In August 2008, the State Council passed the so-called China WEEE Regulations, *regulations on Recovery Processing of Waste Electrical and Electronic Products*, which came into effect on January 1, 2011. This regulation definitely proposed the implementation of Extended Producer Responsibility (EPR) which emphasized that producers should be liable for WEEE<sup>[36]</sup>. In theory, this regulation is of great importance to establish China's entire management framework of e-waste recycling<sup>[26]</sup>; however, there are obvious loopholes in this regulation. For instance, the regulation covers the WEEE including refrigerators, TVs, washing machines, air conditions and computers, but without cell phones. Actually, the specious and abundance of precious metals in mobile phones are more complicated than home appliances.

In the meanwhile, legislations were also made to set force "3R" (Reduce, Reuse and Recycling) principles<sup>[37]</sup>, ban illegal importation of e-waste<sup>[38]</sup>, set the examination approaches for poisonous and deleterious materials contained in EEE<sup>[39]</sup>, and so on<sup>[40, 41]</sup>. Despite various kinds of existing laws and regulations, the framework of China's WEEE management is still faultiness. It is not only lack of effective enforcement and supervision, but also lack of profession standard and profession norm. Even in the new regulation carried out in 2011, the activities of disassembling and recycling e-waste don't include WEEE's repair, renovation and reuse of above-mentioned WEEE. Actually, such activities are exactly part of informal workshops' businesses. There is no doubt that the existence of so many informal recyclers directly indicates the weakness of China's legislative framework.

Table 1 overview of China's national e-waste management-related regulations

Law or regulation	major contents	Effective data and source
Law of the People's Republic of China on the prevention and Control of Environmental Pollution by Solid wastes (NPC)	Disposal of waste; Responsibilities of producers, retailers, importers and consumers; 3Rs (reduction, recycling and reuse)	Enacted in October30,1995; amended inDecember29,2004; effective from April 1,2005 <a href="http://www.gov.cn/">http://www.gov.cn/</a>
The measures for the Administration of Permit for Operation of Dangerous Wastes (the State Council)	Mandatory regulations on business licensing for the collection, storage, and disposal of hazardous wastes	Effective from July 1, 2004 <a href="http://www.gov.cn/">http://www.gov.cn/</a>
The Technical Policy on Pollution Prevention and Control of WEEE (MEP)	Promotes eco-design; defines requirements on the collection, transport, storage, reuse,disposal and treatment of WEEE;set forth the guiding principles of "3R" and "polluter pays principle"	Effective from April 27, 2006 <a href="http://bz.mep.gov.cn/">http://bz.mep.gov.cn/</a>
Requirements for Concentration limits for certain hazardous substances in electronic information products(SJ/T 11363-2006)	Concentration limits to the six hazardous substances of EEE; labeling and packaging requirements for controlled substances on recycling;	Effective from November 6, 2006 <a href="http://www.miit.gov.cn/">http://www.miit.gov.cn/</a>
Measures for the Control of Pollution from Electronic Information Products(MIIT, NDRC,MOFCOM, GAC, SAIX, AQSIQ, MEP)	Restrictions on the use of six toxic and hazardous substances;requirements for eco-design; mandatory provision for producers to provide information on components, hazardous substances and recycling about their products	Effective from March 1, 2007 <a href="http://www.miit.gov.cn/">http://www.miit.gov.cn/</a>
Administrative measures for the prevention and control of environmental pollution by electronic waste(MEP)	Intent to prevent and control the pollution caused by WEEE during disassembly, recycling and disposal; undertake environmental impact assessment (EIA) for e-waste dismantling, utilization and disposal projects; definition of responsibility of manufacturers, importers and retailers	Effective from February 1, 2008 <a href="http://www.zhb.gov.cn/">http://www.zhb.gov.cn/</a>
Circular Economy Promotion Law of the People's Republic of China	Put forward principles of Extended Producer Responsibility (EPR); specifications of 3R(reduction, recycling and reuse);build incentive mechanisms; control the total emissions from enterprises	Effective from January 1, 2009 <a href="http://www.gov.cn/">http://www.gov.cn/</a>
Technical specifications of pollution control for processing waste electrical and electronic equipment(MEP)	Technical requirements and contents of controls on the collection, transport, storage, disassembly and disposal of WEEE	Effective April 1, 2010 <a href="http://www.zhb.gov.cn/">http://www.zhb.gov.cn/</a>
Regulations on Recovery Processing of Waste Electrical and Electronic Products	Implementation of Extended Producer Responsibility (EPR); establish of a e-waste recycling fund;encourages partnerships in recycling of WEEE; certification for second-hand EE appliances;	Effective January 1, 2011 <a href="http://www.chinarohs.com/">http://www.chinarohs.com/</a>

## 4. Recommendations

### 4.1. *Effective regulatory system of e-waste management*

An effective regulatory system is needed for monitoring shipments, appropriate labeling and recycling of e-waste. So far, China has already carried out a serious of legislations on WEEE management. But there are still many defects in China's e-waste disposal industry. One of the most prominent problems is the booming of informal sector. Although most laws and regulations are enacted consulting to similar EU or USA' models, differences in social formations, people's values and current e-waste situations make laws difficult to implement. What's more, driven by the pressure of GDP and family interests, local government in major e-waste sites turned a blind eye to informal disposal. Under such conditions, China' central government should take measures to make sure the consistent implementation of WEEE policy.

### 4.2. *Vigorous development of China's formal sector*

Although China's recycling pilot programs haven't received a huge success, it's essential to develop formal recyclers vigorously, which is environmental friendly. As the dominant means for WEEE, informal recyclers cannot be forbidden in a short time. Hence, the main challenge is how to transfer or integrate the informal sector into the formal one. And price for collection is playing a key role in the current e-waste disposal industry. Therefore, Chinese government should formulate reasonable collection costs and recovery system to promote formal recycling.

### 4.3. *Extended Producer Responsibility (EPR)*

China should make specific actions to improve the current extended producer responsibility (EPR). Though EPR has already been defined in China's WEEE regulations, it's still a problem on how to carry it out effectively, for there are no explanation about advance recycling fees (AFRs), product take-back mandates, virgin material taxes and even the time to implement.

## 5. Conclusion

As enormous amounts of e-waste are being generated every year, China faces problems in both WEEE generation and disposal. However, China's informal recycling sectors play a much more significant role in WEEE recycling industry, leading to plenty of environmental and health problems. Through analyzing and comparing current legal system with developed countries', this article emphasizes the importance of regulatory system and the implementation of EPR. Additionally, more effects should be made by Chinese government and enterprises to pay attention to product life cycle.

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