Different Strategies and Management between Countries towards Waste Electrical and Electronic Equipment (WEEE) to the Realization of Sustainability

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Abstract. As one of the major waste streams towards the global environment, waste electrical and electronic equipment (WEEE), also called e-waste, is a huge problem needed to solve. Different countries are using various types of strategies and management to ensure the WEEE is limited to the minimum effect on the environment. Using China and the United States as the typical countries to disclose the action different countries have taken towards the management of e-waste. The legislations of e-waste policies are implemented in many countries which the major e-waste produced countries are considered in this paper to form the comparison between those countries. Most countries in Europe are showing more attention towards the management of WEEE and countries such as India or Brazil are less focused on the recycling of WEEE. The major e-waste produced countries tend to have more moderate management to balance the economy and the environment.

1 INTRODUCTION

Environmental problems have been inseparable with humans since the industrial revolution. After the 21st century, anthropogenic activities have been affecting the global environment more and more. Over-population, air pollution, light pollution, water pollution, and waste production are all the culprits for climate change and global environmental destruction. In 2015, the United Nations established Sustainable Development Goals (SDG) which are 17 interconnected global goals to build "a shared blueprint for peace and prosperity for people and the planet, now and into the future" (United Nations). SDG 12 is defined as ‘responsible consumption and production’ which includes Waste electrical and electronic equipment (WEEE) management as one of the target fields. By 2040, CO2 emissions from WEEE generation will approach around 14% of global total emissions [1]. WEEE is also called the e-waste which are the end-of-life or discarded electronic products, such as laptops, cell phones, printers, televisions, etc. E-waste also includes electronic devices that can be reused, refurbished, resold, recycled through material recovery which can potentially be part of e-waste management. Because e-waste has contributed to a large scale on the environment and consequently governments are starting to realize the importance of e-waste management. Policies have been put into practice in different countries. Countries with e-waste regulations are highlighted in Figure 1 as green. E-waste is a very unique waste stream with complex interactions between countries at an international level which needs to be further instructed by designated legislation [2]. They all have a distinguished intensity towards e-waste management. Because of political and strategic issues, the perfect model for the global is still not identified [3]. The materials of e-waste have to keep altering with the newest technology for recycling processes and the requirements from each countries’ legislation [4]. Composition of e-waste materials can be categorized into five classifications, including Ferrous metals, non-ferrous metals, glass, plastics, and other materials, as Ferrous metals are the most majority out of all five types [5].

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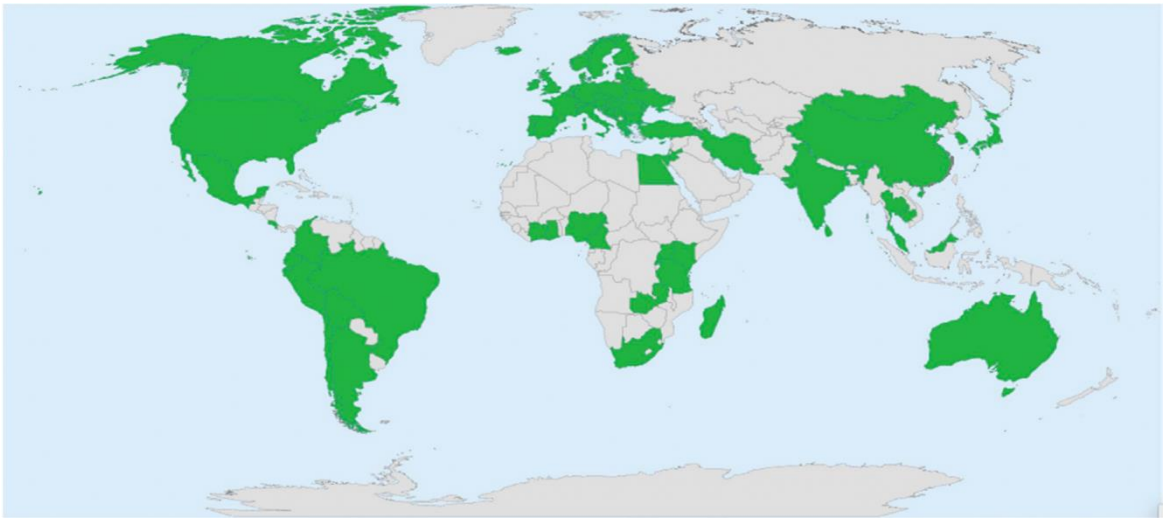

Figure 1. Countries with e-waste legislation (green) [6].

The United States Environmental Protection Agency (EPA) collects and analyzes data to determine how e-waste can be categorized and the severity of different e-waste impacts. The size and total population growth of different countries could influence the severity of e-waste management, as the larger size of one country, the more challenging and expensive the recycling and collection system is [1]. Extended producer responsibility (EPR) is one of the e-waste policies that ensure producers of e-waste acknowledge their liability of post-consumer products treatments. EPR involves mandatory implementation that requires collection targets and voluntary implementation that has no specific collection targets [7].

United Nation Institute of Training and Research (UNITAR) established e-waste monitors to measure differences between regions. Data shows that the top e-waste produced countries, such as China and the United States are trying to increase the recycling rate from around 15 percent to much higher. According to the past research by Chen and Ogunseitan [8], the best ideal method to manage e-waste is apparently to have a cooperative action at a global scale. By putting e-waste into regulation, pollution can become a resource (see Figure 2). Comparing the advantages and disadvantages of different e-waste management between countries and consider how to make sustainability much easier through the management or what could have been done better.

Figure 2. E-waste regulations transition [2].

2 LITERATURE REVIEW

2.1 Global Scale Analysis

The global e-waste generation was roughly around 54 million tonnes in 2019 [7]. The projected increasing rate of e-waste production is around 33% in the next decade, as developing countries will have 400-700 million and 200-300 million outdated computers needed to be handled by 2030 [9]. The data shown is always an approximation rather than a precise one, because of several reasons, including the unregulated collection systems in developing countries and developed countries, and the transboundary movement of e-waste from developed countries to developing countries, and the difficulty to quantify e-waste caused by different electronic types [10].

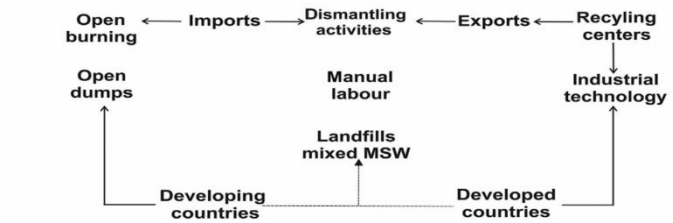

Figure 3. Different e-waste management in developing and developed countries [2].

The accurate e-waste generation statistics can be hard to obtain, but the overall data approximation can easily illustrate the distinction between countries. In Figure 3, the treatments of developed countries and developing countries are depicted. Developed countries tend to have more e-waste generation per-capita compared with developing countries. Although the e-waste generation per-capita is relatively higher in developed countries, the collection and recycling rate is much higher as well, for example, Switzerland, France, Germany, etc. Because of the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and WEEE Directive 2012/19/EU published by the European Community, the majority of the countries in Europe have a higher collection and recycling target and can be the excellent benchmark for e-waste management globally. The WEEE Directive from the European Union enlightened several other developed countries to build-up similar policy and management, including Japan, Australia, some states in the United States and Canada [11]. Shown in figure 2, 78 countries legislated laws, policies, institutional framework regarding e-waste management with 71% global population covered in 2019, increased by 27% from 44% in 2014 [8].

2.2 E-waste in the United States

According to the United States EPA, only approximately 1.2 million tonnes of e-waste is recorded to be collected or recycled out of the estimated 13.1 million tonnes generated with 13.3 kg per capita usage in 2020. The transboundary movement occurs with 314,000 to 376,800 tonnes of e-waste from the United States to developing countries [9]. Because the different states in the United States have their own legislation, the difficulty rises up. E-waste is not defined as a hazardous waste in the United States. Most commonly, municipal waste management is used to deal with e-waste [12]. The state government provides opportunities for people to use collection and recycling facilities which results in 65% of the United States population being covered under the e-waste policy [9]. Some of the states have functioned the EPR policy to safeguard the environment with disposal fees and compulsory take-back system [13]. Legislation of several states are illustrated in the coming paragraph as the case studies for the United States.

The California state government enacts the policy named the 2003 Electronics Waste Recycling Act (SB 20) which limits the use of hazardous substances in some of the electronic products in the California market, especially cadmium (Cd), hexavalent chromium (Cr (VI)), lead (Pb) and mercury (Hg). It also states to charge electronic devices consumers a recycling fee, especially on displays. A 3% collection fee can be reserved by retailers and the remaining part will be received by the Board of Equalization to cover the cost for recycling organizations [14].

In the state of Maine, the e-waste legislation was implemented in 2006 with the Manufacturers Responsibility model which indicates that manufacturers are mainly responsible for almost every part of e-waste management. The manufacturers are accountable for consolidations, transportation, and processing costs, as municipalities are in charge of only collection and some processing costs [14]. Apart from this regulation, manufacturers also need to take care of orphan waste that has no more business value [12].

In 2012, the New York State Electronic Equipment Recycling and Reuse Act (NYS-EERRA) was carried out to enforce the manufacturers of electronic products to provide consumers with free recycling of e-waste within the state of New York [12]. The yearly statewide reuse and recycling targets are also set up. The take-back program gives consumers more advantages of free collection and postage paid mail-back system. The New York State Wireless Recycling Act is also implemented which allows consumers to reuse or recycle up to 10 mobile devices with no fee [14].

2.3 E-waste in China

One of the largest electronic manufacturing countries on the earth and also one of the biggest e-waste producers in the world with 10.1 Mt generated in 2019. The total amount of e-waste recycling in China is shown in Figure 4. As one of the developing countries, other developed countries with strict regulations tend to send more e-waste to China which damages

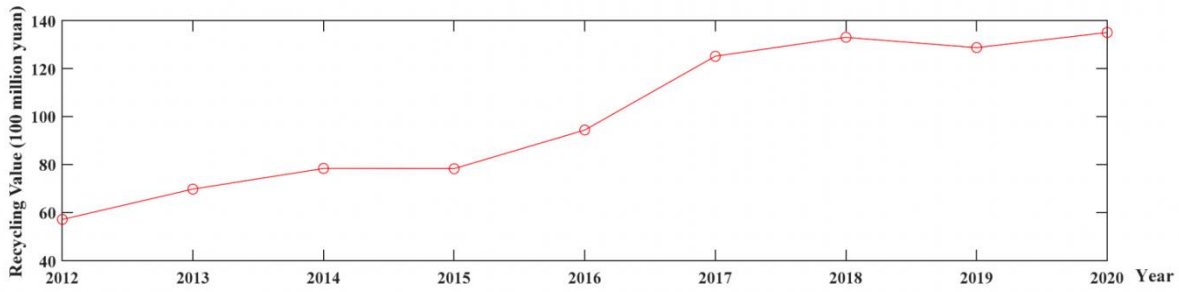

Figure 4. E-waste recycling trend in China between 2012-2020 [15].

the environment in China severely [9]. Several e-waste regulations have been established to reduce the harm of large e-waste generation, from a national and international perspective. Unlike the United States, the whole country has only one government which is much simpler for the execution of each policy. Chinese Management Regulation for WEEE Recycling and Disposal was issued in 2011 which set the goals for e-waste collection and

recycling in China. The policy of Adjustment of Import Waste Management strictly prohibits e-waste imports and prompted the domestic recycling development [16]. The Ministry of Environmental Protection (MEP) is the priority enforcer and coordinator for any e-waste regulations with the collaboration from the National Development and Reform Commission (NDRC) and the Ministry of Industry and Information Technology (MIIT). In 2011, China Household Electric Appliance Research Institute (CHEARI) and NDRC assessed and developed the application of the Chinese 'WEEE Catalog', for instance, laptops, televisions, refrigerators, air conditioners, etc. After considering environmental, economic, and social perspectives, CHEARI built up a review to ensure the Chinese e-waste management is on the right track by providing the government with promptly information and advanced technological support [17]. In May 2020, NDRC enacted the "Implementation Plan on Improving the Recycling and Processing System of Waste Home Appliances and Promoting the Renewal and Consumption of Household Appliances" with seven other departments. With this policy, the improvement of the e-waste recycling and disposal system is required for local government and relevant departments [16].

Collection rates in the old-for-new pilot scheme.

Region	Inhabitants	TV sets	Refrigerators	Washing machines	Air conditioners	Computers	Total
	(1000)				(kg/cap/yr)		
Beijing	19,600	0.64	0.16	0.73	0.05	0.04	1.62
Tianjin	12,280	0.50	0.08	0.42	0.02	0.02	1.04
Shanghai	23,019	1.62	0.07	0.33	0.02	0.03	2.08
Jiangsu province	77,250	0.67	0.04	0.27	0.01	0.01	1.00
Zhejiang province	51,800	0.54	0.03	0.12	0.01	0.03	0.74
Fuzhou	6380	0.74	0.03	0.21	0.01	0.01	0.99
Shandong province	95,790	0.30	0.03	0.13	0.00	0.01	0.47
Changsha	7044	0.55	0.05	0.25	0.02	0.00	0.86
Guangdong	104,300	0.19	0.03	0.18	0.03	0.00	0.44

Figure 5. Collection rates with OfN in different provinces [18].

There are three stages for the Chinese e-waste system development. The first stage was before 2009 and it was called the regional pilot stage where only certain locations, such as Qingdao, Guangdong, Zhejiang, were equipped with e-waste recycling enterprises to form a circular economy [16]. The second stage was between 2009 to 2011 which developed from the first pilot stage and this second stage was recognized by the term of "Old for New" (OfN), with nine areas positively affected, including cost management, collection channels, recycling technologies, etc [18]. The e-waste collection rates for OfN are listed in Table 1. After the policy became invalid along with the new e-waste regulation enforced on informal enterprises, the overall e-waste recycling rate decreased drastically for a year. The third stage was after 2012 with the establishment of a multi-level e-waste management system. As the majority of recycling enterprises receive the corresponding qualifications, the e-waste recycling rate increases every year [16]. The stage differences with e-waste recycling quantity can be illustrated in Figure 6.

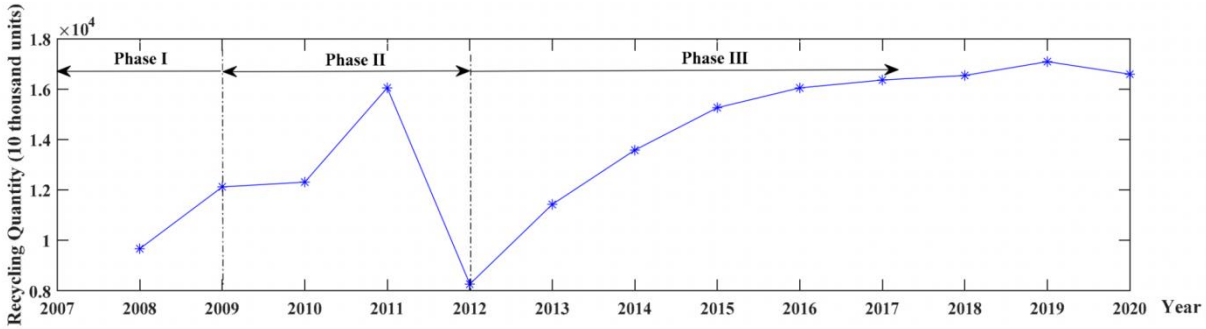

Figure 6. E-waste recycling value within different phases between 2008 and 2020 [17].

In China, the informal structure of e-waste collection is still the most dominant with the well-established collection network. On the other hand, the Chinese government tried to use OfN policy to make people want to use a formal e-waste collection system rather than informal ones. For example, giving the recyclers and formal take-back entities much higher subsidies which also offer benefits to consumers and prompt them to return e-waste to formal ones [18]. The China WEEE directive "The Regulation on Management of Waste Electrical and Electronic Equipment, Recycling and Disposal" and the China RoHS "The Regulation for the Control of Pollution caused by Electronic Information Products" are still active, similar to the directive established by the European Community [18].

3 RESULT

The United States has different policies in every state. As mentioned, California has SB20, New York has NYS-EERRA and the New York State Wireless Recycling Act, and Maine has stricter regulations towards manufacturers. Vice versa, China has several distinguishable policies but under one government management. The policies include the Adjustment of Import Waste Management, Implementation Plan on Improving the Recycling and Processing System of Waste Home Appliances and Promoting the Renewal and Consumption of Household Appliances, OfN, and most significantly, the China WEEE directive along with the China RoHS. By comparing the different e-waste legislation between China and the United States, both of them can be successful by using their own approach as long as they can keep increasing the recycling and collection rate. Not only for the two largest e-waste producing countries, but also for every country around the world with different solutions towards e-waste management. The main purpose for all the e-waste management or strategies is quite simple. The goal of reaching sustainability is always the objective.

4 CONCLUSION

The e-waste problem has drawn more and more attention not only by the governments but also by the individual citizens. More environmental policies regarding e-waste regulations have been established to counteract the rising issues with e-waste. Different countries react differently. The European Union with their own collaborative policies of Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and WEEE Directive 2012/19/EU which have been modified several times to adapt the current trend. Several other countries, including Australia, Japan, Canada, the United States, China, all follow the path of the European Union to create similar regulations towards e-waste. The most efficient way to treat e-waste is always global scale cooperation. There is no exact perfect model for e-waste management around the world, but it has been always optimized throughout time. As countries are focusing on the treatment of e-waste increasingly, the future can be promising.

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