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International Regulatory Frameworks to Solve the Electrical and Electronic Waste (E-Waste) Problem

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ABSTRACT

Electrical and electronic waste (e-waste) is one of the fastest-growing waste streams worldwide, estimated to reach 52 million tonnes by the year 2021. E-waste contains many metals and toxic compounds that can cause environmental and health impacts if not properly managed. The European Union pioneered the e-waste regulatory framework by introducing Directives on Waste Electrical and Electronic Waste (WEEE) and Restriction of Hazardous Substances (RoHS) based on the Extended Producer Responsibility (EPR) principle. Many other countries, including China, Japan, India and Australia, have developed similar regulatory frameworks. The paper deals with the latest developments in regulatory frameworks related to e-waste management.

Keywords E-waste, WEEE, Extended producer responsibility, Regulations, Health impacts.

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INTRODUCTION

Electronic and electrical equipment (EEE) such as computers, televisions and mobile phones have become essential devices in modern-day society. The benefits of such devices are well recognized among the personal consumers and business world. Many countries depend upon information and communication technologies (ICT) towards achieving economic development. However, not much is known about the potential environmental and health impacts of these devices if they are not properly managed at the end of their life cycles. Generally referred to as electronic waste or e-waste, used EEE is one of the fastest-growing waste streams in the world today. The world generated around 45 million tonnes of e-waste in 2016 and predicted to reach 52 million tonnes by 2021 (Baldé *et al.* 2017). There is a significant gap between the 'operational time' of modern EEE (time during which the device can operate mechanically) and the 'functional time' (time during which the device satisfies the need of the customer). Most of the computers and mobiles are discarded well in advance of the expiry of operation time as they do not fulfill the customer's needs anymore due to the availability of newer designs, increased memory.

E-waste consists of several toxic compounds as well as precious ones. The policymakers in the world have developed or in the process of developing suitable regulatory frameworks to deal with sustainable management of e-waste. Such frameworks include making the manufacturer or the importer

Table 1. Some popular EEE (Baldé *et al.*2017).

EEE type	Product
Temperature exchange equipment	Freezers, fridges, air conditioners, cooled dispensers
Monitors and screens	Laptops, cathode ray tube monitors, flat display panel monitors (LCD), cathode ray tube televisions, flat display panel televisions, iPads, notebooks
Large equipment	Washing machines, dryers, dishwashing machines, household heating and ventilation, professional tools, PV panels, photocopiers, electric stoves
Small equipment	Microwaves, electric kettles, video cameras, calculators, toys, electrical tools, small medical devices, toasters, shavers, hairdryers, scales, many small electrical and electronic items used in the kitchen
Small IT and telecommunication equipment	Mobile phones, personal computers, printers, telephones, routers, game consoles

physically and financially responsible for managing their products at the end-of-life (EOL), commonly known as Extended Producer Responsibility (EPR), or recovering an advanced recycling fee from the customers to finance the EOL recycling operations. The paper aims to describe some of the regulatory frameworks developed around the world and some major international initiatives related to solving the e-waste problem.

Global generation of e-waste

E-waste consists of many EEE and related accessories used and discarded by the consumers. Typically, any used EEE which has an electronic circuit or powered by electrical power or batteries belong to the e-waste category. Table 1 below lists some of the popular EEE used by the consumers.

One of the challenges in solving the e-waste problem is the difficulty of developing a meaningful inventory of the amount of e-waste generated. This occurs due to a lack of data on import of EEE, the tendency of households to store used EEE, the existence of the informal e-waste recycling sector in several developing countries. The literature provides estimates of e-waste generated in many countries in the world. However, given the discrepancies of data, even within one country, the correctness and reliability of this data are uncertain. One of the most comprehensive and reliable studies to estimate e-waste generated around the world was conducted by the United Nations University and International Telecommunication Union (Baldé *et al*. 2017). According to this study, the world generated around 44.7 million metric tonnes (MT) in 2016, with a per capita generation of 6.6 kg. It also estimated that e-waste generation would reach 52.2 MT in 2021, with an annual growth rate of 3 to 4%.

Table 2. E-waste generated in different regions during 2016 (Baldé *et al.* 2017).

Region	Annual e-waste generation (MT)	% of world e-waste generation	E-waste (kg/person)
Asia	18.2	40.7	4.2
Europe	12.3	27.5	16.6
Americas	11.3	25.2	11.6
Africa	2.2	5	1.9
Oceania	0.7	1.6	17.3

Tables 2 and 3 highlights the e-waste generated in different regions of the world and some selected countries.

The generation of e-waste varies significantly among the regions and countries of the world. The Asian region is by far the highest generator of e-waste in the world, followed by Europe. Eight out of the top ten countries generating the highest amounts of e-waste belong to these two regions. Although the Asian region produces the highest amount of e-waste, the European region leads the world on per capita e-waste generation. Nine out of the top ten countries generating the highest amounts of e-waste per capita belong to the European region.

The e-waste consists of different metals and compounds which are dangerous to human health and

Table 3. E-waste in selected countries (Baldé *et al*. 2017).

Country	E-waste (tonnes/year)	E-waste (kg/person)
United kingdom	1,632,000	24.9
Denmark	141,000	24.8
Netherlands	407,000	23.9
Australia	574,000	23.6
Germany	1,884,000	22.8
Switzerland	184,000	22.2
Sweden	215,000	21.5
France	1,373,000	21.3
Belgium	241,000	21.2
Finland	116,000	21.1
Spain	930,000	20.1
Canada	724,000	20.0
United states of America	6,295,000	19.4
Hong Kong	140,000	19.0
Italy	1,156,000	18.9
Singapore	100,000	17.9
Japan	2,139,000	16.9
Saudi Arabia	508,000	15.9
Czech republic	168,000	15.9
Republic of Korea	665,000	13.1
Poland	453,000	11.9
Russian federation	1,392,000	9.7
Argentina	368,000	8.4
Brazil	1,534,000	7.4
China	7,211,000	5.2
Indonesia	1,274,000	4.9
India	1,975,000	1.5
Nigeria	277,000	1.5

the environment when poor end-of-life management processes are implemented. E-waste recycling in several developing countries is predominantly conducted by the informal recycling sector using sub-standard processes. These processes result in toxic metals such as lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr) and many types of flame retardants such as polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) entering the environment through waterways and air emissions. Due to the complex chemical structure of e-waste, proper recycling of e-waste has become a challenging task. Unfortunately, e-waste processing facilities in many developing countries where most of the world's e-waste finally end up, lack high-technology applications. The processes such as the open burning of plastics to recover precious metals and rudimentary methods extract metals are causing significant environmental and health impacts in those countries. The environmental and health effects of poor e-waste recycling are discussed in detail in the next section.

Human health and environmental impacts of e-waste recycling

The human health and environmental impacts due to poor e-waste processing are well documented in the scientific literature. These impacts can be broadly categorized into three categories; impacts on soils and sediments, impacts on human health and impacts on general biota. Geographically, these studies are concentrated on countries such as China, Ghana and India, where significant informal e-waste recycling occurs. The Agbogbloshie e-waste recycling facility in Accra, Ghana, is one of the largest informal e-waste recycling facilities in the world and renowned for

Table 4. Impacts on soils and sediments near e-waste recycling sites.

Study details	Reference
Investigation of phthalic acid esters (PAEs), bis (2-ethylhexyl) adipate (DEHA), bisphenol A (BPA), polycyclic aromatic hydrocarbons (PAHs) and heavy metals in the soil of informal e-waste recycling sites in India	Chakraborty *et al*. 2019
Concentration of PAHs in soils near Agbogbloshie e-waste dismantling site	Daso *et al*. 2016
Impact of metals Cu, Pb, Zn, Fe, Co and Sr and bromine in formation of dioxin-related compounds concentrated in e-waste open burning soil	Fujimori *et al*. 2016
Pollution from heavy metals in soil at a an e-waste processing facility near Shanghai, China	Gu *et al.* 2017
Distribution of heavy metals in soil from an informal e-waste recycling site in Lagos State, Nigeria	Isimekhai *et al.* 2017
Flame retardant emission from e-waste recycling operation in Bui Dau , Vietnam	Matsukami *et al*. 2015
Metal concentrations in top soils and dusts in three study locations in Lagos, Ibadan and Aba in Nigeria	Ohajinwa *et al*. 2018
Heavy metal concentrations in water and soils near e-waste processing plant in Greece	Tzoraki *et al*. 2018
Exposure of flame retardants through dust ingestion by workers in e-waste processing plant in Vietnam	Wannomai *et al*. 2020
Impact of heavy metals and PBDEs on microbial activities in soils near an e-waste processing facility	Wu *et al.* 2019

Table 5. Impact on human health near e-waste recycling sites.

Study details	Reference
Effect of Pb exposure on blood morphology in preschool children from an e-waste area in China	Dai *et al*. 2017
Urinary mercury levels in e-waste workers and airborne mercury levels in e-waste shops in Thailand	Decharat S (2018)
Effect of blood levels toxic metals and rare earth elements on hemoglobin concentrations in sub-Saharan immigrants	Henríquez-Hernández *et al.* 2017
Association of hydroxylated PAH in maternal urine on adverse birth outcomes in an intensive e-waste recycling area	Huo *et al.* 2019
Heavy metal concentrations in pregnant women and neonates living near an informal e-waste recycling site in China	Kim *et al.* 2019
Human health risks associated with PBDEs and metals from an informal e-waste recycling site	Ohajinwa *et al.* 2019
Human health risks of PAHs via fish consumption downstream of an e-waste recycling site	Shi *et al*. 2016
Health impacts of workers exposed to the heavy metals in e-waste recycling site in India	Singh *et al*. 2018
Impact on hearing loss and DNA methylation signatures in preschool children due to exposure of lead and cadmium from an e-waste recycling facility	Xu *et al*. 2020

its human health and environmental impacts into their surrounding areas. Akortia *et al*. (2017) used gas chromatography and atomic absorption spectrophotometry to study concentrations of PBDEs and selected metals and found concentrations of Σ PBDEs ranging from 15.6 to 96.8 ng g^{-1} dry weight with an overall mean of 54.8 ng $g^{-1.}$ Through geoaccumulation index, the study found pollution in the soils from metals such as Cu, Pb and Fe. A similar study conducted in South China by Ge *et al*. (2020), found high concentrations of PBDEs, polybromobenzenes (PBBzs), dechlorane plus (DP), organophosphate esters (OPEs) in surrounding soils of the e-waste recycling facility.

Tables 4 and 5 below summarize some studies undertaken to measure the impact of e-waste recycling in soils and sediments and human health, respectively.

European union waste electrical and electronic equipment (WEEE) directive

The aim of the Waste Electrical and Electronic Equipment (WEEE) directive is to minimize the environmental and health impacts of used EEE by increasing re-use and recycling thereby reducing the amount of e-waste going to landfills. To achieve this, the directive requires producers to take financial and physical responsibility of their goods by financing the collection, treatment and recovery of e-waste and arranging the retailers and distributors to allow consumers to return their used EEE free of charge. The original Directive 2002/96/EC, agreed upon by the European Parliament in February 2003, came into force in August 2005 (European Commissions 2003b). The directive required producers to set up public collection points for the consumers to return their used EEE free of charge and to achieve at least 4 kg of e-waste per person/year from December 2006. Following this, the European Commission proposed to revise the directive in December 2008 to deal with significant increase in e-waste generation. The new Directive 2012/19/EU entered into force in August 2012 and became effective in February 2014 (European Commission 2012). The notable feature of the revised directive is moving away from a fixed collection rate (4 kg) to a different recycling targets based on incremental percentages of EEE sold in the national market. The directive introduced a collection target of 45% of the average weight of EEE placed on national market from 2016, increasing to 65% of EEE sold or 85% of e-waste generated from 2019. The new directive also requires all the exporters of e-waste to other countries to test and provide detailed documentation to prevent illegal export of e-waste. The revised directive is strongly based on the principle of 'Extended Producer Responsibility' (EPR), where the producers pay for costs associated with collection, transportation and recycling of their products at the end of their life, free of charge to consumers. The producers pay an upfront fee based upon the proportion of their goods placed in the market. They will have the option of setting up their own EPR administration scheme or utilize the services of a third-party organization, commonly known as the ‘Producer Responsibility Organization’ (PRO). Apart from making the producer responsible for the collection and recycling of their used products, the directive also encourages the producers to consider repair, reuse, remanufacture, disassembly and recycling during the design and production of their products, herby mining the e-waste generated.

Most countries within the European Union (EU) (e.g. Switzerland, Denmark, Sweden, Norway and Belgium) were operating e-waste management systems prior to the establishment of WEEE Directive. Such countries within EU were able to revise their national legislation to adopt the WEEE Directive without significant challenges. However, for other countries with EU, especially new EU member states have encountered significant challenges in adopting and reporting the requirements of the WEEE directive as they still depend on landfill disposal activities. Outside EU, several countries in the Asia Pacific region (e.g., China, Korea, Japan and Australia) have adopted WEEE directive type regulations to manage their e-waste.

European unionrestriction of hazardous substances (RoHS) directive

The Restriction of Hazardous Substances Directive 2002/95/EC (RoHS 1) was developed by the European Parliament in February 2003 to restrict the use of certain hazardous substances in EEE manufacture. The RoHS 1 directive came into effect in July 2006 which required EEE manufacturers to avoid six substances of immediate concern:Lead, mercury, cadmium, hexavalent chromium, ploybrominated diphenyl ethers (PBDE) and polybrominated biphenyls (PBB) (European Commission2003a). The directive has the provision to accommodate new scientific knowledge and technical progress to establish maximum concentration values and add further substances. It was closely linked to the WEEE Directive 2002/96/EC. During 2005, RoHS 1 was amended to establish maximum concentration values for lead, mercury, hexavalent chromium, PBB and PBDE to be set at 0.1% by weight in homogenous materials and 0.01% by weight in homogenous materials for cadmium (European Commission 2005).

RoHS 1 was recast in 2011 to accommodate the growing volumes of e-waste in the EU. The new RoHS, officially referred to as the Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) or RoHS 2, came into force in January 2013 (European Commission 2011). The RoHS extended the scope more products as well as creating administrative harmonization within the EU to reduce the burden of implementation. The revised RoHS did not restrict more substances to he original six substances restricted in RoHS 1, however, added hexabromocyclododecane (HBCDD), bis (2- ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP) and dibutyl phthalate (DBP)as four substances to consider for future restrictions. The EU member states were required to adopt RoHS by January 2013.

In January 2017, the European Commission adopted a proposal to make further amendments to the directive. In November 2017, the RoHS 2 was amended by the Directive (EU) 2017/2102 (European Commission 2017). Furthermore, a general review of the directive is ongoing to be completed by July 2021 to further investigate the effectiveness, efficiency and relevance, particularly towards circular economy.

E-waste regulations in Japan

The Ministry of Environment, Japan (MOE) sets and implements the legislation related environment and waste. The MOE is also the competent authority for the Basel Convention. Japan has a long tradition of recycling due to the shortage of natural resources. The Japanese ‘Law for Promotion of Utilization of Recyclable Resources’ (LPUR) was issued in 1991 to promote recycling in industries including design for resource recovery. This law was in 2000 to ‘Law for Promotion of Effective Utilization of Resources’, to accommodate concepts such as waste prevention, eco-design and design for recycling.
Japan’s legislation related to e-waste relates to the following laws:

Law for recycling of specific kinds of home appliances, commonly known as the ‘Home Appliance Recycling Law’.

Law for Recycling of Small Electronic Applianc es, commonly known as ‘Small WEEE law’.

The‘Home Appliance Recycling Law’ came in to effect in April 2001 covers air conditioners, refrigerators/freezers, televisions and washing machines/ clothes dryers. The cost of recycling is covered by consumers. The consumers pay a collection fee when they drop off their used product to finance the collection, transport and recycling costs. The retailers are responsible for the collection of used home appliances and the manufacturers are responsible for the recycling of them.The consumers are required to return their above-used appliances to retailers or municipalities and pay the required fees.The law also has provisions for the manufacturers to contract with organizations like Association for Electric Home Appliances (AEHA) to collect the used appliances on their behalf. The consumers could purchase recycling tickets from the Center for Home Appliances Recycling Tickets operated by AEHA.

In 2013, the ‘Law for Recycling of Small Electronic Appliances’ was developed and enforced to extend the coverage to all household appliances such as personal computers, cameras, video game consoles and mobile phones that are not covered by the ‘Home Appliances Recycling Law.’ A separate law was required for these items due to their shorter life spans and rapid innovations in manufacture. Under this law the consumers are required to deliver the used small appliances to the retailer of the designated collector, the retailers are obliged to corporate with the consumers for appropriate disposal of those items and the manufacturers are required to reduce the costs for recycling by improving design and also using recyclable materials in their production. The Government will ensure there are sufficient funds to sustain the system. The incentive for the Government to fund the system emanates from the fact the small household appliances heavily contains valuable rare earth metals.

In 2006, an amendment to the ‘Law for the Effective Utilization of Resources’ was adopted to introduce the Japanese version of EU’s RoHS Directive. This is referred to as J-MOSS or JIS C 0950 and covers televisions, refrigerators, washing machines, clothes dryers, microwaves and unit air conditioners. The amendment requires the manufacturers to label their products and provide information on the six substances covered by the EU’s RoHS. The J-MOSS does not prohibit appliances that contain the restricted substances but requires the manufacturers to state in the label if they exceed the allowable concentrations.

E-waste regulations in China

China, considered as one of the fastest-growing economies in the world and the largest producer of EEE, has developed quite a number of environmental laws and regulations to manage e-waste. The main three main overarching laws that relate to e-waste management in China are :

Law on the Promotion of Cleaner Production (2002) promotes concepts of waste prevention during the design and production of EEE and their treatment the end of life.

Law on the Promotion of Circular Economy (2008) specifies concepts of 3R (Reduce, Reuse, Recycle) during the production, consumption and other stages of the life span of EEE.

Law on the Prevention of Environmental Pollution from Solid Waste (2004) stipulates that e-waste treatment plants obtain permits from local environmental protection agencies to safely handle hazardous components of e-waste.

China has also adopted a number of Administrative Measures to complement the above laws. The ‘Administrative measures on the prevention and control of environmental pollution by WEEE’ issued in 2007 deals with the prevention and control of environmental impacts resulting from the disassembly, recycling and disposal of e-waste with defined responsibilities of relevant stakeholders. The ‘Administrative measures on the qualification of WEEE treatment’ issued in 2010 further stipulates the licensing procedure and qualification of e-waste treatment facilities, including supervision activities. The ‘Administrative measures on the distribution of used electrical and electronic products’ issued in 2013 deals with the procedures related to the purchase or sale of used EEE.

China also passed the following two laws to further strengthen e-waste management :

Ordinance on Management of Prevention and Control of Pollution from Electronic and Information Products (2006) - referred to as China's RoHS Directive.
Administrative Regulation for the Collection and Treatment of Waste Electronic and Electrical Equipment (2009) – referred to as China's WEEE Directive, came into force in 2011 with emphasise on EPR, centralized disassembly of e-waste and qualification of recycling plants.

In 2016, China established 'Restriction of Hazardous Substances in Electrical and Electronic Equipment' which superseded China's ROHS issued in 2006. The new RoHS proposed a compliance management list to control the use of hazardous substances in EEE.

Historically, China's email problem has come about mainly due to the recycling operations conducted in the labour intensive, unlicensed informal business sectors. Typically these operations concentrate on extracting valuable metals while disposing of heavy metals and toxic substances to open the environment. The situation has vastly improved in the last few years with the development of laws, licensing operations. However, China is still struggling to cope with the situation, as the current legal framework lacks an integral effort.

E-waste regulations in India

India is facing significant challenges in handling the e-waste problem mainly due to the high generation domestically as well as imports from developed countries. Further, India's high technology industry is one of the fastest-growing industries in the world. As with China, India's e-waste is predominantly handled by the informal sector providing high employment. To overcome the growing e-waste management challenges, India's Central Pollution Control Board (CPCB) published the 'Guidelines for Environmentally Sound Management of E-waste in India' in 2005. The guidelines assist in the identification of various sources of e-waste and recommended procedures for the handling of e-waste. India's Ministry of Environment and Forest (MoEF), as part of the Environmental Protection Act of India, enacted the 'E-waste (Management and Handling) Rule of 2011', which came into force in May 2012. The Rule stipulates manufacturers to take responsibility for the collection and financing of the e-waste management system through EPR. In 2016, the Government of India announced that 'E-waste (Management) Rules, 2016' (the EWM Rules 2016) will supersede the E-waste (Management and Handling) Rules, 2011, which came into effect from October 2016. The revised Rule further improved the EPR concept. In 2018, the Ministry of Environment, Forest and Climate Change (MoEF and CC) amended the 2016 Rules introducing e-waste collection targets to be met according to a graduating scale from10% in 2018 to 70% in 2023. The amended Rule 'E-waste (Management) Amendment Rules, 2018' has the provision of registering a Producer Responsibility Organization (PRO) for managing the EPR system.

E-waste regulations in Vietnam

The Decision No. 50/2013/QD-Ttg of Prime Minister on Prescribing Retrieval and Disposal of Discarded Products was the first legislation for e-waste. It stipulated all of the responsibility on retrieval and disposal of the discarded product to the producer/importer/distributor. In 2014, The Law on Environmental Protection clearly pointed out that the producer/distributor has responsibility to collect and treat the discarded products (Article 87) and the customers are responsible for taking discarded products to proper places (Article 88). These terms are repeated in more clearly in the Decision 16/2015/QD-TTg (replaced the Decision 50/2013/QD-TTg). Moreover, according to the Article 1 of this Decision, the e-waste is not considered to be managed in the Government's Decree No. 38/2015/NĐ-CP on providing regulations on waste and scrap management (Huynh Trung Hai *et al.* 2015). However, this decree does not set the target of collection, so that it is difficult to assess the retrieval effectiveness of the manufacturers. The Decree No. 69/2018/ND-CP dated May 15, 2018 stipulates conditions that used goods specified in Section II of Annex I such as used electronics, electrical appliances… is prohibited for importation. In addition, the list of goods (including some e-wastes) banned to import for re-export shows in Annex 6, Decree No. 69/2018/ND-CP on guidelines for the law on foreign trade management (VEA and MoNRE 2020).

Like China, most e-waste in Vietnam is handled by informal private sector. Most of valuable parts from e-waste are manually reprocessed at craft villages. The recyclers or refurbish companies dismantle the devices/components to get the profitable parts and dispose unusable parts. From that, it causes serious impacts on environment and the worker's health as well as wasting of secondary materials (Vietnam Environment Administration 2014).

Vietnam has started a trial project to collect and treat e - waste called the Vietnam Recycles in Hanoi inner city area and Ho Chi Minh City. The project has been carried out since the beginning of 2015. The application range are businesses and households. It has set up and operated 10 collection points (5 points in Hanoi and 5 point in Ho Chi Minh City) so that people can properly dispose of e-waste (Vietnam Recycles 2015). The amount of e - waste received by the project has increased over the years. In the first year of operation, Vietnam recycles collected only about 840 kg of e- waste. But by 2018, it has collected more than 10 tons of broken electronic devices. In particular, Vietnam Recycles has collected more than 24 tons of e- waste in 2019. However, EEE in Vietnam is mostly discarded by selling to the collectors/ junk buyers for dismantlement while Vietnam Recycles does not have any preferential policies or exchange material to receive e- waste. Besides, Vietnam Recycles is supported by the two leading electronic companies, namely HP Technology Vietnam Company Ltd and Apple Vietnam LLC, so the Project's operating budget is still quite limited. Therefore, it is rather difficult to scale up to other provinces and cities nation wide (Mai Ngan 2020).

E-waste regulations in Australia

The Australian Government introduced the National Television and Computer Recycling Scheme (NTCRS) in 2011 to provide Australian households and small businesses access free, industry-funded recycling schemes to dispose of their used televisions, computers, printers and computer accessories. The scheme's objective was to reduce e-waste going to landfill and to recover reusable materials safely and environmentally sound manner through a free, industry-funded recycling scheme. The 'Product Stewardship Act 2011' provided the regulatory framework for the scheme under the 'Product Stewardship (Televisions and Computers) Regulations 2011'. Under this scheme, the companies who import or manufacture computer and television products over a certain threshold are required to pay a fee based on the proportion of recycling by becoming a member of the co-regulatory arrangement (PRO). The co-regulatory arrangement appointed by the Government is responsible for the day-to-day operations of the scheme by organising the collection and recycling of e-waste on behalf of their members. The households and small businesses can dispose of their used televisions and computers at designated collection points. Under the Product Stewardship (Televisions and Computers) Regulations 2011, the PROs are required to provide independently verified annual reports to the department outlining the achievements in the given period. The department has the authority to cancel the co-regulatory arrangement if the PRO is found to be unsatisfactory. Currently, Ecycle Solutions (Ecycle), Australian and New Zealand Recycling Platform (ANZRP), Electronics Product Stewardship Australasia (EPSA) and MRI PSO (MRI) manage the day-to-day operation of the scheme.

CONCLUSION

E-waste is considered to be one of the fastest-growing waste streams in the world due to the high uptake of information and technology products and early obsolescence of EEE as a result of rapid developments in newer designs and technology. The proper management of e-waste is vital due to the metals and toxic compounds contained in e-waste. Many countries have developed regulations that deal with the issue driven mainly by the European Union regulatory framework. Even with sound regulatory frameworks, the percentage of e-waste recycling still low in these countries, meaning further refinement of the regulations is necessary. Several developing countries lack such policies and regulations to deal with the growing e-waste problem. While the regulatory frameworks developed and successfully implemented in industrialized counties could be utilized as a guide to establishing regulations in developing countries, it is important to consider the socio-economic conditions within the country to ensure strengths of both formal and informal e-waste recycling sectors are combined towards a sustainable e-waste management regulatory framework.

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