SUSTAINABLE EXTENDED PRODUCER RESPONSIBILITY (EPR) MODEL FOR MANAGING HOUSEHOLD E-WASTE IN MALAYSIA

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ABSTRACT

Household E-waste generation in Malaysia is estimated to increase 1% yearly. However, the collection, inventory, treatment and disposal practised at present are not optimum due to unavailability of a proper framework for Household E-waste Management. Therefore it is a known fact that Malaysia requires a sustainable and affordable system to manage E-waste. One option is to introduce Extended Producer responsibility (EPR) environmental policy, which focuses on shared responsibility by all the stakeholders. Hence, in this paper, four objectives were set up which are to determine the current status of Household E-waste Management in Malaysia, to compare Household E-waste Management systems in other countries from the EPR perspective (Germany, Japan, Taiwan, Malaysia), to identify the mechanism in implementing sustainable EPR model for managing Household E-waste in Malaysia and last but not least, the objective is to develop summaries sustainable EPR model for managing Household E-waste in Malaysia and overall recommendation. The methodologies adopted in order to complete this research are combination of literature review, non-participant observation method (attending a seminar), comparative analysis, flow diagram and SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. EPR model practised in Germany, Japan and Taiwan are analysed in detail and assessed for suitability with or without modification for Malaysian scenario. It was found that even though there is variation in the ways that EPR is implemented in these countries, however, some main components are similar. Based on this finding, a total of seven components are identified for possible Malaysian EPR Model. The above mentioned components include regulation, Household E-waste inventory, collection, reporting, recycling, fee and Fund Management Board. In additions, a possible implementation plan complete with strengths, weakness, opportunities and threats is performed. The analysis confirms that EPR model for managing Household E-Waste is suitable in Malaysia.

ABSTRAK

Sisa Elektrik Isi Rumah di Malaysia dijangka meningkat sebanyak 1% setiap tahun. Pengumpulan, inventori, rawatan dan pelupusan Sisa Elektrik Isi Rumah diamalkan tidak optimum kerana ketiadaan rangka kerja yang sewajarnya pada masa kini. Oleh itu adalah diketahui hakikat bahawa memerlukan sistem yang mampan dan mampu untuk menguruskan Sisa Elektrik Isi Rumah di Malaysia. Salah satu pilihan adalah untuk memperkenalkan *Extended Producer Responsibility* (EPR) iaitu dasar alam sekitar yang memberi tumpuan kepada tanggungjawab bersama oleh semua pihak yang berkepentingan. Oleh itu dalam laporan ini, terdapat empat objektif dalam kajian ini iaitu untuk menentukan status semasa Sisa Elektrik Isi Rumah di Malaysia, untuk membandingkan sistem Pengurusan Sisa Elektrik Isi Rumah di negara lain dari perspektif EPR (Germany, Jepun, Taiwan, Malaysia), untuk mengenal pasti mekanisme dalam melaksanakan model EPR yang mampan untuk menguruskan Sisa Elektrik Isi Rumah di Malaysia dan akhir sekali, objektif adalah untuk membangunkan ringkasan model EPR yang mampan untuk menguruskan Sisa Elektrik Isi Rumah dan cadangan keseluruhan. Metodologi yang diguna dalam kajian ini adalah kombinasi *literature review* , menghadiri seminar , analisis perbandingan, carta aliran dan analisis SWOT (*Strengths, Weaknesses, Opportunities, Threats*). Model EPR diamalkan di German, Jepun dan Taiwan dianalisis secara terperinci dan dinilai untuk kesesuaian dalam senario Malaysia. Ia telah mendapati bahawa beberapa komponen utama adalah sama walaupun terdapat variasi dalam cara-cara yang melaksanakan EPR di negara-negara tersebut, Berdasarkan ini tujuh komponen dikenal pasti untuk melaksanakan model EPR di Malaysia. Komponen termasuk peraturan, inventori E-waste, mekanisme pengumpulan, mekanisma pelaporan, mekanisme kitar semula, mekanisme bayaran dan mekanisme Lembaga Pengurusan Dana. Pelan pelaksanaan mungkin lengkap dengan kekuatan, kelemahan, peluang dan

ancaman yang dilakukan. Analisis ini mendapati bahawa model EPR adalah sesuai untuk menguruskan Sisa Elektrik Isi Rumah di Malaysia.

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LIST OF SYMBOLS AND ABBREVIATIONS

AEHA	:	Association of Electronics Home Appliances
ACGs	:	Auditing and Certification Groups
BFRs	:	Brominated Flame Retardants
CRTs	:	Cathode Ray Tubes
CVLB	:	Commercial Vehicles Licensing Board
CePSWaM	:	Certified Environmental Profesional in Scheduled Waste Management
CTS		Collective Take Back Scheme
DOE	:	Department of Environment
DTIE	:	Division of Technology, Industry and Technology
EAR	:	Elektro-Altgeräteregister
EPR	:	Extended Producer Responsibility
EEE	:	Electrical and Electronic Equipment
EoL	:	End-of-Life
EIA	:	Environment Impact Assessment
EQA	:	Environment Quality Act
ESM	:	Environmentally Sound Management
EMS	:	Environment Management System
EPA	:	Environment Protection Administration
EPAT	:	Environmental Protection Administration Taiwan
ESP	:	EoL Service Provider
FMs	:	Focus Material
FMB	:	Fund Management Board
FRRC	:	Fee Rate Reviewing Committee

IBTS	:	Individual Brand-selective Take Back Schemes
IETS	:	International Environmental Technology Centre
INTS	:	Individual Non-selective Take Back Schemes
JICA	:	Japan International Cooperation Agency
LCDs	:	liquid crystal displays
LPUR	:	Law for the Promotion of Effective Utilisation of Resources
LRHA	:	Law for Recycling Specified Kinds of Home Appliances
LRSR	:	Law for Promotion of Resources Saving and Reutilization
NSWMD	:	National Solid Waste Management Department
OECD	:	Organization for Economic Co-operation and Development
PCBs	:	Printed circuit boards
PBB	:	Polybrominated Biphenyls
POP	:	Persistent Organic Pollutants
PBDE	:	Polybrominated Diphenyl Ethers
PCDDs/Fs	:	polychlorinated dibenzo-p-dioxins and furans
PEDEs	:	poly-brominated diphenyl ethers
PRO	:	Producer Responsibility Organization
RoHS	:	Restriction of Hazardous Substances
RFMC	:	Recycling Fund Management Committee
RKC	:	Home Appliances manifest data management centre
RRW	:	Regulated Recyclable Waste
SPAD	:	Land Public Transport Commission
SWOT	:	Strengths, Weakness, Opportunities, Threats
TBBPA	:	tetrabromobisphenol-A
UNEP	:	United Nations Environmental Programme
WEEE	:	Waste Electrical and Electronic Equipment

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CHAPTER 1:

INTRODUCTION

1.1 Background

E-waste, or Electrical and electronic waste, included all parts of electrical and electronic equipment (EEE) which were disposed of by its owner as waste without the intention to be reused in future. It is also being known as WEEE (Waste Electrical and Electronic Equipment), E-scrap or electronic waste. This E-waste, if being handled via improper approach, for instance, open burning will cause environmental pollution which then exposes human being to hazardous substances. Hence, the recycling and recovery of E-waste will able to conserve the natural resources which contain valuable materials, that beneficial to the environment or human beings (Step Initiative, 2014).

The lifespans of the electrical and electronic equipment (EEE) is shorter due to the rapid growth of the technology trigger the diversity of the EEE products recently. Thus, the amount of the E-waste is growing (Osibanjo and Nnorom, 2007). Improper techniques to manage E-waste during the collection, storage and recycling process can pose risk to environment and human health because comprising toxic materials and heavy metals such as cadmium, lead, mercury, hexavalent and arsenic through the pathway of inhalation of fine particles, skin contact and contaminated dust is ingested (Chan and Wong, 2013). Furthermore, persistent organic pollutants (POPs) such poly-brominated diphenyl ethers (PBDEs) containing in E-waste(Leung *et. al.*, 2006) with the characteristic of longer half-life can affect neighbouring resident and ecosystem.

Extended Producer Responsibility (EPR) is one of the environmental policy to extend the manufacturers responsibility to minimise the environment impact of their product throughout the product lifecycles. According to Kojima *et. al.* (2009), EPR intentions at "giving electronic appliance manufacturers and importers responsibility for the collection and recycling of discarded electronic equipment", thus, the amount of E-

waste that disposes of in a landfill can be reduced (Ongondo and Williams, 2011). Many of the countries do implement EPR environment policy to manage the E-waste successful such as Germany, Japan and Taiwan.

Malaysia is also in the directions towards the implementation of the EPR concept which involves shared the responsibility of the producers, consumers and retailers in extending their responsibility for collections, disposal or recycling. Some of the multinational electronics companies in Malaysia are initiated to implement EPR such as Hewlett-Packard, Motorola, Dell, Nokia and Apple voluntarily to take back their end of life product as part of their global corporate responsibility policy (Agamuthu and Victor, 2011).

1.2 Problem Statement

In Malaysia, the E-waste management is only applicable for industrial E-waste which classified as schedule waste with the code of SW 110 as stated under the Environmental Quality (Scheduled Wastes) Regulations 2005. Nevertheless, the E-waste generated from a household in Malaysia is currently not regulated and there are no mechanisms to control and collect E-waste from a household to another.

Waste separation at source, in general, is not a common practice in Malaysia which led to the collection of all types of municipal solid waste in one single bin then dispose at the landfill sites. Consequently, E-waste is directly disposed of together with other household wastes. The Household E-waste which disposed of together with other household wastes has created an opportunity for illegal waste contractors to scavenge through the waste to collect E-waste, which has scrap value. Such scavenging activities will have an adverse impact towards the environment and expose a human being to hazardous substances.

Thus, the research questions in this project are as stated below:-

1) What is the current status of Household E-waste Management in Malaysia? The future plan to tackle the increased quantity of the Household E-waste in Malaysia in order to protect the environment and human health from the hazard material contain in the E-waste.
2) There are different systems in managing the Household E-waste effectively in the Asian country. How is the EPR model for managing Household E-waste implementing in Asian countries such as Germany, Japan and Taiwan can be adopted in Malaysia?
3) There are existing E-waste Management standards in other countries related to environmentally sound management. What is the mechanism to be implemented in sustainable EPR model for managing Household E-waste in Malaysia?
4) What are the challenges to implementing the sustainable EPR model for managing Household E-waste in Malaysia?

1.3 Aim of Research

The aim of this research is to assess an appropriate model for managing Household E-waste in Malaysia. To achieve the aim the following objectives are defined.

1.4 Objectives and Scopes of Research

The objectives include:-

1) To determine the current status of Household E-waste Management in Malaysia.
2) To compare Household E-waste Management systems in other countries from the EPR perspective (Germany, Japan, Taiwan, Malaysia).
3) To identify the mechanism in implementing sustainable EPR model for managing Household E-waste in Malaysia.
4) To develop summaries sustainable EPR model for managing Household E-waste in Malaysia and overall recommendation.

The scope of this research only focuses on the EPR model in managing household E-waste in Malaysia.

1.5 Report Layout

The report layout of this research has been established as below:

Chapter 1 introduces the background information of impacts of improper manage of E-waste and the EPR concept to minimise the environment impact of their product throughout the product lifecycles. This chapter also highlights the problem statements, aim, objectives and scopes of research.

Chapter 2 is literature review which including an overview of E-waste, regulation related to E-waste, Extended Producer Responsibility (EPR) Theoretical Framework, overall E-waste management system, Extended Producer Responsibility (EPR) in Germany, Japan, Taiwan and last section include literature review summary.

Chapter 3 is methodologies that adopted in order to complete this project which including literature review, non-participant observation (attending seminar), comparative analysis, flow diagram and Strength, Weakness, Opportunity and Threat (SWOT) Analysis.

Chapter 4 is results and discussions which will present and discuss the finding of current status of Household E-waste Management in Malaysia, comparison of EPR implementation in Germany, Japan, Taiwan and Malaysia, implementation mechanism and last but not least, present the summary of the EPR Model for Household E-waste Management in Malaysia and overall recommendations.

Finally, chapter 5 concludes all the finding for this research.

CHAPTER 2:

LITERATURE REVIEW

2.1 Overview of E-waste

Electrical and electronic waste or E-waste included all parts of electrical and electronic equipment (EEE) that disposed of by its owner as waste without the purpose to reuse in future. It is also known as WEEE (Waste Electrical and Electronic Equipment), electronic waste or E-scrap in different regions(Step Initiative, 2014).

E-waste are mainly generated from a number of sources such as obsolete electrical and electronic equipment generated from governments, companies, and other facilities, , residue from electronic products making process, leftover parts of EEE from a repair shop, superseded electrical or electronic products brought in by smuggling and superseded electrical or electronic products generally from households (Wen *et. al.*, 2008).

In European Union, the definition for the E-waste is defined in the WEEE Directive as "'waste electrical and electronic equipment' or 'WEEE' means 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" (WEEE Directive, 2012b)

In Japan, there is no specific definition to distinguish the E-waste. The "waste" in Japan defined in the Waste Management and Public Cleansing as "refuse, bulky refuse, ashes, sludge, excreta, waste oil, waste acid and alkali, carcases and other filthy and unnecessary matter, which are in solid or liquid state"(Yolin, 2015). However, in the Home Appliance Recycling Act, "specific household appliance waste" means specific household appliances that have become general waste.

In Taiwan, there is no specific definition to distinguish the E-waste. However, in the Waste Disposal Act, categories 11, 12 and 13 of the Regulated Recyclable Waste

(RRW) define WEEE in Taiwan as shown in table 2.6. RRW is defined to include 13 categories and 33 items such as metal containers, glass containers, plastic containers and aluminium containers (United States Environmental Protection Agency, 2012).

In Malaysia, the E-waste management is only applicable for industrial E-waste which classified as schedule waste with the code of SW 110 as stated under the Environmental Quality (Scheduled Wastes) Regulations 2005. E-waste in Malaysia is defined as waste from electrical and electronic assemblies that contain components such as glass from cathode-ray tubes, mercury-switches, accumulators and other activated glass or polychlorinated biphenyl-capacitors or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyl.

2.1.1 Total Quantity E-Waste Generation

E-waste generation data are mostly estimated based on the electrical and electronic equipment life span and the production or sales volume data. Many of the countries are facing difficulties in obtaining the real E-waste generation data. Although there are some of the countries has collected E-waste inventories data, however, some of the consumers kept their E-waste inside the home, which becomes one of the issues in estimating the E-waste generation accurately (Herat and Agamuthu, 2012). Ongondo *et.al.*(2001)summarised and reviewed the E-waste generated data for various countries as showed in table 2.1. The data denoted the E-waste generation per capita in the different country, however, there are no complete data on yearly basis for these countries.

Table 2.1: Global Generation of E-waste. Source: (Ongondo *et. al.* , 2011).

Country	Per Capita generation (kg/person)
Germany	13.3[a]
UK	15.8[b]
Switzerland	9[c]
China	1.7[d]
India	0.4[e]
Japan	6.7[f]
Nigeria	NA
Canada	2.7[g]
South Africa	1.2[h]
Argentina	2.5
Brazil	3.5
USA	7.5[i]
Kenya	0.2[j]

[a] Per capita generation in the year 2005.
[b] Per capita generation in the year 2003.
[c] Per capita generation in the year 2003.
[d] Per capita generation in the year 2007.
[e] Per capita generation in the year 2007.
[f] Per capita generation in the year 2005.
[g] Per capita generation in the year 2002.
[h] Per capita generation in the year 2007.
[i] Per capita generation in the year 2007.
[j] Per capita generation in the year 2007.

Table 2.2: The E-waste weight (metric tonnes) collected from household and business entities and institutions.

Source: (The E-waste Inventory Project in Malaysia Report, 2009)

E-waste Item	Year							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Television	278,170	228,000	236,820	206,740	215,180	231,750	242,320	261,840
Computer	162,260	190,120	222,820	256,980	294,340	328,480	379,140	418,990
Mobile Phone	470	600	780	1,030	1,280	1,520	1,730	1,890
Refrigerator	70,840	11,770	73,460	60,990	59,060	60,890	62,560	64,100
Air Conditioner	145,360	146,200	142,980	139,520	140,940	145,560	148,230	146,880
Washing Machine	30,880	31,220	29,300	29,710	29,630	29,550	31,205	33,150

The evolution and rapid developments of technologies coupled with high demand from consumers are the reason behind the increasing of E-waste quantity in Malaysia, which generated from industry, households and institutions (Afroz *et. al.*, 2013). Table 2.2 shows the increasing trends of the estimated quantity on E-waste (in metric tonnes) between the year 2008 and 2016 in Malaysia. According to the E-waste inventory Project, household e-waste in Malaysia is breakdown into six items which are television, computer, mobile phone, refrigerators, air conditioner and washing machine.

The summary of literature review revealed that quantity of the E-waste generation is increasing not only for global, also happen in Malaysia. However, the downside would be the data compiled are mostly on estimation. Most of the countries are experiencing difficulties in getting the real E-waste generation data. Thus, a sustainable system to manage Household E-waste is required in order to get the full information of the E-waste generated and properly manage it during the end of life instead of disposing of it in the landfill and reduce the lifespan of the landfill and for a clean environment for the next generation.

2.1.2 Categories of the E-waste

In the Waste Electrical and Electronic Equipment Directive (WEEE Directive), from European Union, there are 10 categories of the electrical and electronic equipment such as large household appliances (washing machine, refrigerator), small household appliances (vacuum cleaner, hair dryers), IT and telecommunications equipment (notebook, printers), consumer equipment and photovoltaic panels (radio sets, video camera), lighting equipment (fluorescent lamp), electrical and electronic tools (drills, welding tools), toys leisure (video games, biking), medical devices (dialysis equipment, radiotherapy equipment), monitoring and control instruments (smoke detector, laboratory equipment) and automatic dispensers (for drinks) as summarize in table 2.3 (Poulios *et. al.*, 2006; WEEE Directive, 2012a).

Table 2.3: Categories of Electrical and Electronic Equipment in the WEEE Directive. Source:(Poulios *et. al.*, 2006; WEEE Directive, 2012a).

No	Categories	Labels
1	Large Household Appliances	Large HH
2	Small Household Appliances	Small HH
3	It and Telecommunications Equipment	ICT
4	Consumer Equipment and Photovoltaic Panels	CE
5	Lighting Equipment	Lighting
6	Electrical and Electronic Tools (With the Exception of Large-Scale Stationary Industrial Tools)	E & E tools
7	Toys, Leisure And Sports Equipment	Toys
8	Medical Devices (With the Exception of All Implanted and Infected Products)	Medical equipment
9	Monitoring and Control Instruments	M & C
10	Automatic Dispensers	Dispensers

The summary of this section is there are 10 categories of E-waste generation, which are large household appliances, small household appliances , IT and telecommunications equipment, consumer equipment and photovoltaic panels (radio sets, video camera, lighting equipment (fluorescent lamp), electrical and electronic tools (drills, welding tools), toys leisure (video games, biking), medical devices (dialysis equipment, radiotherapy equipment), monitoring and control instruments (smoke detector, laboratory equipment) and automatic dispensers (for drinks) as stated in the WEEE Directive. However, in Malaysia, industrial E-waste is categorised as scheduled waste (SW 110), and there are no categories that further segregate the household E-waste in Malaysia.

2.1.3 Composition of the E-waste

The substances in the E-waste are toxic in general, of which it comprises heavy metals (lead, cadmium, and mercury), persistent organic pollutants (brominated flame retardants) and dioxins (polyaromatic hydrocarbons). Based on studies, approximately 70% of the heavy metals in US landfills arise from E-waste are cadmium and mercury, however, ferrous metals, non-ferrous metals, plastics, glass and "others" are the other categories that also found in the E-waste. According to the Switzerland recycling system, metals formed the highest fraction, around 60% in electrical and electronic equipment as shown in Figure 2.1. Plastics are the second largest component, followed by a screen of CRT and LCD, metal-plastic mixture, heavy metals, cables, printed circuit boards and others (Widmer *et. al.*, 2005).

The summary of this section is the E-waste contained heavy metals which will pose risk to the environment and human health, thus proper management system to handle the E-waste after the end of life span is deemed necessary.

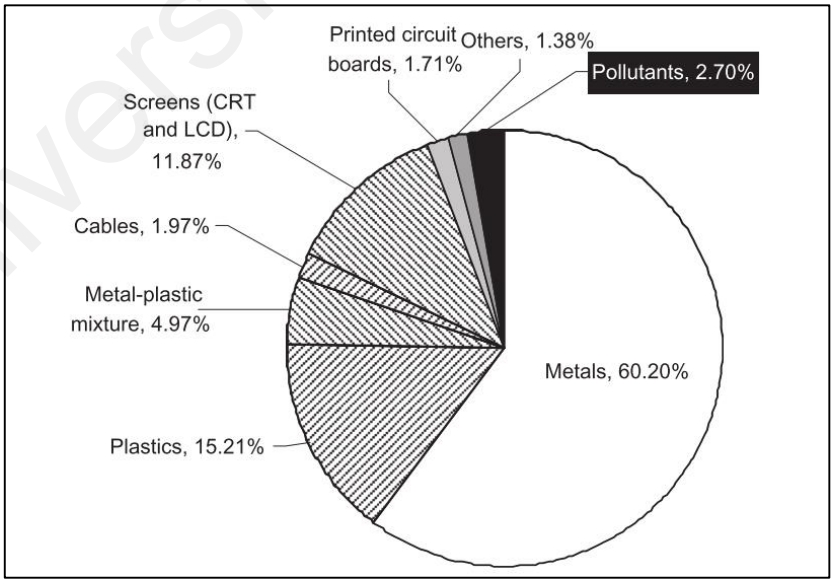


Figure 2.1: Material Fraction in E-waste. Source:(Widmer *et. al.*, 2005)

2.1.4 Impacts of the E-waste

Improper handling of the E-waste will lead towards negative impacts on environment and human health due to hazardous substances such as heavy metals (lead, cadmium, mercury), brominated flame retardants (polybrominated diphenyl ethers (PBDEs)) , dioxin (polychlorinated dibenzodioxins (PCDDs)) and other substances (Tsydenova and Bengtsson, 2011). For instance, lead in the components of cathode ray tube (CRTs), batteries may induce miscarriage for pregnant women, increase blood pressure and anaemia. Lead will also cause damages to nervous connections and brain disorders for children. Apart from lead, cadmium in the components of batteries and semiconductor chips has long half-life and stability structure, which can bioaccumulate in the body. Low-level exposures of cadmium will cause kidney disease and bone brittleness whilst long exposures will cause lung cancer (Luis Liwanag and Bantoxics, 2015).

Mercury which is found in batteries, thermostats and fluorescent lamps, will accumulate in the central nervous system of which if chronic exposure to mercury will result in kidney damage (NEWMOA, 2008).

Wires and cables usually have insulation coating with PVC. However, chlorine in PVC will cause the polychlorinated dibenzo-p-dioxins and furans (PCDDs/Fs) released with uncontrolled burning and will bring adverse effect on the environment and human. In addition, funnel part of CRT contains lead while fluorescent phosphors coating with zinc, cadmium and rare earth metals can be found inside cathode ray tubes (CRTs) panel (OECD, 2003). Furthermore, Printed circuit boards (PCBs) contain hazardous substances such as cadmium in contacts and switches, lead in solder, brominated flame retardants in plastics and beryllium in connectors. However, PCBs also contain not hazardous substances such as valuable gold, silver and palladium.

In the disassembly stage of electrical and electronic appliances, the accidental releases and spillages will have a risk for the personnel to have direct or indirect contact with the hazardous substances. These include mercury being released into the air in the scenario where breakage of the fluorescent lamp in recycling plant happen(Aucott *et. al.*, 2003). Vacuum the phosphor coating on the inner side of CRTs will make the hazard through the route of inhalation exposure. Furthermore, the incomplete combustion of computer plastic casings at low temperature will emit toxic fumes from incineration that contain polyhalogenated dioxins and furans. In addition, the shredding and grinding process will release dust to the atmosphere and might cause a hazard to the worker via the pathway of dermal exposure and inhalation (Tsydenova and Bengtsson, 2011).

The improper manage in E-waste recycling will cause environment pollution such as soil, air and water pollution around E-waste recycling sites (Wong *et. al.*, 2007). The hazardous material that released into the environment will affect the ecosystem chain, food contamination and bioaccumulation(Chan and Wong, 2013). The ecological may exposure to the hazardous substances in the E-waste which consequently exposed a human to health risk as the E-waste have a longer life span to be degraded in the environment due to its high environmental persistence characteristic. (Sepúlveda *et. al.*, 2010).

The section summarises that impacts of the E-waste are not only on the adverse to human health but also pollute the environment such as food contamination, bioaccumulation and disturb the ecosystem chain. There is a research gap in this research that lacking occupational health data on exposure and health impacts in workers involved in reclaiming metals from E-waste in smelters and refineries in Malaysia.

2.2 Regulation Related to E-waste

2.2.1 European Union

In the European Union, Waste Electrical and Electronic Equipment Directive (WEEE Directive) is amongst the regulation related to E-waste, which enforced since August 2005. The purpose of this directive is to decrease the electrical and electronic waste disposal and encourage the sustainable development and conserve the resources via recycling and recovery electrical and electronic waste. In order to achieve the purpose, a system was developed, which allowed consumers return their E-waste to the manufacturer without any financial charges. Nevertheless, manufacturers have the financial responsibility to collect and further process of the E-waste such as recycling and recovery activities (WEEE Directive, 2012b). However, only a third of E-waste was treated according to WEEE Directive after four years implementation, other two-thirds of the E-waste were still disposed to landfill. Thus, on December 2011, WEEE Directives was revised that the collection rate will be increased from 45% to 65% of the volume electrical and electronic equipment which put on the market effectively in the year 2019 (Herat and Agamuthu, 2012). There are 10 categories of the electrical and electronic equipment as summarise in table 2.3 (Poulios *et. al.*, 2006; WEEE Directive, 2012a).

Restriction of Hazardous Substances Directive is another legislation in the European Union, which restricted the use of hazardous substances in electrical and electronic equipment which named as RoHS Directive 2009/95/EC and came effectively in July 2006. This legislation is applicable to new manufactured electrical and electronic equipment which sell in the Europe market after July 2006. This directive aims to substitute the hazardous substances in the electrical and electronic equipment by less hazardous materials, that pose the risk to human health and the environment in or around the recycling plants. The hazardous substances that mentioned are cadmium, lead, mercury, Polybrominated Diphenyl Ethers (PBDE), hexavalent chromium,

Polybrominated Biphenyls (PBB) and (WEEE Directive, 2002).The maximum concentration of the 6 hazardous substances as stated in table 2.4.(RoHS Guide, 2016)

Table 2.4: Maximum Concentration for the 6 Hazardous Substances in RoHS Directive. Source: (RoHS Guide, 2016)

No	Hazardous Substances	Maximum Concentration (ppm)
1	lead	< 1000
2	mercury	< 100
3	cadmium	< 100
4	hexavalent chromium	< 1000
5	Polybrominated Biphenyls (PBB)	1000
6	Polybrominated Diphenyl Ethers (PBDE)	< 1000

2.2.2 Japan

There are two regulations in Japan to handle the E-waste which is Law for the Promotion of Effective Utilisation of Resources (LPUR) and Law for Recycling Specified Kinds of Home Appliances (LRHA). LPUR stresses on E-waste recycling that comprises small sized batteries and personal computers to reduce waste generation. Consumers have the financial responsibility to pay the recycling fee upon disposing of for item computers that bought before October 2003. However, consumers need not pay the extra recycling fee as the recycling fee is included in the product price after October 2003. The recycling rates are suggested for the CRT monitors is 55%, notebook computers is 20% and desktop computers is 50% (Chung and Murakami-Suzuki, 2008).

There is an amendment to LPUR in 1st July 2016 through introduced the Japanese version of the RoHS (also known as J-Moss or JIS C 0950). The amendment is required manufacturers and importers provide material information on the six EU RoHS substances and label it on their products. The six substances include cadmium, chromium VI, mercury, lead, polybrominated diphenyl ethers (PBDE) and polybrominated biphenyls (PBB). Since the Japan RoHS does not prohibit products containing restricted

substances, thus, domestic manufacturer, manufacturer and importers all are obligatory to accomplish the criteria of Design for Environment (DfE) (Herat and Agamuthu, 2012).

LRHA which stresses consumers and producers have the responsibility to recycle of used home appliances such as air-conditioners, washing machines, refrigerators and televisions. Consumers have the financial responsibility for paying the recycling and transportation cost when disposing of home appliances. Moreover, manufacturers have the physical responsibility to set up proper E-waste recycling facilities and achieve recycling rates such as washing machines and refrigerators, television and air conditioners are 50%, 55% and 60%, respectively (Chung and Murakami-Suzuki, 2008). The legal system in Japan to manage Household E-waste as stated in table 2.5

Table 2.5: Legal system in Japan to manage Household E-waste. (Source: (Yolin, 2015)

No	Regulations	Target items
1	Act on the Promotion of Effective Utilization of Resources	small sized batteries and personal computers
2	Home Appliance Recycling Act	Television, washing machines and clothes dryers, refrigerators and freezers, air conditioners
3	Small Home Appliances Recycling Act	Small electric or electronic appliances (eg: hair dryers, mobile phones)

2.2.3 Taiwan

The regulation in Taiwan to manage E-waste is Waste Disposal Act 1979 (amended in March 1997) under the Recycling Fund Management Committee (RFMC) system which launched in year 1998 as a bureau of the Environment Protection Administration (EPA). 4-in-1 Recycling Program is developed in order to fulfil the requirement of recycling and recovery resource for regulated recyclable waste (RRW). This program integrates 4 components such as manufacturers and importers, recyclers and waste collectors, waste generators and fund management board in order to success this program (Chung and Murakami-Suzuki, 2008).

There are different role of each stakeholder in 4-in-1 Recycling Program. For waste generators, they are required to segregate the waste of recyclable, non-recyclable and organic waste at the municipal collection points. For waste collectors and recyclers, they are required to buy the RRW from waste generators in order to proper recycler and recovery resources. For local governments, they are collect back the RRW from residents and sell to the recyclers. For managing the fee, Recycling Fund Management Board (RFMB) is developed in order to manage the recycling fee to subsidise the activities of recycling and collection of RRW (United States Environmental Protection Agency, 2012)

Tabel 2.6 show the regulated WEEE item under the 4-in-1 Recycling Program in Taiwan.

Table 2.6: Regulated WEEE item under the 4-in-1 Recycling Program in Taiwan. (Source:(United States Environmental Protection Agency, 2012).

No	Categories	Items	Year of Enforced
1	Waste IT Equipment	waste laptops	1998
		waste shells	1998
		waste motherboards	1998
		waste monitors	1998
		waste hard-disks	1998
		waste printers	2001
		waste power packs	1998
		waste keyboards	2007
2	Waste Electrical Appliances	waste televisions	1998
		waste washing machines	1998
		waste refrigerators	1998
		waste air-conditioners	1998
		waste fans	2007
3	Waste Light Bulbs/Tubes	waste Light Bulbs/Tubes	2002

2.2.4 Malaysia

In Malaysia, Bani *et.al* (2001) stated that scheduled wastes are regulated in Environmental Quality (Scheduled Wastes) Regulations 2005 (EQSWR 2005) under Environmental Quality Act 1974 categorised according to waste category (Kalana, 2010). Thus, E-waste is characterised as scheduled waste (SW 110) in First Schedule under the Environmental Quality (Schedule Wastes) Regulations 2005 and handled by Department of Environment (DOE). The SW 110 outlined the waste from electrical and electronic assemblies that contain components such as glass from cathode-ray tubes, mercury-switches, accumulators and other activated glass or polychlorinated biphenyl-capacitors or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyl. Thus, the E-waste must be collected by licensed transporter and treatment at the prescribed premises which licensed by DOE. (Alias *et. al.*, 2014; Department of Environment (DOE), 2016a).

In this section summaries, it was known that there are existing regulations by other countries to manage E-waste such as WEEE directive and RoHS in Europe Union, LPUR and LHRA in Japan, Waste Disposal Act in Taiwan and EQSWR 2005 in Malaysia. The common feature shared by these legislations is the emphasis of proper management and the limitation in using hazardous substances in the E-waste in order to protect the environment and human health.

2.3 Extended Producer Responsibility (EPR) Theoretical Framework

2.3.1 Definition

Extended Producer Responsibility (EPR) is defined as 'an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle including its final disposal' by Organization for Economic Co-operation and Development (OECD). This policy is to shift the recycling responsibility of physical or financial to upstream producers and also integrate to encourage environmental concern product design (OECD, 2001 cited in (Walls, 2006; Widmer *et. al.,* 2005). Therefore, incentives will be provided to the producers and consumers in this system in order to promote appropriate waste management and shape the behaviours to have environment awareness (Nahman, 2010).

2.3.2 Types of Extended Producer Responsibility (EPR) Responsibility

EPR is the view of shifts and shares the responsibility between waste generators which include producers and consumers to ensure the whole life cycle of the product is being proper managed. The purpose of the EPR to ensure the sustainable development of the entire life cycle of the product, from the development stage until disposing and recovery stage (Milojković and Litovski, 2005). The physical responsibility, economic responsibility, liability responsibility, ownership responsibility and informative responsibility are the five main components of EPR models that developed by Lindhqvist (2000) and as depicted in figure 2.2 (Lindhqvist, 2000; Milojković and Litovski, 2005).

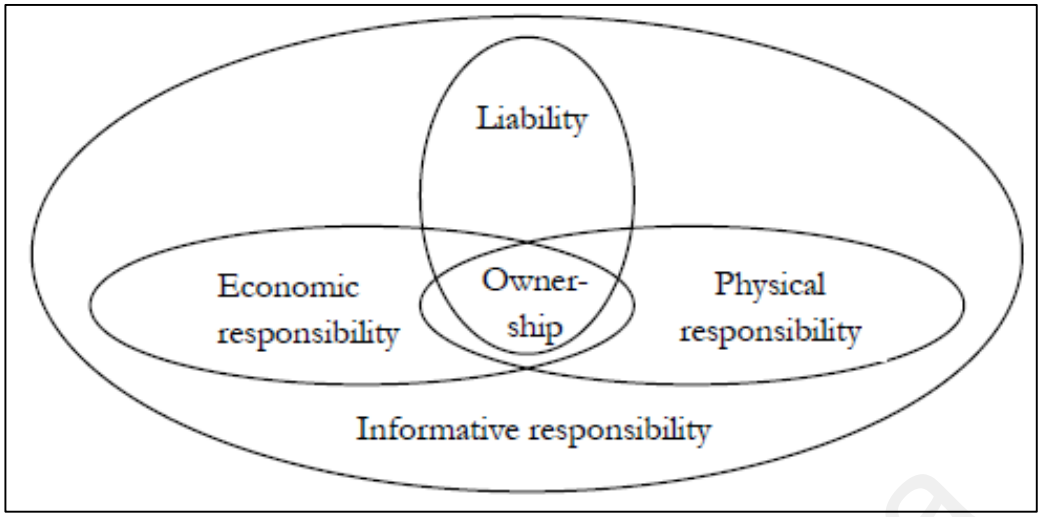


Figure 2.2: Extended Producer Responsibility Model. Source: (Lindhqvist, 2000)

There are five types of the responsibility incorporated in the EPR models which developed by Lindhqvist (2000) which are physical responsibility, economic responsibility, liability responsibility, ownership responsibility and informative responsibility.

For physical responsibility, the producer has the physical responsibility to collect back during the end of life for the product from the consumer via "take-back" system.

For economic responsibility, the producer is accountable to bear the handling cost after the end of their manufactured product life, where the cost incurred including collection expenses and recycling expenses.

For liability responsibility, the producer is liable to minimise the pollution to the environment from their manufactured product and ensure their products are not harmful to the environment, during both consumption stage by the consumer and the final disposal stage, through compliance the legislation.

For ownership responsibility, the producer is to carry out both economic responsibility and physical responsibility. In addition to that, the producer is also responsible towards the environment issues which arise from their manufactured products.

For informative responsibility, the producer has the responsibility to share the information of their manufactured product such as the type of the component or material which will bring environmental impact in the product life cycle from cradle to grave. This information also useful for the recyclers, when handling and recovery the resource from the product.

2.3.3 Extended Producer Responsibility (EPR) Policy Instruments

Some of the policy instruments are used in order to succeed the implementation of EPR. The mandatory of taking back from administrative instruments and economic instruments are widely used and practice in Organization for Economic Co-operation and Development (OECD) countries. There are three types of policy instrument such as administrative instruments, economic instruments and informative instruments as shown in figure 2.3 (Gupt and Sahay, 2015; Nnorom and Osibanjo, 2008; Walls, 2006).

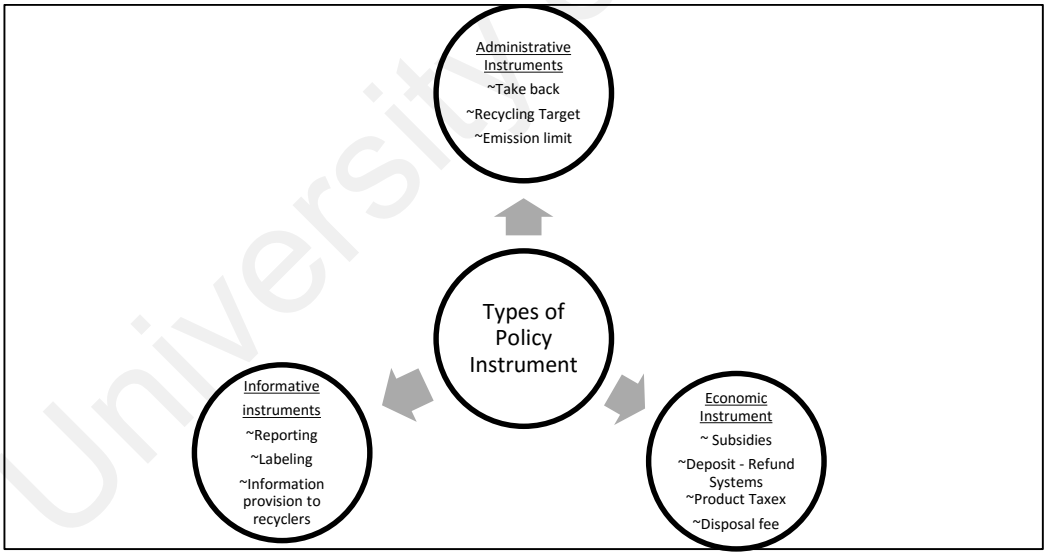


Figure 2.3: Types of Policy Instrument Used for Implementation of EPR. Adopted from Source:(Gupt and Sahay, 2015; Nnorom and Osibanjo, 2008; Walls, 2006)**.**

In the administrative instruments, one of the examples is *'Product take-back mandate and recycling rate targets*', which the producers or retailers are compulsory to collect back the end of life products and is required to fulfil recycling targets. Thus, the

producers will cooperate in order to fulfil the EPR responsibility by establishing a 'producer responsibility organisation, PRO' and work together to collect back and recycle the end of life products. The second example is '*Voluntary product take-back mandate and recycling rate targets*' which the producers will not have penalties without fulfilling the target and this is not compulsory to collect back the end of life products, only on voluntary basis. The third example is '*Mandatory take-back and targets with a tradable recycling scheme*' of which the producers or retailers are compulsory to collect back the end of life products and need to fulfil recycling targets by permitting the trade of end of life products among producers (Widmer *et. al.*, 2005).

In the economic instruments, one of example is '*Advanced recycling fee (ARF)*', recycling expenses for the end of life products are embedded in the products price. The fee is according to one unit of the item.

The second example is '*Recycling fee combined with recycling subsidy*', which the recycling fee that collected from the consumers, by embedded in the products price are used to subsidise the recyclers in the recycling process.

The third example is '*Deposit refund system (DRS)*' of which the deposit is payable by the consumer during their purchases of a product, which will then be returned if the product is brought back for recycling instead of disposal in a landfill.

The summary of literature review for the EPR theoretical framework is EPR is sharing the responsibility among waste generators in order to ensure the life cycle of the product to the environment. The EPR models comprise physical, economic, ownership, liability and informative responsibility. There are three types of the policy instruments that widely use in implementing EPR which are administrative, economic and informative instruments.

2.4 Overall E-waste Management System

Overall E-waste management system consists of collection, processing and financing system (Fredholm, 2008). There are some factors will affect the efficiency of the collection and transport E-waste in this system. The effective system will avoid and reduce the inadequate handling such as break the E-waste which consist of hazardous material and release it's to the environment which will increase the exposure risk to human. The factors to warrant the efficiency are accessible of collection points, minimise handle the E-waste manually, avoid to remove hazardous materials purposely, trustworthy information such as the handling methods and the composition of the E-waste hazardous material (United Nations Environmental Programme, 2007).

There are few collection networks of the E-waste widely been used such as municipal, retailer and producer take-back (United Nations Environmental Programme, 2007). For example, producers take the initiative and cooperative with municipalities to organise take back E-waste in order to encourage the consumer to bring the E-waste to the collection point instead of disposing of it in a landfill. For retailer take back, retailers are obligated to take back the old E-waste during delivering a new electronic equipment which purchased by consumers. Thus, the old E-waste is able returned to the retailer from consumers when they are buying a similar replacement product. The consumer also can post back the small E-appliance to manufacturers via national postal service which is practising in Japan such as mobile phones and laptop computers. For municipal collection sites, the municipalities take the responsibility to manage the collection site and collect back the E-waste from households where the location is strategic and can be accessed by the public (Van Rossem, 2008).

In Europe, 5 general categories are classified according to the similar characteristic in the E-waste collection points such as refrigeration equipment, large household appliances, small domestic appliances, equipment containing CRT and

lighting which contain mercury (Van Rossem, 2008). E-waste will be sorted and stored in collection centre until adequate quantities before transport to recycling facilities. However, the E-waste categories are minimising due to the consideration of the storage capacity at the collection points is one the factor to affect the efficiency.

2.4.1 Mechanical Recycling of E-waste

There is a risk in disposing of E-waste by the method of incineration and landfilling whereby the E-waste's hazardous material has probabilities to release into the environment. Thus, E-waste needs to be recycled by the process of disassembly, mechanical recycling process and recovery are important in order to reduce the hazardous material content before sent to dispose of in a landfill (United Nations Environmental Programme, 2007). Three core steps are categorised in E-waste recycling which is dismantling for separating out the hazardous material in the E-waste , upgrading through the physical or mechanical process for preparing materials to refine stage and refining is the materials from E-waste are recovered and returning to its life cycle (Cui and Forssberg, 2003).

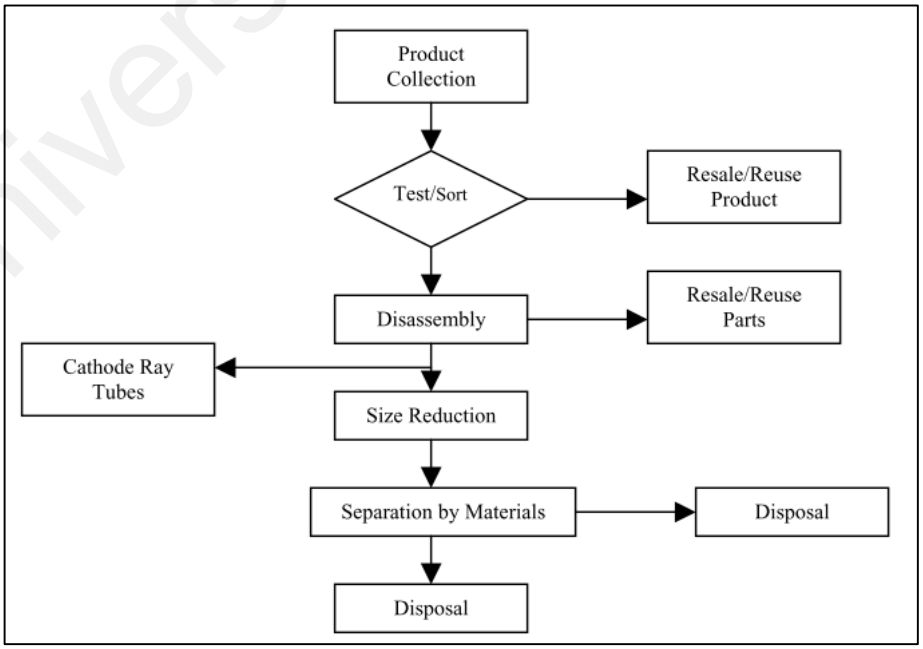


Figure 2.4: Flow diagram for the E-waste recycling.
Source:(Kang and Schoenung, 2005).

There is three core phase general flow for the E-waste recycling which is shown in figure 2.4. The collected E-waste will be tested in order to separate non-reusable and reusable E-waste. Then, the fractions of the non-reusable E-waste after the dismantling process are grouped into non-reusable and reusable parts. Non-reusable E-waste parts will continue the step of reducing the size, separation by materials and eventually the residual from this step will be disposed of (Kang and Schoenung, 2005).

2.4.1.1 Disassembly (Dismantling)

There are two categories of dismantling process which is partial or complete disassembly. Partial dismantling is a product is detached into subassembly part while complete disassembly is a product is separated into all of its parts for dedicated functions.

Initially, all liquids and gases are removed in the dry process under the conditions of negative pressure and without using water, follow by disassembling and the final is to complete separation. Next, non-hazardous E-waste which is segregated out will proceed with physical or mechanical process whereas the segregated hazardous E-waste which is segregated out will proceed for recovery(United Nations Environmental Programme, 2007). Numerous of the recycle facilities used manual disassembling. Figure 2.5 shows the usual dismantling process in electronics recycling plant that runs by Ragn-Sells Elektronikåtervinning AB in Sweden (Cui and Forssberg, 2003).

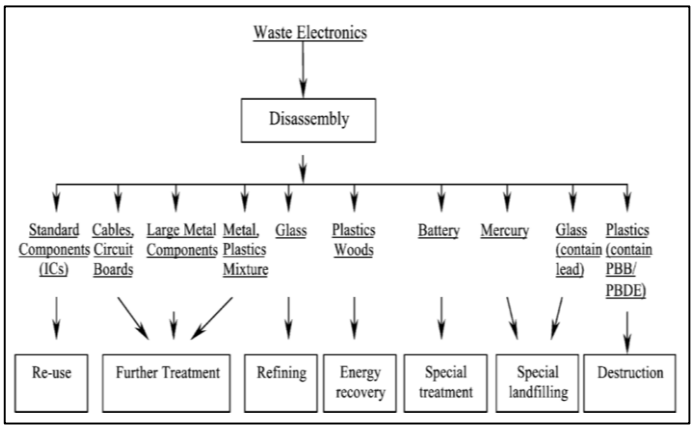


Figure 2.5: Recycling process developed by Ragn-Sells Elektronikåtervinning AB Source: (Cui and Forssberg, 2003).

2.4.1.2 Mechanical / Physical Recycling Process

Screening, shape separation, magnetic separation, electric conductivity-based separation and density based separation are the mechanical recycling process involved in recycling E-waste. Flow diagram for physical or mechanical recycling process E-waste treatment showed in figure 2.6 (Kang and Schoenung, 2005).

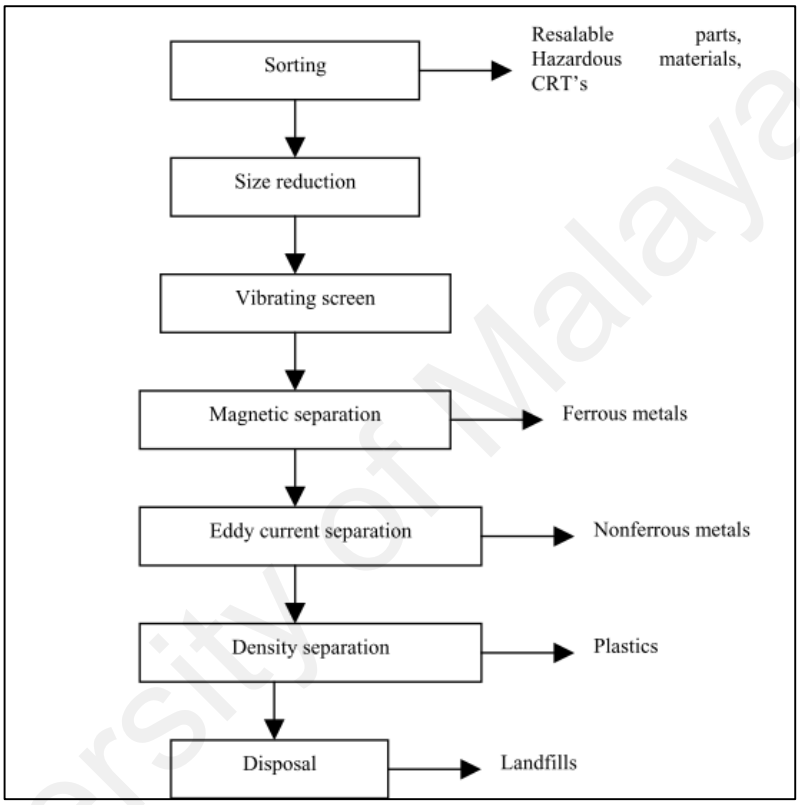


Figure 2.6 Flow diagram for mechanical/physical recycling process E-waste treatment. Source: (Kang and Schoenung, 2005).

Different compositions of E-waste ranged from plastics and ceramics is needed to undergo screening because each of them has different properties in terms of particle size and shape properties of metals. The rotating screen is generally used in solid waste processing for metals recovery. The important characteristic in rotating screen is having high resistance to blinding in order to manage the different sizes and particle shapes in waste. Vibratory screening is also regularly practised in non-ferrous recovery sites, nevertheless having the disadvantage of wire binding difficulty (Cui and Forssberg, 2003).

Low-intensity drum separators are used in magnetic separators in order to the recovery of ferromagnetic metals from other non-magnetic wastes and non-ferrous metals. Gravity concentration is practised in density based separation. The purpose is to separate resources with dissimilar specific gravity by their relative movement in gravity strength and other force. Furthermore, in electric conductivity-based separation, there are three methods which are Eddy current separation for non-ferrous metal, corona electrostatic separation for metal or non-metal separation, and triboelectric separation for separate non-conductor material such as plastics (Cui and Forssberg, 2003).

2.4.1.3 Recovery Process

The recovery process is to recover the metals in E-waste. There is few recovery process in E-waste such as precious metals, copper and lead recovery.

For precious metal recovery, anode slime is recovered by a copper electrolytic process which using pressure to leach anode slime. Then, fluxes are added in precious metals furnace in order to smelt the dried leached residue. The smelting process will recover the selenium. The high-purity silver cathode and anode gold slime will get through electrolysis process from the remaining substantial from the smelter. The anode gold slime is additional leached to recover palladium, high purity gold and platinum sludge (Kang and Schoenung, 2005).

For lead recovery process, 99.9% of lead bullion and slag contains 60-70% wt. % lead and the pure lead product will be produced during lead-containing materials and reductants pass through the reverberatory furnace. Lead from the slag will be recovered in a blast furnace by using limestone and iron (Kang and Schoenung, 2005).

For copper recovery process, “black copper” consist of 70-85 wt. % copper, Zinc(Zn), Lead (Pb) and Tin (Sn) are produced from E-waste fraction containing Cu in a blast furnace by scrap iron and plastics. After that, the black copper is going through the

converter and will be oxidised by air to produce blister copper consist of 95 wt. % purity (Kang and Schoenung, 2005).

2.4.2 Financing Mechanism in E-waste

Manufacturers, society and consumers are the important stakeholders to share the financial responsibility in E-waste management such as the collection cost and recycling cost. For the manufacturers, they are application the principle of "Extended Producer Responsibility" in the financial responsibility. The financial impact is either fully accepted by the manufacturers through reduce the sale margin or increase the sales price whereby the consumers will affect indirectly. Furthermore, the manufacturers also need to achieve recycling target in order to fulfil the obligation of taking back their end of life product in the market. For the society, the E-waste management system may be supported through taxes if the system's regulator by the government. For the consumers, also play the important role by sharing the responsibility to pay the fee for proper manage the E-waste align with the principle of "polluter pays principle". Thus, consumers will pay the fee upon purchase where the fee will be embedded in the product price (United Nations Environmental Programme, 2012).

There are five financing models which are the compliance cost model, the compliance cost visible fee model, the reimbursed compliance cost model, the recycling fee model and the end-of-life model. In the *compliance cost model*, manufacturers direct involve as stakeholders in the financial model. They will pay the fee by taking part in compliance scheme, financing their own collect-back system and take part in overwhelmed orphan and historical waste(United Nations Environmental Programme, 2012).

The compliance cost and visible fee model are including producers and consumers involve as stakeholders in the financing of the system. They will pay the fee by taking part in compliance scheme, financing their own take-back system and joining to

overwhelmed orphan and historical waste. The revenues from consumers as paying the visible fee to cover management cost of historical and orphan waste (United Nations Environmental Programme, 2012).

The *reimbursed compliance cost model* is including producers and consumers involve as stakeholders in the financing of the system. They will pay the fee by taking part in compliance scheme, financing their own take-back system and joining to overwhelmed orphan and historical waste. The revenues from consumers as paying the visible fee to cover management cost of historical and orphan waste. Consumers will pay the visible fee upon purchase new product and the cost will be reimbursed by the producers who pay for compliance schemes such as to achieve the recycling target (United Nations Environmental Programme, 2012).

The *recycling fee model* does not include manufacturers in the financing E-waste management. Thus, consumers accept the whole of E-waste management cost by paying the fee during purchasing new products (United Nations Environmental Programme, 2012). The *end-of-life (EoL) fee model* is the last owner who decides to recycle the EoL product have the responsibility to involve end-of-life fee payment.

In summary, the overall E-waste management system consists of collection, processing and financing system. For collection system including how to collect E-waste from end, the position and number of collection points, the operation costs from collection points and transportation cost of the E-waste from collection points to the recycling plant. For processing system, it is to studies the quantity materials that can be recovered in the recycling process which including the operational costs. For management and financing system, it includes the whole E-waste operational costs such as logistic cost, collection cost and recycling cost. There are 5 models to manage this cost which including compliance cost model, the compliance cost visible fee model, the reimbursed compliance cost model, the recycling fee model and the end-of-life model.

2.5 E-waste Extended Producer Responsibility (EPR) in Other Countries

2.5.1 E-waste Extended Producer Responsibility (EPR) Practice in Germany

E-waste management flow in Germany as shows in figure 2.7. Municipalities in Germany have the both physical and financial responsibility of collection Household E-waste by setting up the collection points. However, the containers for segregating the E-waste must be provided by the manufacturer. After that, municipalities need to pass back the collected E-waste to manufacturers with free of charge (Cahill *et. al.*, 2011).

For the manufacturers, they can collect back E-waste by three methods which are set up individual brand-selective take back schemes (IBTS), individual non-selective take back schemes (INTS) or take part in collective take back scheme (CTS). In IBTS, manufacturers have the responsibility to collect own brand of the E-waste only but have to coordinate with the municipalities and retailer to separate the brand of the E-waste. In INTS, manufacturers not only collect back their own brand but also under other brands within each collection group based on market share. In CTS, manufacturers only collect back own members of the E-waste only. In INTS and IBTS, manufacturers will contract out the work such as logistic, recycling, recovery and disposal to the EoL Service Provider (ESP) while CTS will perform this task if the manufacturers take part in CTS (Deubzer, 2011).

The role for the Clearing House, Elektro-Altgeräteregister" (EAR), which is set up by the producers with the purpose to coordinate between the municipalities and the manufacturers such as register the manufacturers and their electrical and electronic equipment sales, date reporting to EU and coordinate pick up containers from municipalities to them for treatment (Kristensen *et. al.*, 2012).

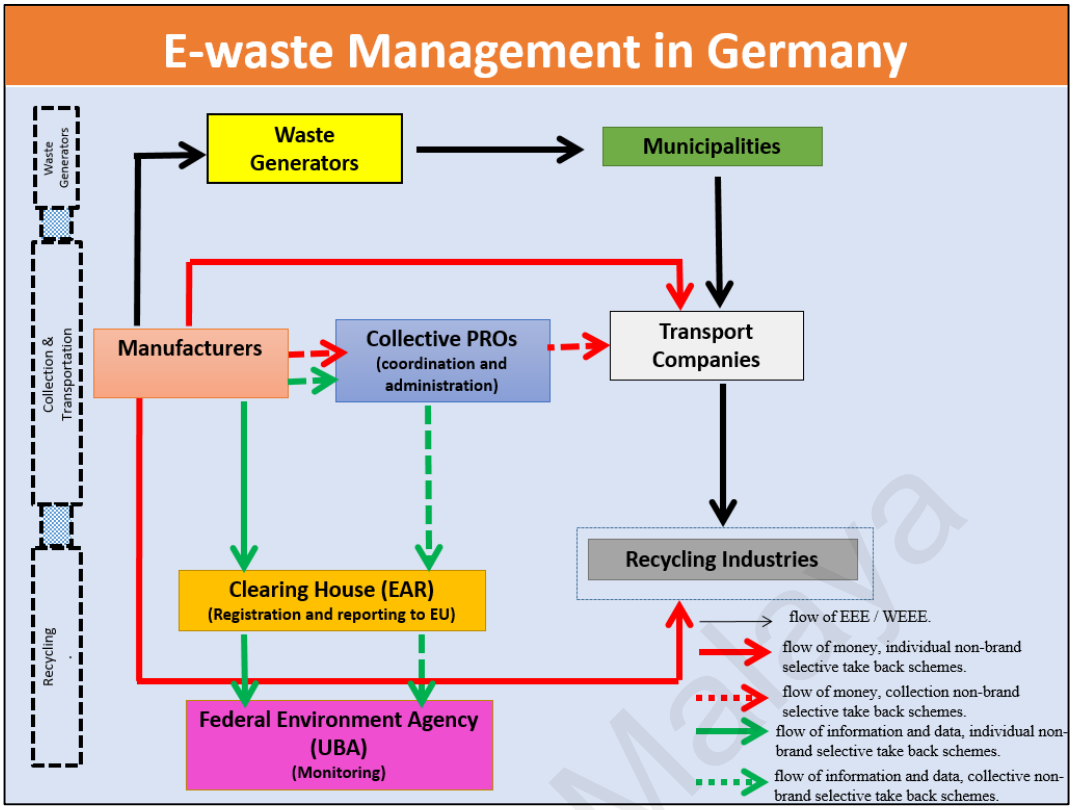


Figure 2.7: E-waste management in Germany.
Adopted from Source:(Kristensen *et. al.*, 2012).

2.5.2 E-waste Extended Producer Responsibility (EPR) Practice in Japan

E-waste management system in Japan as shown in figure 2.8. For the E-waste flow, retailers will collect back the E-waste from consumers and channel it to the designated collection site and eventually the E-waste will be sent to the recycling industries. The manufacturers will contract for acceptance of used home appliances to the designated collection sites, contract of management to the management company and contract of recycling operations to the recycling facilities. For the fee flow, consumers will pay the recycling fee to the retailer during disposal and retailer will channel it to RKC (Home Appliances manifest data management centre) under AEHA (Association of Electronics Home Appliances). The manufacturers and recycler will get the subsidies if fulfil the requirements.

For the information flow which is a manifest system in Japan, the retailers will issue one copy of the ticket which was filled into the waste generators and then the

retailers transport the waste and the remaining of the ticket to the designated collection site. After that, the designated collection site will distribute one copy to the retailers and another copy to the RKC.

In summary, the E-waste management in Japan is three of the stakeholders are sharing responsibility and the role are stated in the regulation. The producers have the physical responsibility to collect E-waste and achieve the recycling rate. For retailers, they have the responsibility to collect E-waste from the consumer when they purchasing new electrical and electronic equipment. For consumers, they have the financial responsibility to pay the collection and recycling fee. The system is monitored by RKC under AEHA.

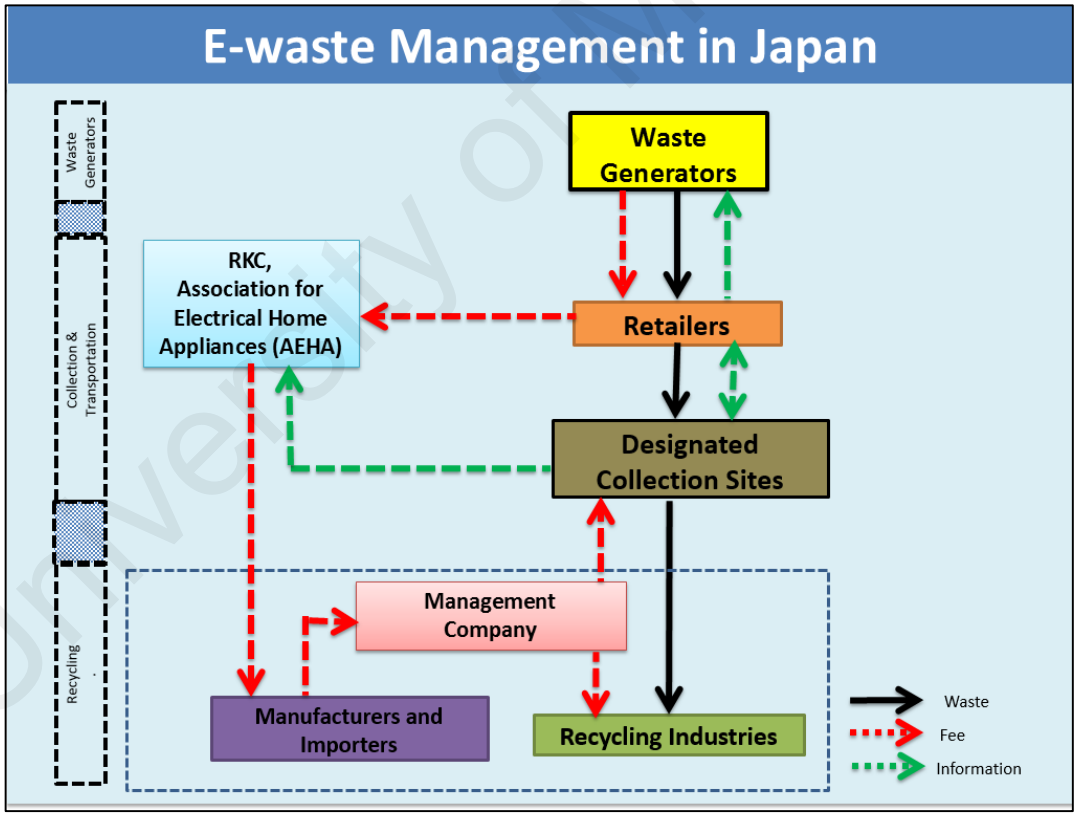


Figure 2.8: E-waste management in Japan.
Adopted from Source:(Hotta *et. al.*, 2014)).

2.5.3 E-waste Extended Producer Responsibility (EPR) Practice in Taiwan

The regulation in Taiwan to manage E-waste is Waste Disposal Act under the Recycling Fund Management Committee (RFMC) system which launched in year 1998 as a bureau of the Environment Protection Administration (EPA). E-waste management flow in Taiwan as shows in figure 2.9. In RFMC system, producers and importers have the financial responsibility to pay for the recycling and collection cost of E-waste by the total cost are multiple with the previous year amount sales.

Fee Rate Reviewing Committee (FRRC) is developed to review collection and recycling fee according to the market price for recyclable materials and other influences. The member of this committee from representatives of producers, consumer communities, academia, authorities and other stakeholders. FRRC will distribute the collected fund as subsidies to the organisations that fulfil the requirement of proper collect and recycle E-waste.

In Taiwan, recyclers will buy E-waste from the collection and recycle them. After recycling, RFMC will pay the subsidies according to the unit counts that fulfil requirements. In addition, recycler only qualified to entitlement the incentive after an audit by the third party. Somehow this system is not compulsory for the recyclers to participate. If the recyclers do not join in the system, they are not allowed to claim subsidies but will not get penalised(Chung and Murakami-Suzuki, 2008). Thus, under the RFMC system, only manufacturers have the financial responsibility pay fee to the RFMC in E-waste management. Collectors, retailers, community residential and recycling facilities will get the subsidies through the RFMC system if fulfil the requirements of proper manage E-waste.

In summary, there is three core part in Taiwan E-waste management system. First, the producers have the financial responsibility under RFMC system. Second is the producers will pay the recycling fee as subsidies to promote recycler to participate in this

system. Lastly, this system will be monitored and audited by the third party. However, there is a limitation in this system as producers no involve in the physical responsibilities such as set the recycling target or compulsory take-back system because of most of the producers in Taiwan due to only includes of small and medium-sized manufacturers. In addition, another limitation of this system is the recyclers are not obligatory to contribute in RFMC system (Chung and Murakami-Suzuki, 2008).

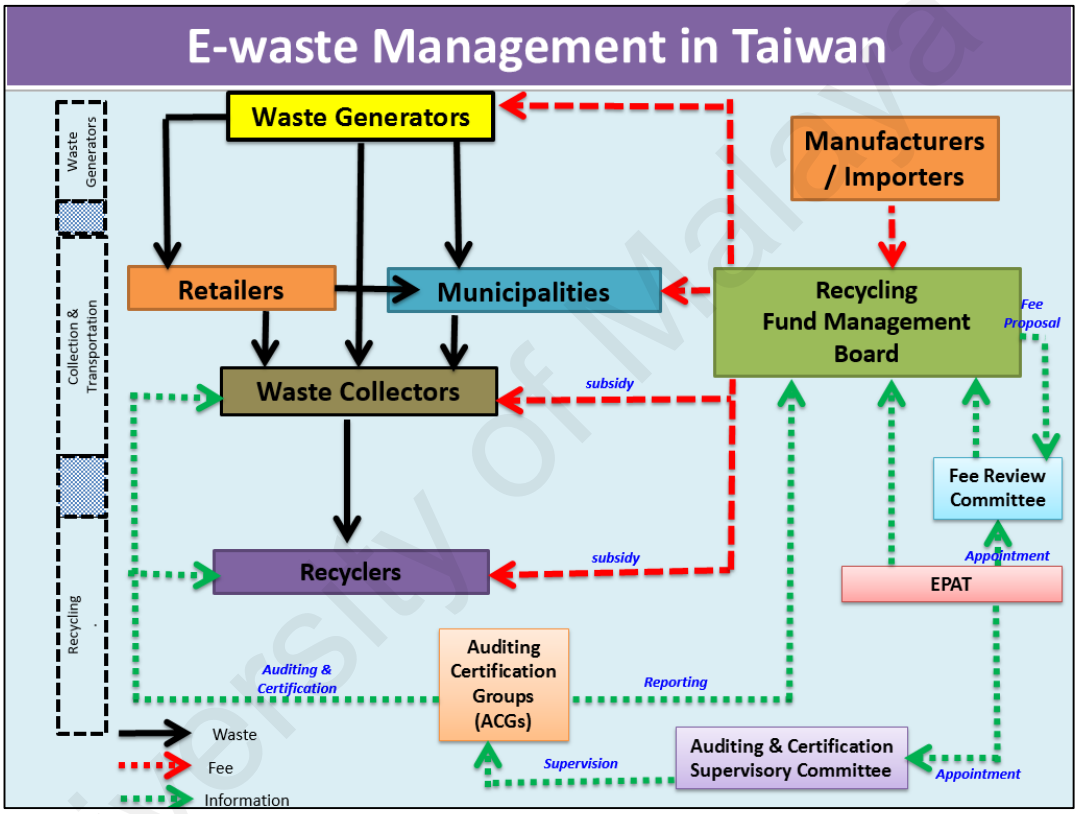


Figure 2.9: E-waste Management in Taiwan.
Adopted from Source:(United States Environmental Protection Agency, 2012)

2.5.4 E-waste Flow in Malaysia

In Malaysia, there were 107 licensed contractors who are liable to collect and handle Industrial E-waste which is not a complete set of E-waste from households or institutional. The non-licensed private contractors will collect the Household E-waste rather than solid waste concessionaires. The components that take apart such as metal, wires and plastics produced from electrical and electronic manufacturers will be collected by the licensed contractor's collector and send to recovery facilities. The components producers will collect the processed components raw materials purpose and the residues will send to scheduled waste facilities. Nevertheless, the high value of plastic and metal in E-waste will be collected by non-licensed contractors and sell to scrap recyclers (Afroz *et. al.*, 2013). The Household E-waste flows from the generator to disposal in Malaysia is shown in figure 2.10. It shows a major disconnect of the Household E-waste collected by DOE licensed E-waste collectors and recovery facilities. The final destination of the Household E-waste which collected by non-licensed contractors is undefined. Though, there is a few used computers from household are collected back by producers because of their voluntary policy practised and channelled it to the solid waste concessionaires and go to the licensed recovery facilities (The E-waste Inventory Project in Malaysia Report, 2009).

In summary, the current E-waste flow is some of it will be sent to license recovery facilities if collected by licensed collector but the final destination of the Household E-waste which collected by non-licensed contractors are undefined. Thus, a proper Household E-waste Management system need to be developed as the hazardous material in the E-waste will pose risk to human health and the environment.

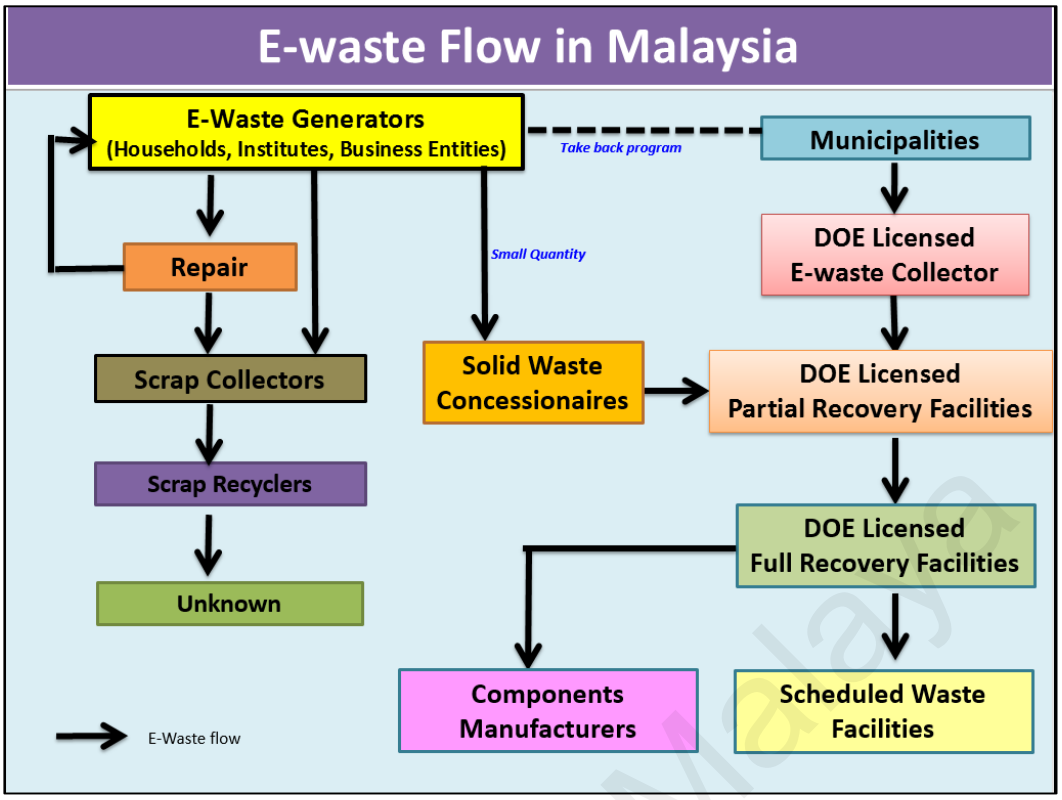


Figure 2.10: E-waste flow in Malaysia.

Adopted from Source: (The E-waste Inventory Project in Malaysia Report, 2009).

2.6 Literature Review Summary

The quantity of E-waste generation is getting an increase in globally as well as in Malaysia. There are 10 categories of the E-waste categories as stated in WEEE Directive in European which is Large Household Appliances, Small Household Appliances, IT and Telecommunications Equipment, Consumer Equipment and Photovoltaic Panels, Lighting Equipment, Electrical and Electronic Tools, Toys, Leisure And Sports Equipment, Medical Devices and automatic dispensers. In Malaysia, E-waste is characterised as scheduled waste (SW 110). According to the E-waste Inventory Project in Malaysia in the year 2009, it shows that significant disconnect between the E-waste generation from household or institutes and the DOE licensed E-waste collectors and processors. The E-waste that collected by non-licensed contractors will be directed to scrap recyclers due to the high price of metals and plastics to recycle in E-waste.

There are existing regulations by other countries to manage E-waste such as WEEE directive and RoHS in Europe Union, LPUR and LHRA in Japan, Waste Disposal

Act in Taiwan and EQSWR 2005 in Malaysia. The common feature shared by these legislations is the emphasis of proper management and the limitation in using hazardous substances in the E-waste in order to protect the environment and human health.

There are three smaller systems contained in the E-waste management system which a collection system, processing system and financing system. A collection system comprising the collect of E-waste from household, the location and number of collection centre, the collection sites operation costs and the E-waste transportation cost to the recycling plant. For processing system, E-waste recycling can be classified into three main stages which are disassembly, upgrading and refining. For financing models, these include the compliance cost model, the compliance cost visible fee model, the reimbursed compliance cost model, the recycling fee model and the end-of-life model.

EPR is a perception which shifts the balance of responsibility among the waste generators (producer and consumers) in order to assure the E-waste is properly managed throughout the entire of the product life cycle. The EPR model comprises of liability, economic, physical, ownership and informative responsibility. There are few policy instruments used for the implementation of EPR such as administrative, economic and informative instruments. Germany, Japan and Taiwan developed their E-waste recycling systems based on the EPR model where the physical responsibility, economic responsibility, and informative responsibilities are shared among the stakeholder such as manufacturers, retailers, recyclers, consumers and government.

The research gap that found out in this literature review is the lack of the quantity of Household E-waste in Malaysia, lack of category of the Household E-waste in Malaysia, and lack of occupational health data on exposure and health impacts in workers involved in reclaiming metals from E-waste in smelters and refineries in Malaysia. Thus, further research in this fields is recommended.

CHAPTER 3:

METHODOLOGIES

The methodologies adopted in order to complete this project are combination of literature review, non-participant observation method (attending a seminar), comparative analysis, flow diagram and SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis which were carried out in order to achieve the aim and objective in this research as shown in Figure 3.1.

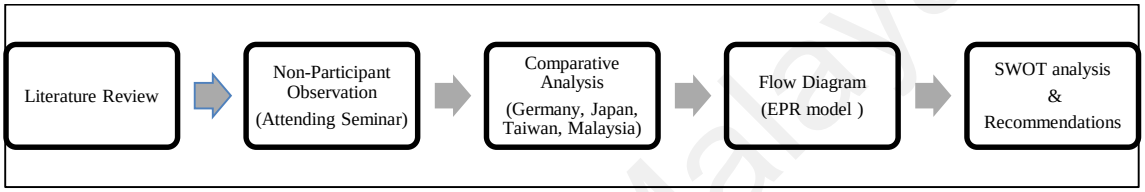


Figure 3.1: Flow of the methodologies.

3.1 Literature Review

Literature review has been carried out via published journal, published article, and website. Sources to locate the journals, papers and article include ScienceDirect database, Springer database and Waste Management & Research Database, which are retrievable from University of Malaya database. Other sources of information are from internet search engines such as Google and Google Scholar.

The method of the literature review was used primarily to collect secondary data, to achieve the objective, The literature review will focus on the topics related to quantity, category and impacts of the E-waste, current Household E-waste flow in Malaysia, existing and future plan to manage the Household E-waste in Malaysia, existing E-waste management standard, EPR model theory and the EPR model to manage Household E-waste in the country of Germany, Japan and Taiwan.

Three countries were chosen for this studies, which are Germany, Japan and Taiwan. The European Union is one of the few regions in the world where there is uniform legislation regarding the collection and processing of E-waste. This is formulated in the WEEE Directive. Germany, in particular, EPR as a waste management measure was first introduced in Germany in 1991 in Plastic packaging (Cahill *et. al.*, 2011). The regulations of ElektroG is the transposition of both the European (WEEE Directive 2003) and of the European (RoHS Directive 2003) into German national legislation. For Asian countries such as Japan and Taiwan, the rationales in arriving at these two countries are attributed to the present regulations in respective countries in managing E-waste since 10 years ago and considered to be the pioneer amongst the Asian country which deemed to be an appropriate model for the developing Asian country, which has their E-waste management system still at a relatively infant stage. Furthermore, Japan has different regulations for different products, some with compulsory recycling targets, with other products falling under voluntary initiatives that are worth for learning and benchmarking. In addition, Taiwan is a developing country where the manufacturing industry made up from small and medium–sized manufacturers same as Malaysia, thus, their EPR implementation mechanism could be suitable and can be adopt to Malaysia culture.

The relevant website was researched to retrieve various information in achieving the objective of this project. The source of information were retrieved from Google scholar, DOE website, International E-waste Management Network (IEMN) website and WEEE official website.

3.2 Non-Participant Observation (Attending Seminar)

Non-participant observation is to observe what is happening and recorded the information on the spots which involve no interaction between the observers and participants such as attending meeting or seminar.

A valid seminar that attended was held in Dewan Baiduri, DOE Putrajaya on 2nd November 2015. This seminar was organised by the headquarter of Department of Environment (DOE) with the purpose to raise public awareness particularly on the responsibility and the importance of proper Household E-waste management. The title of the seminar, namely "Existing and future direction to manage the Household E-waste" was presented by DOE director from Hazardous Substances Division, of which the presented content focus on proposed EPR model. The target information to obtain is the existing and future plan to manage the Household E-waste in Malaysia.

3.3 Comparative Analysis

The comparison method is the basic tool of analysis. Comparative research has historically played a significant role in their development as scientific disciplines. This improves the description and concept formation role by bringing into focus suggestive similarities and contrast among the cases that choose. Many comparative methodology texts achieve at least a brief discussion of the issue.

In this report, the goals of case-oriented comparison will be used as this method is historically interpretive and causally analytic. The criteria selected for comparison are the fundamental EPR model including physical responsibility, economic responsibility and informative responsibility amongst the producers, retailers, consumers and government in the Household E-waste Management System.

The information is collected and analysed according to suggestive similarities and contrast among the cases, of which the component of the producer responsibility

(Physical, Financial, Recycling Target) and local authorities responsibility (government, retailer, consumer) are illustrated in table 3.1 as below:-

Table 3.1. Template for comparison of different form of EPR Implementation in Germany, Japan, Taiwan and Malaysia.

Selection Criteria		**Countries**			
		Germany	Japan	Taiwan	Malaysia
Regulation					
Producer Responsibilities	Physical				
	Financial				
	Recycling/ Recovery Target / DfE				
Role of stakeholder	Local Government				
	Retailer				
	Recyclers				
	Consumers				
Monitoring					

3.4 Flow Diagram

Data flow diagramming (DFDs) is a representation of the flow of information within a system. DFDs are used in to support and provide a better understanding of the current system as well as to represent a required system. The DFDs consist of four basic components that will show the way of data flows in a system. which cover external entities sending and receiving information (entities), the processes that change information (processes), the flow of information (data flows), and where information is stored (data store).

The flow diagram was used to represent the EPR model for managing Household E-waste in Malaysia. The boundary for this model including various entities such as manufacturer, retailer, waste generators, waste collector, recyclers, Fund Management Board, Audit Company and DOE. The components that to be presented in the flow

diagram are electrical and electronic waste flow, collection flow, fee flow and reporting flow within the abovementioned entities which act for sending and receiving information. The method of flow diagram was applied to illustrate the summary a sustainable EPR model for managing Household E-waste in Malaysia. The components ranged from manufacturer, retailer, waste generators, waste collector, recyclers, Fund Management Board to Audit Company and government will be represented in a rectangle box and connected with the flow of electrical and electronic waste flow, collection flow, fee flow and reporting flow with the direction represented by an arrowhead that shows at the end of the flow connector with four different color.

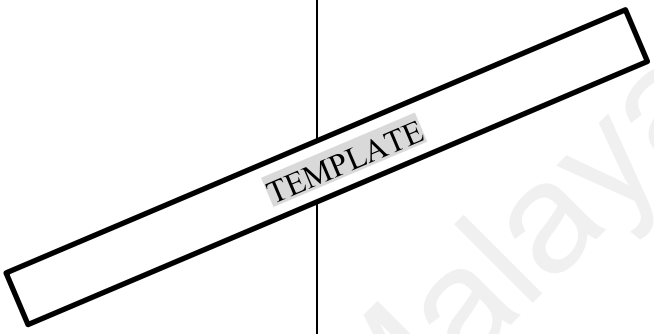
3.5 SWOT Analysis

SWOT analysis is one of the analytical tools to identify strengths, weaknesses, opportunities, and threats of a system. SWOT analysis is to examine the system's internal strengths and weaknesses, its opportunities for improvement and growth and the threats the external environment presents to its survival. This analysis will provide the balance points by evaluating the new system and maximising the system performance.

The integrated mechanism implementation of sustainable EPR model for managing Household E-waste in Malaysia will be arranged into four categories which are strengths, weaknesses, opportunities, and threats. Strengths as current factors that have prompted outstanding and benefit to the Household E-waste Management in Malaysia. Weakness as internal factors that will increase operation costs or the inefficiencies that reduce the EPR model implementation's quality. From the external perspectives, opportunities will be the significant new improvements available towards this EPR model, whilst threats are the factors that could negatively affect this EPR model for managing Household E-waste Management's system performance. Hence, an overall recommendation will be discussed according to the SWOT analysis based on the

sustainable EPR model for managing Household E-waste in Malaysia. Table 3.2 show the template for the SWOT matrix.

Table 3.2: Template for the SWOT matrix.

	POSITIVE	**NEGATIVE**
INTERNAL	STRENGTHS	WEAKNESSES
		
	OPPORTUNITIES	THREATS
EXTERNAL		

CHAPTER 4:

RESULTS AND DISCUSSIONS

4.1 Current Status of Household E-waste Management in Malaysia

Department of Environment (DOE) finalised the legal framework regarding the management of the Household E-waste on 17th November 2014 with the assisting from the Japan International Cooperation Agency (JICA). The framework for the proper manage of the Household E-waste mainly includes 3 areas which are E-waste Flow, Fee Flow and Reporting Flow as shown in figure 4.1, figure 4.2 and figure 4.3.

DOE get the technical cooperation with the Japan International Cooperation Agency (JICA) where this project is planned and conducted in accordance with the agreement between the Government of Malaysia and Japan in March 2015 after a series of discussions between JICA and relevant government stakeholders of Malaysia, represented by the Department of Environment, the Ministry of Natural Resources and Environment. DOE is currently in the process of drafting the new E-waste management regulation under the principle of "Shared Responsibilities" that incorporates the concept of "Extended Producers' Responsibility (EPR)" into the regulation with the responsibilities of other stakeholders. To identify the scope of technical cooperation that best meets the needs of Malaysia in line with the current trend of legal/regulatory/policy framework development over the Household E-waste management, JICA sent another survey mission to discuss and determine the details of the next technical cooperation project. The survey found that DOE needed transfer of experience and know-how on Household E-waste management including the basic legal/regulatory framework, time frame and schedule of works, analytical methodology and works for estimating the overall cost of collection and recycling, recycling fee charging and collection system, management of the fund raised from the collected recycling fees, and so forth.

In the E-waste Flow as shown in figure 4.1, the E-waste generators who from individual or households, from commercial or institution, or from other E-waste generators such as repair shops do have the responsibility to dispose their E-waste to the authorized collection centers or E-waste collectors such as concessionaire companies, local government recycling centers, Charity Organization, community and initiatives take back from producers. In addition, E-waste generators do dispose their E-waste to the authorised retailers such as individual shops or hypermarket. The retailer must collect the E-waste if requested by the Household E-waste generators. Then, all E-waste collectors required to transfer the collected Household E-waste to the licensed Household E-waste Recovery Facilities and the activity of dismantling of the E-waste is prohibited. This is an important step in order to prevent the leakage of the E-waste to the informal sector. Household E-waste Full Recovery Facility is the licensed facility by DOE and able to proper manage the E-waste with well control the pollution and ensure the safety manner according to the specified Guidelines.

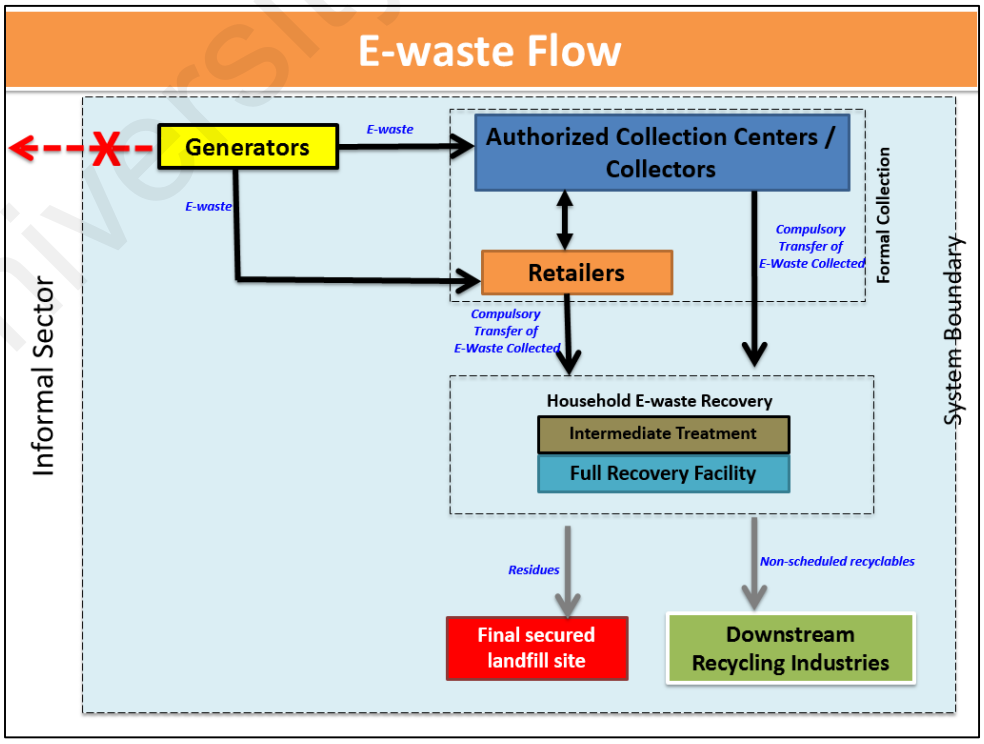


Figure 4.1: Framework of E-Waste flow for Household E-Waste management in Malaysia . Adopted from Source: (Department of Environment (DOE), 2016b)

In the fee flow as shown in figure 4.2, the recycling fee and the EPR fee will be collected from consumers and manufacturers or importers, respectively. This is to base on the shared responsibility concepts among the manufacturers and consumers in order to ensure the fee that collected to manage and treat the hazardous content in the Household E-waste properly. The recycling fee which collected from consumers will be transferred to manufacturers or importers through the retailers. Then, manufacturers will pay the EPR fee and transfer the recycling fee to the Fund Management Board. The Fund Management Board have the proposed functions and in the discussion stage to develop it such as managing and monitor the mechanism, managing the report and fee flow of the E-waste, awareness raising programme and provide subsidies for recycling and collection activities in order to encourage take part actively within this new framework.

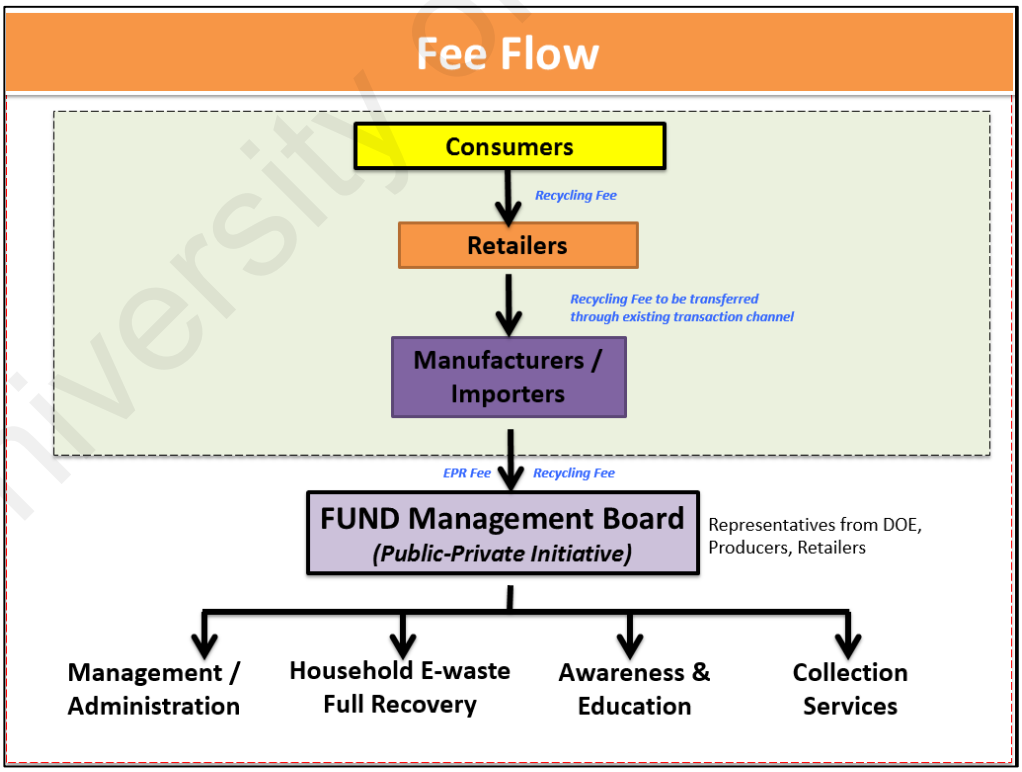


Figure 4.2: Framework of fee flow for Household E-Waste management in Malaysia. Adopted from Source:(Department of Environment (DOE), 2016b)

In the reporting flow as shown in figure 4.3, manufacturer or importers are required to report on the sales of the products in the market annually as well as paying the EPR fee according to reported sales volume and channel the recycling fee which received from consumers to the Fund Management Board. In addition, collection center or waste collectors or retailers are required to report monthly on the quantity, types and brands that received from the waste generators to the Fund Management Board and similar to the Household E-waste Full Recovery Facility to report monthly on the quantity, types and brands that received from the collection center or waste collectors to the Fund Management Board. This system will be using Manifest System by using consignment note in order to proper record and manage the subsidised the Collection Centres or waste collectors or Household E-waste Full Recovery Facilities that are compliance with the regulatory requirements.

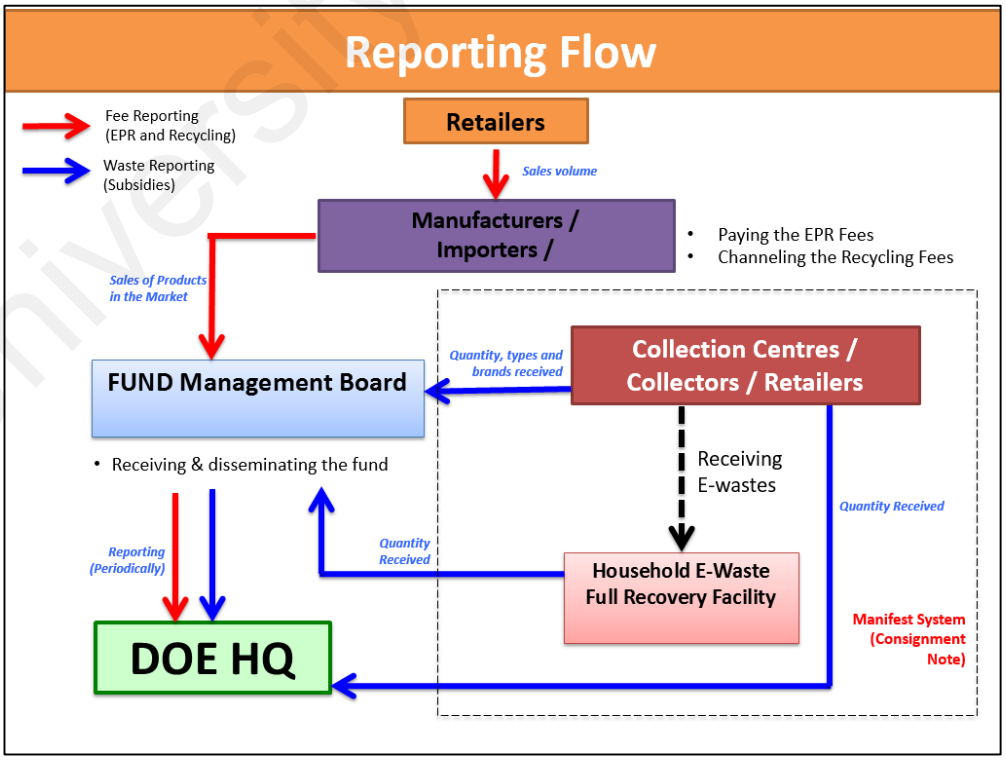


Figure 4.3: Framework of reporting flow for Household E-Waste management in Malaysia.Adopted from Source:(Department of Environment (DOE), 2016b).

4.2 Assessment E-waste Extended Producer Responsibility (EPR) in Different Countries

4.2.1 Comparison of EPR Implementation in Different Countries

Table 4.1: Comparison of different form of EPR Implementation in Germany, Japan, Taiwan and Malaysia.

		Germany	**Japan**	**Taiwan**	**Malaysia**
Regulation		Act Governing the Sales, Return and Environmentally Sound Disposal of Electrical and Electronic Equipment 2005 (ElektroG)	1) Law for the Promotion of Effective Utilisation of Resources (LPUR) 2) Law for Recycling Specified Kinds of Home Appliances (LRHA)	Waste Disposal Act	Draft Household Schedule Waste Regulations
Producer Responsibilities	Physical	-provide containers for 5 categories of the large appliances	-the obligation to collect appliances subject to the act	Voluntary to take bake (no clear stipulation)	Voluntary to take bake
	Financial	Pay fees for recycling E-waste (according to market share)	NA	Pay fees for the collection & recycling E-waste (amount sale of previous year X collection & recycling cost per item)	Pay EPR fee to FMB

Table 4.1(continue): Comparison of different form of EPR Implementation in Germany, Japan, Taiwan and Malaysia.

		Germany	Japan	Taiwan	Malaysia
	Recycling/Recovery Target / DfE	- Must compliance minimum targets for recycling and recovery target	-the obligation to recycle appliances in accordance with the standards (recycling rate)	no clear stipulation	no clear stipulation
Role of stakeholder	Local Government	Municipalities take up the physical and financial responsibility for collection by setting up collection points.	Ministry of Environment (MOE) and the Ministry of Economy, Trade and Industry (METI) ~set recycling fee & rates	Fee Rate Reviewing Committee (FRRC) ~representative from government, academia, consumer, manufacturer, other ~fee are revised on annual basic	Department of Environment (DOE) ~ develop the new EPR mechanism for managing Household E-waste in Malaysia

Table 4.1(continue): Comparison of different form of EPR Implementation in Germany, Japan, Taiwan and Malaysia.

		Germany	Japan	Taiwan	Malaysia
	Retailer	-the obligation to collect home appliance from the consumer (free of charge)	-the obligation to collect home appliance from a discharger -the obligation to hand over the appliances to the manufacturer	no clear stipulation	the obligation to collect home appliance
	Recyclers	no clear stipulation	Get subsidies from RKC if fulfil requirements	Get subsidies from RFMC if fulfil requirements	Get subsidies from FMB if fulfil requirements
	Consumers	Bring back the E-waste to the authorised collection centre	Pay for collection and recycling fee	no clear stipulation	Pay for recycling fee
Monitoring		"Elektro-Altgeräteregister" (EAR)	RKC (Home Appliances manifest data management centre) under AEHA (Association of Electronics Home Appliances)	Recycling Fund Management Committee (RFMC) system	Fund Management Board

For the regulations in managing E-waste, Taiwan in year 1998, Japan in year 2001 and Germany in year 2005 have their specific regulations to manage the E-waste while in Malaysia, currently there are draft regulation with the technical cooperation from Government of Japan to develop the EPR model to manage Household E-waste in Malaysia and estimated to start to implement in the year 2018.

For the producer responsibilities, in Germany, they need to pay fees for recycling E-waste (according to market share) and can collect back E-waste by three methods which are are set up individual brand-selective take back schemes (IBTS), individual non-selective take back schemes (INTS) or take part in collective take back scheme (CTS). Besides that, manufacturers have the responsibility to provide containers for 5 categories of the large appliances at the collection points which manage by municipalities. Somehow in Japan, producer have no responsible for the fee which will be borne by the consumer. The producer is responsible for taking back the E-waste and achieving the recycling target. However, this is different with Taiwan and Germany. In Taiwan, there is no clear stipulation for the producer to collect the E-waste, it is the voluntary basis for them to collect back the E-waste and no clear stipulation for them to achieve recycling target. Thus, the producer needs to pay for the collection and recycling fee to the RFMB. In Malaysia, the draft framework is similar with the Taiwan which is no clear stipulation for the producer to collect the E-waste, it is the voluntary basis for them to collect back the E-waste and no clear stipulation for them to achieve recycling target. Thus, the producer/importer need to pay EPR fee and manage by FMB. This is due to most of the manufacturers in Malaysia is small and medium enterprise, unlike in Japan or Germany, the manufacturer has their manufacturer group to work together for collecting back Household E-waste.

For the retailer, in Japan, the retailers have the responsibility to collect back the Household E-waste from consumers during they sell the same type of the home appliance to consumers and required transfer back to manufacturers or importers. This is similar practice in Germany but is show different in Taiwan where no clear stipulation for the retailer's role. In Malaysia, the retailers are proposed to have the responsibility to collect the Household E-waste from customers and transfer back to licensing recovery facilities. As retailers are one of the places for the consumers to purchase the new E-waste and some will provide service to collect back the old or E-waste. Retailers need to get the authorised from DOE and have to ensure the collected Household E-waste no leak to the informal sector.

For the recyclers, there are similar that the recyclers will get the subsidies from the managing system board in Taiwan and Japan, while Malaysia also in the ways to develop the Fund Management Board to manage the fee and subsidies to the recycler who fulfill the requirement in order to encourage proper manage the hazardous material in the E-waste.

For the consumers, in Japan, they have to pay the recycling upon disposal the household E-waste, while Malaysia is developing the EPR model that consumers also need to involve in paying recycling fee upon purchasing which will embed in the product price. This will give the awareness to the consumers as the “Polluter Pay Principle” as consumers also have the responsibility to their own purchasing product which containing focused material that will affect human health and environment, thus need the extra cost to proper manage it. Somehow is one of the challenges that there is low willingness to pay the recycling fee from consumers in Malaysia.

In summary, Germany, Japan and Taiwan developed their E-waste recycling systems based on the EPR model where the physical responsibility, economic

responsibility, and informative responsibilities are shared among the stakeholder such as manufacturers, retailers, recyclers, consumers and government. The clear defined the role of all stakeholders in the regulation is important to enforce as in Japan EPR model. In addition, the manifest system in Japan also important for the reporting and trace the E-waste to the correct final destination as well as data collected for manage the subsidy fee. In Taiwan EPR model, the proper and monitoring system for the Fund Management Board by the third party is imperative. In Germany EPR model, the municipalities setting up collection point while producer provides E-waste container will provide sufficient collection infrastructure and increase the efficiency to manage the E-waste.

4.3 Implementation Mechanism

Extended Producer Responsibilities (EPR) policy in Household E-waste management in Malaysia is important to encourage manufacturer, retailers and consumers to work together and share the responsibilities of physical and financial during the collection, recycling and disposal of Household E-waste in order to achieve proper E-waste management system and minimize the environment issue posed by the hazardous substances in the E-waste. In addition, implementation of EPR can act as one of the driven force for producers to ensure and improve the product design in order to make the heavy metal substance in the electronic compound easily accessible and removed from E-waste for further treatment. For example, the mercury backlight at the design of LCD flat panel can be removed more quickly and easily which will reduce the labour cost. Thus, this will encourage the producers to improve their end of life product design if they are sharing the financial responsibility in EPR system.

Figure 4.4 show the implementation mechanism of EPR model in managing Household E-waste in Malaysia. There are 7 elements which are enforcement regulations, E-waste Inventory, collection mechanism, reporting mechanism, recycling mechanism, financial mechanism and Fund Management Board are the elements that will assist the developing the sustainable EPR model in managing Household E-waste in Malaysia. This seven mechanism will be discussed further under section 4.3.1 for enforcement regulations, section 4.3.2 for E-waste Inventory, section 4.3.3 for collection mechanism, section 4.3.4 for reporting mechanism, section 4.3.5 for recycling mechanism, section 4.3.6 for financial mechanism and section 4.3.7 for Fund Management Board, respectively.

These results of 7 implementation mechanism of EPR model are incorporate literature review from the International Environmental Technology Centre (IETC) of

Division of Technology, Industry and Technology (DTIE) of United Nations Environment Programme (UNEP), which has produced manual from input of training workshop in Japan that attended by international organizations, national governments, private sector and civil society to assist the E-waste Management system, existing practice in E-waste Management system from European Union, Japan and Taiwan. There are different systems in managing the Household E-waste effectively in these countries. Their implementation mechanism is reviewed which applicable to Malaysia to suit the local context.

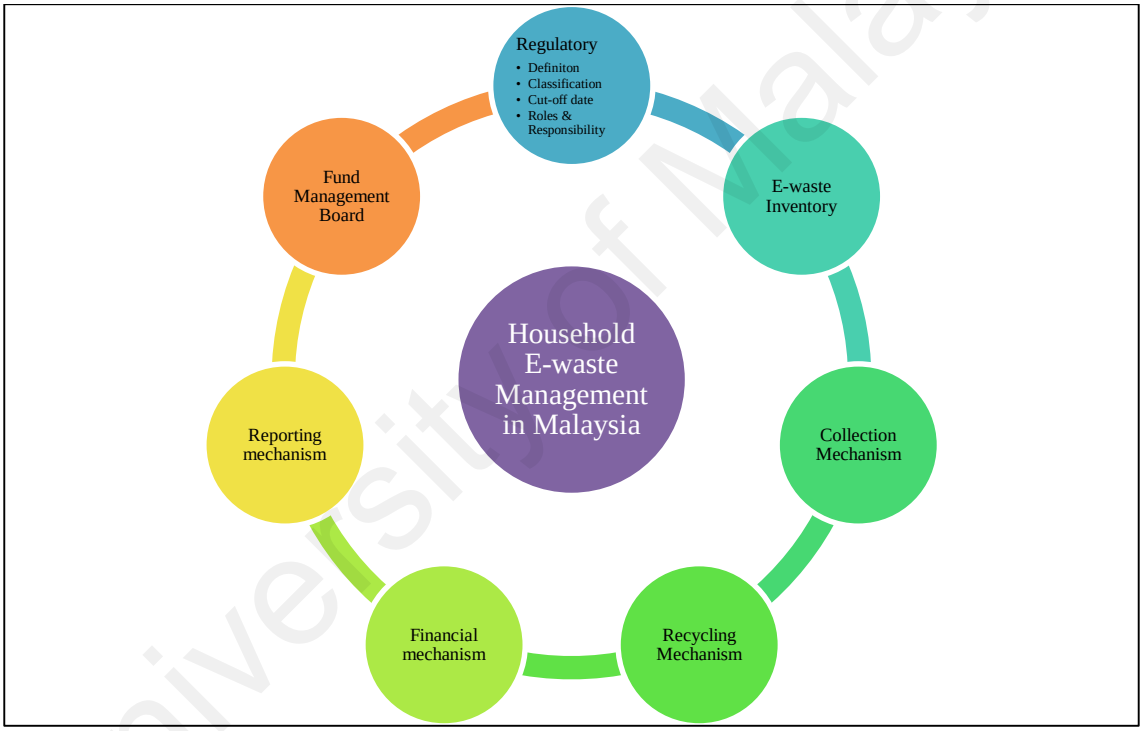


Figure 4.4: Implementation mechanism of EPR model in managing Household E-waste in Malaysia (Source: (United Nations Environmental Programme, 2012; United States Environmental Protection Agency, 2012; Yolin, 2015)

4.3.1 Regulatory Framework

From literature review finding, there are 4 major components have to include in the regulatory framework for the implementation of Household E-waste management system. such as the definition of Household E-waste, classification of the Household E-waste, cut off date for implementation and roles and responsibilities of the stakeholder.

Type of the Household E-waste needs to be stated clearly in the regulations or guidelines same as the Industry E-waste is classified as SW 110 in Malaysia and another coding need to be generated to identify the type of Household E-waste. Currently, in this new framework, there are 6 items of the Household E-waste will be covered and will be tested in the pilot project such as television, air-conditioners, washing machine, refrigerators, mobile phone and computer. For example, in Japan, there are three different regulations stated clearly to manage different categories of the E-waste which are Home Appliance Recycling Act, Small Home Appliances Recycling Act and Act on the Promotion of Effective Utilization of Resources.

The cut-off date for implementation the new system is important to proper manage the historical Household E-waste. For example, the regulation ElektroG was enacted in Germany on 13 August 2005. Thus, the EEE that put on the market before 13 August 2015 are considered as historical E-waste and all manufacturers have to share the financial responsibility to collect and proper recycle it. However, after 13 August 2005, manufacturers have to compliance with the regulation ElektroG and responsible to label all EEE that put on the market in order to specify to consumers that E-waste not allowed be disposed of in the domestic waste container (Deubzer, 2011).

In non-participant observation (attending seminar) finding, for the role and responsibilities of stakeholders, the physical and financial responsibilities of the waste generators, manufacturers, importers, waste collectors, retailers, transporter, recycling

facilities and final disposal need to be clearly defined in the proposed framework EPR framework for Household E-waste Management in Malaysia by DOE and JICA. For examples, waste generators have the responsibilities to dispose the Household E-waste to the authorised waste collectors in order to prevent the leakage of the E-waste to the informal sector and need to pay for the recycling fee for the proper manage of the hazardous substances in the E-waste. Responsibilities for the manufacturers or importers are paying the EPR fee for proper manage the E-waste and report the sales and hazardous content in the E-waste. For the waste collectors or retailers, they have the responsibilities to get authorised and collect and temporary store the Household E-waste from waste generators and then transfer to the Licensed Household E-waste Full Recovery Facilities for further process. For the Licensed Household E-waste Full Recovery Facilities, they have the responsibility to receive the Household E-waste only from the authorised collection centres, waste collectors or retailers. They need to carry out recycling, recovery and disposal of Household E-waste in an environmentally sound manner in order to minimise the pollution which creates from the hazardous substances content in the E-waste to human health and environment.

4.3.2 E-waste Inventory

From literature review findings, according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste "Take Back System" Management (United Nations Environmental Programme, 2012), it is important to determine the existing and future E-waste inventory according to the type of the E-waste. The inventory information will provide the baseline of the capability existing and proposed treatment capacity with the collection and transport requirement according to within a geographic city. Furthermore, the E-waste inventories will also give the collection target for the E-waste to be collected storage, segregated, transport, recovery and final disposal. The establishment of the

collection target is important for since will be involving the major stakeholder from consumers, manufacturers, retailers, collector, transporter, Full Recovery Facilities and another stakeholder. However, there are no Household E-waste inventory data available in Malaysia, thus, is recommended to develop a baseline of the inventory data in order to sustain the EPR model of managing Household E-waste in Malaysia.

4.3.3 Collection mechanism (collection, storage, transport)

From literature review findings, according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste "Take Back System" Management (United Nations Environmental Programme, 2012), the effectiveness of the collection Household E-waste is played an important role in the whole EPR system. The low collection rate will affect the downstream activities of recycling Household E-waste, thus the overall efficiency of the system will be low too. Therefore, the collection infrastructure must be more sufficient and easy accessibility by the end user in order to disposal their Household E-waste to authorised waste collectors, authorised collection points, retailer shop, authorised Non-Governmental Organization (NGO). For one good practice in Germany, municipalities have the responsible to set up and manage the E-waste collection points which will provide sufficient and easy accessibility to the waste generators.

In non-participant observation (attending seminar), in the proposed EPR framework for Household E-waste Management in Malaysia by DOE and JICA, the process of authorised waste collectors, collection points and retailer shop need to be registered in order to collect the E-waste from the household to be implemented in future. This is to ensure the collected E-waste from household is sent to proper or authorised recovery facilities or send to proper storage station or transfer station before sending to recovery facilities. Furthermore, there are few collection mechanisms are proposed by

JICA Household E-waste Management Team to be implemented in Malaysia such as Household E-waste collected by authorized concessionaire waste collectors which register with National Solid Waste Management Department (NSWMD) such as Alam Flora in KL, Putrajaya and Pahang state, E-idaman for state of Perlis, Kedah, Penang, Perak and SWM Environment Sdn Bhd for Johor, Melaka and Negeri Sembilan state. In addition, waste generators send to authorized collection points which run by the (NGO) or charity organization such as Tzu Chi Foundation, community/school, or consumer also can send back the Household E-waste to authorized retailers shop such as Senheng Electric store, Tan Boon Ming Sdn Bhd, DIGI retailer shop, so that they will send to authorized collection point or recycling center.

Retailers play an important role as having the responsibility to collect back from the consumers during purchasing the new electrical and electronic appliances. The retailer shop is one of the places that provide service and convenient to the consumers in order to proper channel the Household E-waste into the authorised recycler's centre.

In addition, the registered and authorised waste collectors need to compliance some of the requirement to collect, storage and transfer the Household E-waste such as no dismantle is allowed and other requirements based on literature review as stated below:-

4.3.3.1 Collection –Special Handling

From literature review findings, well-trained personnel are required to ensure the precaution step to be taken for the some of the E-waste items that needs the special care during the collection, storage, transport. According to the Taiwan Practice (United States Environmental Protection Agency, 2012), some of the components in the E-waste need to be special handling during the collection such as the lithium batteries, lead in CRT, Freon gas in the refrigerator and air-conditioner, and mercury in a fluorescent lamp. The

lithium batteries in the mobile phone need to be separated and stored in a cool, well ventilation, dry environment without direct sunlight in order to avoid potential fire risk during transportation. For television, it needs to be handled with care because the CRT glass is fragile and contain lead which is hazardous to human health and the environment. It is recommended avoid to stack together with the flat screen and CRT television during storage. For the refrigerator or freezer, the refrigerant in the refrigerator or freezer shall not be released into the air at all time while the used refrigerant needs to be pumped and stored in a refrigerant gas cylinder. The compressor of the refrigerator needs to handle carefully to avoid leaking of refrigerant and lubricant oil. For air-conditioner, the refrigerant contained in the air-conditioner is not allowed to release into the atmosphere, the used refrigerant shall be pumped and stored in a refrigerant gas cylinder. For waste light bulb, the waste lamps must be stored in solid containers, labelled clearly and storage of mercuric compound from recycling waste lamps must be placed in isolated areas.

4.3.3.2 Facilities in collection/storage area

From literature review findings, according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste Management Manual (United Nations Environmental Programme, 2007), E-waste, in general, is being separated into five categories according to their different material composition and treatment groups. This will enable efficient collection, recycling and data monitoring. The first category is refrigeration equipment due to the Ozone Depletion Substances Usage, the second category is other large household appliances because of their shredding with end-of-life vehicles and other light iron, the third category is equipment containing CRTs such as computer monitors and TVs that contain lead, the fourth category is Lighting (linear and compact fluorescent tubes) that needs to be storage in isolated container due to mercury content in the fluorescent tubes and to avoid contaminate with other waste, the fifth category is

considered as all other E-waste can be collected in the same container because there are no health and safety reasons.

For the collection point or storage area requirements, according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste Management Manual (United Nations Environmental Programme, 2007), the collection point/ storage area should be easily accessible by the public such as the identity or location, area of the collection point/ storage should be able to accommodate separated/ sorted E-waste with respect to size, collection point/ storage area should have impermeable surface with sealed drainage system, and weatherproofing of collection point/ storage area. The important of the sealed drainage system with the impermeable surface is to ensure no leaking from the pavement into groundwater system and all liquids entering the system are collected in a sealed and should be treated before discharged. However, spillage from the collection facilities as the primary containment. Thus, spill kits to deal with spillages of oils, fuel and acids should be provided and used as appropriate.

4.3.4 Recycling mechanism

4.3.4.1 Licensing of the E-waste recycling facilities

From literature review findings, in Malaysia, Environment Impact Assessment (EIA) is required under section 34A, Environmental Quality Act (EQA) 1974 which specifies the legal requirements in respect of EIA for Prescribed Activities which including construction of recovery plant (off-site) for toxic and hazardous waste as listed in first schedule and second schedule in Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015 . EIA is a study to identify, predict, evaluate and communicate the environment impacts of the new build recycling facilities and to detail out the proposed measures to prevent, reduce or control the adverse

environment impact. EIA study has to be conducted by competent individuals who are registered with the Department of Environment under the EIA Consultation Registration Scheme. In addition, written approval is required for the construction of the construction prescribed premises under section 19, EQA 1974, while obtaining a license to occupy and use the premises, is under section 18, EQA 1974.

During the issue license to operate the premises, some of the requirements do need comply as stated in the Environmental Quality (Clean Air) Regulations 2014 for air pollution control system as well as the emission limit values and technical standards, the acceptable conditions for discharge of industrial effluent or mixed effluent of standards A and B (fifth and seventh schedule) and record of industrial effluent or mixed effluent discharge monitoring data (section 7 (3)) as stated in the Environmental Quality (Industrial Effluent) Regulations 2009. For the noise limits and control by receiving land use surround the premises, 70dB(A) is permissible daytime from 7 am until 10 pm while 60dB(A) for night time (10 pm until 7 am) as stated in the schedule 1 of Guidelines for Environmental Noise Limits and Control.

Furthermore, based on the Environmental Quality (Scheduled Wastes) Regulations 2005, the containers for storage of the scheduled wastes need to be labelled clearly as according to the requirement stated in the Thrid Schedule (Regulation 10) and remark with the specified waste code as specified in the First Schedule for identification and giving to aware for the hazardous characteristic of the waste such as explosive, flammable, combustible, oxidizing substances, toxic, infectious and corrosive. In addition, the scheduled waste should be stored in the proper container which is compatible to be stored, durable and avoid leakage to environment as stated in the Regulation 9 (1) and the quantity storage for scheduled waste can not exceed 20 metric tonnes for 180 days after been generated as stated in the Regulation 9(5). Furthermore,

the waste generator should notify to Director General of the types and scheduled wastes quantities which are generated as well as the up-to-date inventory of the scheduled waste needs to be recorded in the in the eSWIS system (https://eswis.doe.gov.my/) as stipulated in the Regulation 3 and Regulation 11 (Fifth Schedule). Besides that, consignment notes will be used as stipulated in Regulation 12 (Sixth Schedule) for the record of the scheduled waste movement among the waste generator, contractors and prescribed premises.

For the inventory of scheduled wastes, the owner of the prescribed premises need to keep for up-to-date inventory for the types and quantities of scheduled wastes during the stage of received, stored, treated, recovered, destroyed and disposed as stated in the Regulation 6 in Environmental Quality (Prescribed Premises)(Scheduled Wastes Treatment And Disposal Facilities) 1989 (Amendment) Regulations 2006. This inventory information needs to be submitted to Director General within fourteen days after the end of every period of three months.

An environment audit is required to carry out under Section 33A, Environmental Quality Act 1974 (Act 127) by the qualified personnel who registered to the Department of Environment and the audit report need to submit to Director General. In addition, a competency personnel need to be appointed to manage the scheduled waste in the prescribed premises under Section 49A(1)(b), Environmental Quality (Amendment) Act 2012 (Act A1441). EiMAS is providing the training program (Certified Environmental Profesional in Scheduled Waste Management- CePSWaM) to train the personnel who are involved in managing scheduled waste to be competent.

4.3.4.2 Requirements for the Environmentally Sound Management System

(i) Technology standards to manage the hazardous material in E-waste

The concern to proper manage of the E-waste is to proper recycling the hazardous material (focus material) in the E-waste which will pose the risk to the environment and human health if without the proper manage it. The examples for the hazardous material in the E-waste are mercury in the fluorescent lamp, mercury in backlight of the computer and LCD TV, lead in the CRT glass, lithium in the battery, Freon gas in the refrigerator and air-conditioners, PCB in capacitors, refrigerant oil in refrigerator and air conditioner and Brominated Flame Retardants (BFRs) in circuit board.

Law and regulation in European Union and auditing scheme specify Focus Material (FM). It is a common approach to control recycling facilities and ensures environmentally sound treatment with FMs. The proper identify and manage the Focus Material in order to ensure pollution preventing measures for hazardous substance contained parts at recycling facilities. The proper segregation of the Focus Material during the treatment process and pollution control with special handling is very vital activity.

One of the examples can be seen in WEEELABEX normative requirements are to ensure the human health and environment are protected by preventing the adverse impacts resulted from the collection, storage and handling of waste electrical and electronic equipment (WEEE). This WEEELABEX standard is required to fulfil the safety, health and environment requirements. The audits of conformity verification will be conducted each year. There are some minimum requirements for proper treatment of the CRT display appliances to avoid the lead leaking to the environment, proper treatment of the flat panel displays, proper treatment of lamp as containing mercury, Household Cooling and Freezing Appliances containing CFC, HCFC or HFC as containing ozone depleting substances , proper treatment of Cooling and Freezing Appliances containing

Hydrocarbons (HC) which no ozone depleting potential and only low global warming potential(BIO Intelligence Service, 2013; WEEEFORUM, 2011).

4.3.5 Financial mechanism

From literature review finding, manufacturers, consumers and society are the important stakeholders to share the financial responsibilities in E-waste Management such as logistic cost, collection cost and recycling cost. In Taiwan practice, the recycling fee that collected from manufacturers and importers are used to subsidy the recyclers who have compliance and proper recycler E-waste, activities of auditing and other administrative costs.

For the logistic cost, according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste "Take Back System" Management (United Nations Environmental Programme, 2012), the quantity and category of the E-waste collected and the distance send to recycling centers are the factors that need to be considered for the established of the collection system.

Cost of collection and transport = Cost of collection centre + Cost of transport

The cost of collection and transport is the total amount of the costs of establishing and collection centre operation and transportation for the E-waste. The cost of collection centre is calculated based on the investment costs, facility operations and packaging. The transportation cost can be calculated based on the tonne per kilometre (or per mile) rate provided by transporters.

For the treatment cost (Recycling, Treatment and Disposal),according to the United Nations Environmental Programme (UNEP), the guidance notes of the Waste Electrical and Electronic Equipment (WEEE) or E-waste Management Manual (United Nations Environmental Programme, 2007), the treatment cost (including operation and

maintenance cost) is calculating by labour costs and equipment operating costs (fuel/ electricity/ maintenance). However, the cost implications will be higher as increased sorting process to remove the hazardous components and the different of the technology either by hand manual or technology innovation will affect the labour costs become higher (Van Rossem, 2008). For example, the mercury backlight at the design of LCD flat panel can be removed more quickly and easily which will reduce the labour cost.

4.3.6 Reporting mechanism

From literature review finding, one of the good practice reporting system which is a manifest system in Japan. The Proper reporting system is important to monitor and ensure proper Household E-waste flow and recycling flow. Thus, in order to ensure proper flow of the Household E-waste within the system boundary from E-waste generation until the final receiving points, reporting by relevant players such as manufacturers, retailers, recyclers via manifest system is required. A manifest system to report the flow of the collected E-waste is essential in order to ensure to send the E-waste to the authorised collection centre and recycling facilities. For example, the retailers will issue one copy of the ticket which was filled into the waste generators and then the retailers transport the waste and the remaining of the ticket to the designated collection site. After that, the designated collection site will distribute one copy to the retailers and another copy to the RKC (Home Appliances manifest data management centre) under AEHA (Association of Electronics Home Appliances).

In non-participant observation (attending seminar) finding, in the proposed EPR framework for Household E-waste Management in Malaysia by DOE and JICA, manufacturers or importers need to report the quantity of electrical and electronic appliances that put in Malaysia markers whether it is locally manufactured, assembled or imported, for retailers need to report the sales volumes of electrical and electronic

appliances and total recycling fee collected from consumers, for authorized collection centers and retailers need to report the final destination such as the company name of the licensed Household E-waste Full Recovery Facility after collect the Household E-waste from consumers, and the licensed Household E-waste Full Recovery Facilities only allow to receive Household E-waste from authorizing sources with proper manifest attached. For the number of Household E-waste collected and received, the authorised collection centres, retailers and licensed Household E-waste Full Recovery Facilities need to report the information to FMB in order to justify any subsidy is required. The information reported by the manufacturer's or importer, retailers and recyclers will the basic information for the Fund Management Board to determine the amount of recycling fees paid by manufacturers or consumers.

4.3.7 Fund Management Board (Monitoring / Auditing)

In non-participant observation (attending seminar) finding, in the proposed EPR framework for Household E-waste Management in Malaysia by DOE and JICA, Fund Management Board is to monitor the performance of the collectors and recyclers and manages the EPR fee and recycling fee which collected from the manufacturers and end users. The recycling fee is to subsidise the collection centre, recycling facilities with doing the proper recycling and sending all collected E-waste to the authorised place. The subsidies will be given based on the consignment note that with the complete unit and correct flow of the E-waste which are tally with the generation code of the specific E-waste item that already pastes it. In addition, the fee will be subsidies for another purpose of the awareness, education, research & development, subsidise for the administration fee, collection fee and recycling fee.

From literature review finding, one of the good practice to monitor the fund is in Taiwan's auditing system which consists of Auditing and Certification Supervisory Committee and Auditing and Certification Groups (ACGs). Auditing and Certification

Supervisory Committee is to verify the audit work that carried by ACGs is implemented in compliance with the legal and be fair. The committee is made up of a representative from the government, NGOs, consumers and academia that expert in this field. They will make the ACG's performance annual report which will determine the renew contract of the auditor by EPAT(Environmental Protection Agency, 2012).

ACGs is contracted by Environmental Protection Administration Taiwan (EPAT) to carry out audit independently to verify the subsidised collectors and recyclers compliance with requirements and they receive subsidy amounts are corresponding to the amount of material recycled according to EPAT's standards. During audit the collection or recycling company, ACGs must verify the company own necessary licenses, inspect the company operation to compliance with the environmental and safety protections requirements as well as the verify the sources and downstream destination and mass balance of each type Regulated Recyclable Waste (RRW) collected and recycled. Then, they will need to audit the daily quantities of RRW handled by the company such as items received inventories, stock inventories and resources sales accounts in order to determine the amount subsidy amounts for registered collectors and recyclers. ACGs must report the findings to EPAT. If the company is found out that not compliance with the requirements, EPAT will penalise the company by the methods of levying fines, revoking the license, subtracting the RRW quantities or suspend the subsidy eligibility(Environmental Protection Agency, 2012).

Table 4.2 shown the summaries of the implementation mechanism of sustainable EPR model for managing Household E-waste in Malaysia by literature review the best practice in other countries to manage E-waste.

Table 4.2: Summaries of the implementation mechanism of sustainable EPR model for managing Household E-waste in Malaysia.

No	Implementation mechanism	Best Practice in countries to manage E-waste
1	Regulatory framework	• Japan (E-waste related regulation) • Germany (Historical E-waste)
2	E-waste Inventory	• UNEP
3	Collection mechanism	• Germany (Municipalities setting up collection point; Manufacturer provide container) • Taiwan (Special Handling) • UNEP (Facilities in collection/storage area)
4	Recycling Mechanism	• Malaysia (Existing environmental regulation) • Europe Union (WEEELABEX)
5	Financial Mechanism	• UNEP (logistic, collection and treatment cost) • Japan (consumer pay recycling fee) • Germany, Taiwan (manufacturer pay EPR fee)
6	Reporting Mechanism	• Japan (Manifest System)
7	Fund Management Board	• Taiwan (FMB Monitoring / Auditing)

4.4 Summary of the EPR Model for Household E-waste Management in Malaysia

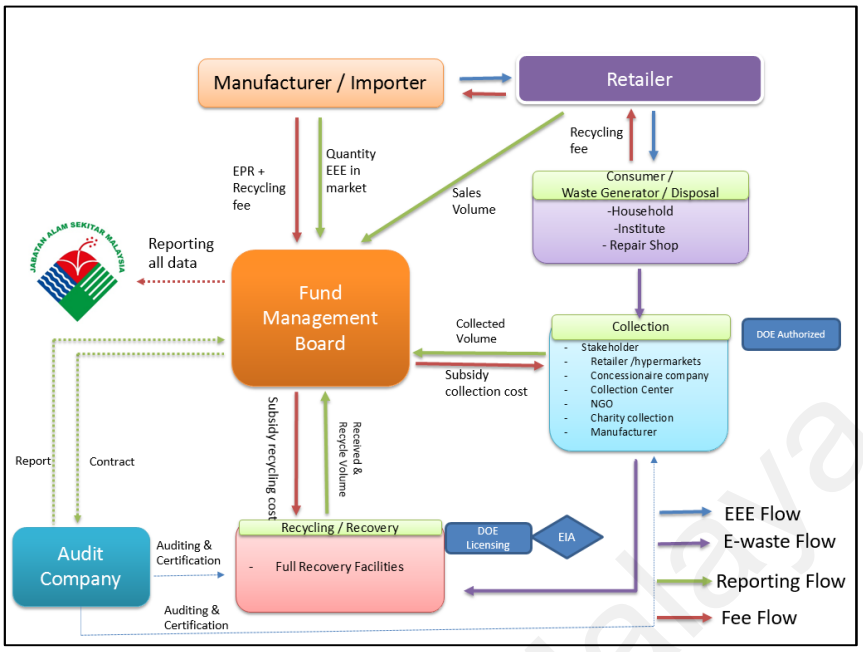


Figure 4.5 Summary of the EPR model for managing Household E-waste in Malaysia.

Figure 4.5 show the summary of the EPR model for managing Household E-waste in Malaysia. This summary EPR model has integrated the information from the framework of E-waste flow (figure 4.1), Fee flow (figure 4.2) and Reporting flow (figure 4.3) for Household E-waste Management in Malaysia. This EPR model is incorporate among the manufacturer, retailers, consumers, E-waste collector, full recovery facilities to work together and share the responsibilities of physical and financial during the collection, recycling and disposal of Household E-waste in order to achieve proper E-waste management system and minimize the environment issue posed by the hazardous substances in the E-waste.

Table 4.3 show the SWOT Matrix of the integrated mechanism implementation of sustainable EPR model for managing Household E-waste in Malaysia will be arranged into four categories which are strengths, weaknesses, opportunities, and threats. Strengths as current factors that have prompted outstanding and benefit to the Household E-waste Management in Malaysia. Weakness as internal factors that will increase operation costs or the inefficiencies that reduce the EPR model implementation's quality. Opportunities

for the significant new improvements available towards this EPR model. Threats are the factors that could negatively affect this EPR model for managing Household E-waste Management's system performance.

Table 4.3: Strengths, Weaknesses, Opportunities and Threats **(**SWOT) analysis for EPR model for managing Household E-waste in Malaysia.

	POSITIVE	**NEGATIVE**
INTERNAL	STRENGTHS	WEAKNESSES
	1) A Proper system to long-term sustain & manage household E-waste (collection, reporting, fee, FMB). 2) Changing allocation of cost for waste management & recycling.	1) Lack of expertise in E-waste management field. 2) Inter minister barrier. 3) The low collection rate of the Household E-waste. 4) High monitoring cost.
	OPPORTUNITIES	THREATS
EXTERNAL	1) Improved waste management & resource recovery (increase landfill lifespan, promote 3R). 2) Product design for the environment. 3) Minimise pose of risk to human health & environment due to the hazardous material content. 4) Conserve natural resources.	1) Low Public Awareness / Low of willingness to pay. 2) Lack of Household E-waste Inventory Data. 3) Lack of Infrastructure (collection point). 4) Online business / second-hand EEE. 5) Competition among formal and informal E-waste recycler. 6) Lack of investment to finance formal recycling facilities, Historical / Orphanage E-waste/transition period.

4.4.1 Strengths

There are some of the strengths, weakness, opportunities and threats for the implementation of the EPR model for managing Household E-waste in Malaysia. For the SWOT analysis (Strength, Weakness, Opportunity and Threat) as shown in figure 4.6, the strength of this EPR model is having a proper system to long-term sustain and manage the Household E-waste in Environmental Sound Management as consist of the Enforcement regulations, E-waste Inventory, collection mechanism, reporting mechanism, recycling mechanism, financial mechanism and Fund Management Board to support this model. In addition, this EPR model also changing the allocation of cost for managing the E-waste and recycling as this model are encouraged manufacturer, retailers and consumers to work together and share the responsibilities of physical and financial during the collection, recycling and disposal of Household E-waste.

4.4.2 Weakness

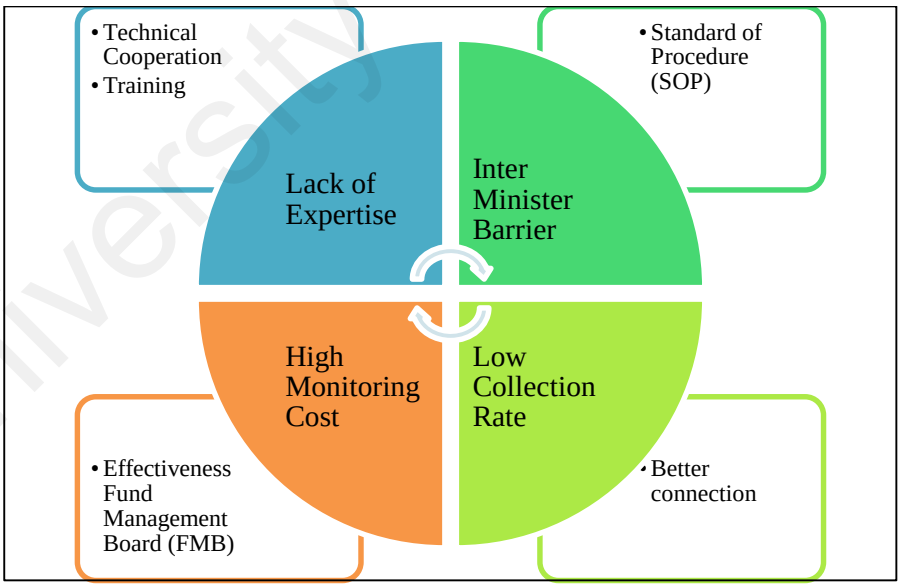


Figure 4.6: Weakness for EPR model for managing Household E-waste in Malaysia and it's recommendation.

However, it also has some weakness to implement this EPR model for managing Household E-waste in Malaysia such a lack of expertise, inter minister barrier, low collection rate and high monitoring cost as shown in Figure 4.6. Recommendations will

be discussed in section 4.4.2.1 for lack of expertise, section 4.4.2.2 for inter minister barrier, section 4.4.2.3 for low collection rate and section 4.4.2.4 for high monitoring cost.

4.4.2.1 Lack of Expertise

For the weakness of lack of expertise (institute) in this Household E-waste Management field in Malaysia, sustainable Household E-waste Management will not be realised without the overall capacity development of the Malaysian society itself in addition to the government management mechanism to support it. Thus, this is the important criteria of institute need to be first prioritized to improve by the mechanism of technical cooperation with some experience country to manage Household E-waste such as Japan and having training programme in other countries such as Japan and Taiwan are the ways to capacity building for the government sector and gain more knowledge and experience from other countries in order to develop sustainable EPR mechanism to manage the Household E-waste in Malaysia. For the collection and recycling facilities sectors, well-trained personnel should be trained as the Household E-waste contain hazardous material, thus special care, safety and health precaution and Emergency Response Plan should be trained all workers and aware during handling with the Household E-waste.

4.4.2.2 Inter Minister Barrier

In addition, the weakness of this EPR model is inter minister barrier during carried out for the collection of the E-waste from the household. As the manage and collect of municipal solid waste are under the authority of the Ministry of Urban Wellbeing, Housing and Local Government. The collection works have been taken over by the Concessionaire Companies such as Alam Flora, SWM Sdn Bhd and E-idaman for the states that have adopted the Solid Waste & Public Cleansing Management Act 2007 (Act 672). Mandatory separation of solid waste at source (known as 2+1 collection system)

has started on 1st September 2015. Residue wastes are collected twice a week while recyclable wastes are collected once a week. However, some of the households will dispose of the E-waste together with the other municipal solid waste, where E-waste is not covered under the Act 672. Thus, this is the criteria of institute need to be second prioritised to improve by the mechanism of developing new Standard of Procedure (SOP) specifically for the collection of Household E-waste by the concessionaire companies. DOE and Ministry of Urban Wellbeing, Housing and Local Government need to work together for the discussion and prepare for the SOP.

4.4.2.3 Low Collection Rate

Moreover, the weakness of this EPR model is getting low collection rate as no specify collection target to the manufacturers or importers. This is the criteria of the technical need to be third prioritised to improve by better connect all parties such as residents, local government, collectors and recyclers and the subsidy or incentives to encourage and involving in the collection channel.

4.4.2.4 High Monitoring Cost

Furthermore, the weakness of this EPR model is required high monitoring cost to implement this system as the need to involve the third parties to verify and auditing the collectors and full recovery facilities in order to compliance with the requirements and standard to get the subsidy from Fund Management Board. Somehow this auditing third parties will ensure the effectiveness and the correct usage of the subsidy from FMB to sustain the whole system.

4.4.3 Opportunities

4.4.3.1 Improved Waste Management and Resource Recovery

One of the opportunity to develop this EPR model is to improved waste management & resource recovery. Through this proper collection Household E-waste system from consumers, it can encourage the recyclers to have environmentally sound

treatment and efficient recycling in order to conserve the natural resources and increase landfill lifespan by reducing the amounts of E-waste into landfill.

4.4.3.2 Product Design for Environment

Furthermore, this EPR model will encourage the manufacturer for better product design for the environment. The manufacturers are involving in the paying of the EPR fee in order to subsidy the recycler to the proper treatment of the E-waste, thus, this will encourage the product design changes towards with less hazardous material content and towards easier recycling, so that increase the recycling rate of the products.

4.4.3.3 Minimize risk to Human Health and Environment

In addition, this EPR model in Household E-waste Management promote the environmentally sound recycling and ensure the proper E-waste flow within that the E-waste is collected by the authorized collectors and send to licensing Full Recovery Facilities for proper treatment and recycling in order to minimize pose of risk to human health & environment due to the hazardous material content.

4.4.4 Threats / Challenges

Figure 4.7: Threats for EPR model for managing Household E-waste in Malaysia and its recommendation.

However, it also has some threats or challenges to implementing this EPR model for managing Household E-waste in Malaysia such as low public awareness, low willingness to pay, lack of inventory data, lack of infrastructure, online business, lack of investment as shown in Figure 4.7. Recommendations will be discussed in section 4.4.4.1 for low public awareness, section 4.4.4.2 for low willingness to pay, section 4.4.4.3 for lack of inventory data, section 4.4.4.4 for lack of infrastructure, section 4.4.4.5 for online business, section 4.4.4.5 for lack of investment.

4.4.4.1 Low Public Awareness

(a) ***Awareness Campaign***

One of the challenge to develop this EPR model is low public awareness in Malaysia. Waste separation is not a common practice in Malaysia and this leads to the collection of all types of waste in one bin. Public awareness is very low for the importance of waste segregation and practising recycling to conserve the natural resources and minimise the waste directly send to landfill. Thus, this is the important criteria of raising awareness need to be first prioritised to improve by some of the action plans such as awareness campaign, education, giving an award and develop of the partnership activities. Enhance implementation of a nation-wide awareness campaign on proper disposal of the E-waste by bringing the message of the importance of segregation and send the E-waste to the authorised waste collectors and the effects of the hazardous material content in the E-waste which post a risk to human health and the environment.

(b) ***Education***

In addition, awareness activities in schools is another important pathway. The philosophy of conservation of resources and through disposal the E-waste into authorised collection centre in order send to the authorised recycling centre to proper recycler and recovery the metal in E-waste. This practices and habits should be inculcated into younger generation through their education in the school and in their co-curricular activities. For

instance, nationwide dissemination of the information about the Household E-waste such as the categories of the electrical and electronic waste, adverse impact of the improper disposal of the E-waste to the environment and human health, the importance and benefits of proper disposal of the Household E-waste.

(c) ***Award***

In addition, implementation of award program for schools in local authorities, State and National Level can encourage the active participant from the students to take part in the programs such as the competition to turn the E-waste into the creative and sustainable product.

(d) ***Partnership Activities***

There are some partnership activities on Household E-waste in Malaysia that organised by government and NGO in order to raise the public awareness such as E-waste Alam Alliance and Mobile E-waste Joint Recycling Programme. The findings of the activities are presented below.

(i) <u>E-waste Alam Alliance</u>

Furthermore, development of partnership activities on Household E-waste collection by NGO is important. Hence, E-waste Alam Alliance Malaysia was set up in the year 2013 in order to establish a network with stakeholders to collect, segregation and transport of Household E-waste effectively. In addition, E-waste Alam Alliance encourages the manufacturers, retailers of electrical and electronic equipment to voluntary take part for the collection household E-waste which involving in 6 states including Kuala Lumpur, Putrajaya, Malacca, Johor, Perak and Selangor. The targeted 6 items of E-waste to be collected are television, refrigerator, air-conditioner, washing machine, handphone and computer. The retailers that take part in this programme are Senheng Electric (KL) Sdn. Bhd., Recycling facilities involved Meriahtek and Shan

Poornaam Metals Sdn Bhd. As an example, in Malacca, Meriahtek(M) Sdn. Bhd. in collaboration with AEON to provide the first drive thru and drop off E-waste Collection Centre at AEON Bandaraya Melaka Shopping Centre under Program "E-waste Alam Alliance in Melaka". This program provides the convenient disposal of E-waste and voucher also provided to the residents which fulfil their requirement.

(ii) Mobile E-waste Joint Recycling Programme

"Mobile e-Waste: Old Phone, New Life" is a joint recycling programme by Malaysian Communications and Multimedia Commission (MCMC) and Malaysian Technical and Standards Forum Berhad (MTSFB) as the Technical Standards Forum under the Communications and Multimedia Act (CMA) 1998 (Act 588). The collections are done in a specially designed box (sponsored by the service providers such as DIGI, Celcom, Maxis, TM, U-Mobile and Altel. The collection is done more as Corporate Social Responsibility (CSR) initiative, not economic driven. currently, the mobile phones are collected from 74 outlets by Shan Poornam for further treatment. The coverage is still expanding. Furthermore, this recycling programme also MCMC's response to the Resolution 79. The role of telecommunications/information and communication technologies in handling and controlling E-waste from telecommunication and information technology equipment and methods of treating it) which is adopted in World Telecommunication Standardization Assembly (WTSA 12) in November 2012 (MCMC, 2015).

4.4.4.2 Low Willingness to Pay Recycling Fee

There have the challenges of low willingness to pay the recycling fee from the consumers. Thus, this is another criterion of awareness need to be second prioritised to

improve by conducting a survey to assess the public awareness regarding Household E-waste management in daily life. Questionnaire form can be distributed to the respondent in order to get the data and information on how they manage their Household E-waste as well as their perception of recycling fee for the implementation EPR in Malaysia. The proposed questionnaire form attached in Appendix A.

4.4.4.3 Lacking Household E-waste Inventory Data

Another challenge to develop this EPR model is lacking the Household E-waste inventory data in Malaysia. The inventories are important to determine existing and future of the E-waste and the existing capacity requirements for the treatment and disposal of E-waste as well as the existing collection and transport infrastructure. Thus, this is the other criteria of data collection need to be third prioritised to improve by collecting data in order start to develop the Household E-waste inventories data such as the electrical and electronic equipment (EEE) domestic manufacturing data, EEE import data, EEE export data and EEE domestic sales volume data. The E-waste generation data can be estimated by the EEE domestic manufacturing data + EEE import data – EEE export data, which also depend on the life span of the EEE.

4.4.4.4 Lack of Infrastructure (Collection Points)

Lack of infrastructure (collection points) also one of the challenges in implement the EPR model in Malaysia. The insufficient and not well-coordinated collection channels will affect the collection rate. Thus, this is the another criterion of technical need to be prioritized to improve by setting up of the collection points in different region is important in order to encourage the consumer to take their E-waste and dispose to their nearest collection points instead of disposing it together with the other municipal solid waste or sell it to the informal sectors.

4.4.4.5 Online Business

Online business also one of the challenges in implement the EPR model in Malaysia. As the online selling of the EEE is also one of the methods and also preferable to the consumer as convenient and saving time in nowadays. However, online business is not so similar concept with the authorised retailer shop which has the permanent shop and location, so that can accept and store the collected E-waste from consumers and need to register their business with Companies Commission of Malaysia (SSM). In this case, this is the another criteria of technical need to be prioritized for improvement by Customs Department is playing important role to control the import and export of EEE to sell it as online business as well have to ensure they play their role to collect the recycling fee from consumers and transfer it to manufacturer and also report the sales volume to FMB.

4.4.4.6 Lack of Investment

Competition among formal and informal Household E-waste recyclers, lack of investment to finance formal recycling facilities and manage the historical or orphanage Household E-waste also the challenge in implement the EPR model in Malaysia. Thus, this is the other criteria of finance need to be prioritised for improvement through the recycling fee and EPR fee which collected from the manufacturers or importers and consumers is important as to subsidy the licensing E-waste recyclers as well as to manage the historical or orphanage E-waste in the market.

CHAPTER 5:

CONCLUSIONS

The rapid growth of the technology causes the increase of the E-waste quantity generation in recent years. The concerns arise from E-waste such as hazardous material content in the E-waste are reported to bring adverse impacts to human health and the environment. To tackle this issue, a number of developed countries have made moves and successfully implemented EPR related policies to manage the E-waste. It is worth noting that, Malaysia at present is in the developing stage to formulate the EPR model in Household E-waste Management to mitigate the risks and concerns from E-waste.

Aim

Extended Producer Responsibility (EPR) model is a model that deemed to be suitable for managing Household E-waste in Malaysia. With Household E-waste management in Malaysia is still in the early stage, various parties of different background including the government, local authority, manufacturers, retailers, recycling facilities and consumers are recommended to work together to formulate and implement a sustainable E-waste management, to ensure better environmental quality for the future generation.

Objective 1: To identify the current status of Household E-waste Management in Malaysia.

DOE has finalised the legal framework regarding the management of the Household E-waste on 17th November 2014 with the assistances from the Japan International Cooperation Agency (JICA). However, it was understood that the EPR model of Household E-waste Management is still in the midst of development. As of now, the framework which aimed to proper manage of the Household E-waste consists of three key focus areas which are E-waste Flow, Fee Flow and Reporting Flow.

Objective 2: To identify and compare Household E-waste Management systems in other countries from the EPR perspective (Germany, Japan, Taiwan, Malaysia)

Germany, Japan and Taiwan have developed their E-waste recycling systems based on the EPR model where the physical responsibility, economic responsibility, and informative responsibilities are shared among the stakeholder such as manufacturers, retailers, recyclers, consumers and government. However, the details of their EPR models are varies attributed to the difference in economic and cultural contexts. However, their system is appropriate to act as a reference, which deemed applicable to Malaysia upon reasonable modification to suit the local context. It is important to note that on the studied system, the roles of all stakeholders, enforcement of the regulations and the existing conditions are defined and challenges are clearly identified prior to the implementation of EPR model.

Objective 3: To identify the mechanism implementation of sustainable EPR model for managing Household E-waste in Malaysia.

The EPR model has factored in some mechanisms to ensure it able to work in a sustainable manner. Mechanisms that were considered covered the regulation, E-waste inventory, collection mechanism, reporting mechanism, recycling mechanism, fee mechanism and Fund Management Board mechanism. The upstream of manufacturers play an important role to pay the EPR fee in order to subside the downstream collection and recycling E-waste activities and changes the design of the product in order to minimise the environmental impacts. Consumers also play an important role to pay recycling fee as also one of the subsidies to recyclers. Meanwhile, environment awareness needs to be raised amongst consumer specifically on day-to-day behaviour such as "Polluter Pay Principle" and send the E-waste to the authorised waste collectors. The downstream retailers and waste collectors physical contribution to collect the E-waste

and deliver to licensing Full Recovery Facilities. In addition, the government also play an important role in enforcing the regulation of the EPR system and keeping control on the informal sectors. The manifest system and auditing are essential to ensure proper E-waste reporting and fee management by the Fund Management Board to subside the recyclers. The success of the EPR model depends on the implementation mechanism and also required the constant monitoring of the effectiveness of the regulations.

Objective 4: To develop a summarise sustainable EPR model for managing Household E-waste in Malaysia and overall recommendation.

There are a number of challenges in implementing this EPR model however the success is foreseeable with the cooperation from all stakeholders such as manufacturers, retailers, consumers, recyclers, waste collectors, government as this EPR model is based on the basis of responsibilities sharing among all stakeholders in order to proper manage this E-waste and ensure no leaking to the informal sector.

Recommendation for Future Works

Since the involvements of all stakeholders are important in order to successfully implement this EPR model, thus, the perception and opinion from manufacturers, retailers, consumers, recyclers, waste collectors such as their willingness to participate , willingness to pay, manpower to support , availability of technology and sales data, as well as the Household E-waste generation data, are crucial. . However, this information is not being studied in this project and hence, it is recommended as further research and survey, which focus area is on the perception from manufacturers, retailers, consumers, recyclers, waste collectors towards the implementation of EPR model to manage Household E-waste Management in Malaysia.

On a separate note, the research can be further extended towards the Household E-waste Inventory Data, which is currently not available in Malaysia, Hence, the

collection of Household E-waste data are required, which then able to facilitate the analysis in determining existing and future of the E-waste as well as existing capacity requirements for the treatment and disposal of E-waste as well as the existing collection and transport infrastructure.

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APPENDIX A

SURVEY FORM
(CONSUMERS PERCEPTION FOR THE IMPLEMENTATION EPR MODEL TO MANAGE HOUSEHOLD E-WASTE IN MALAYSIA)

KXGS 6181: RESEARCH PROJECT

Master of Engineering (Safety, Health and Environment)

Title: Sustainable Extended Producer Responsibility (EPR) model for managing Household E-waste in Malaysia.

Please tick (√) on the relevant questions.

Part A: Profile of Respondent

1. Gender:
   ( ) Male ( ) Female

2. Age:
   ( ) 13-19 ( ) 20-35
   ( ) 36-58 ( ) >58

3. Types of Premises:
   ( ) Flats ( ) Condominiums ( ) Apartments
   ( ) Terraces ( ) Semi-detached ( ) Bungalow
   ( ) OTHERS: _____

4. What is size of your household?
   ( ) 1 person ( ) 2 persons
   ( ) 3 - 4 persons ( ) 5 - 6 persons
   ( ) 7 – 8 persons ( ) OTHERS: _____

5. Highest Level of Education :
   ( ) None ( ) Pre-University – *STPM, Matriculation, A-Levels*
   ( ) Primary ( ) Professional Diploma
   ( ) Secondary ( ) Undergraduate / Postgraduate
   ( ) OTHERS: _____

6. Employment Status:
   ( ) Unemployed ( ) Self-employed
   ( ) Government Sector ( ) Housewife
   ( ) Private Sector ( ) Student
   ( ) OTHERS: _____

7. Individual Monthly Income (RM):
   ( ) no income ( ) < RM1,500
   ( ) RM 1,500-3,000 ( ) RM 3, 000 - RM 5,000
   ( ) > RM 5,000

Please tick (√) or ranking on the relevant questions.

Part B: Survey of View on E-waste Management & Disposal Practice

(*E-waste = Electrical and electronic waste ; EPR = Extended Producer Responsibility)

Single answer – Respondent can only select one answer

Multiple answers – Respondent can select one or more than one answer

Ranking answer - Please rank your answer according to the order of importance, e.g. 1 (being the most important),whilst 4 being the least important.

8. What are the factors that you will consider before purchasing any electrical and electronic appliances? ***(Ranking Answer: Please rank from 1-4)***
   ( ) Price ( ) Hazardous substances content
   ( ) Energy consumption / energy saving ( ) Quality of the product
   OTHERS (Please Specify): _____

9. What are the reasons that drive towards the disposal of an electrical and electronic appliances?
   (Ranking Answer: Please rank from 1-4)
   ( ) End of lifespan ( ) Outdated
   ( ) High repair cost ( ) New products are cheap
   OTHERS (Please Specify): _____

10. How do you dispose **large** electrical and electronic appliances (eg: refrigerator, TV, air-conditioner, washing machine) during end of its operational life? ***(Multiple Answer)***
    ( ) Dispose as household waste ( ) Send to recycling /collection centre
    ( ) Store in own premises ( ) Donate to charity centre
    ( ) Sell to scrap collector ( ) Sell as second hand equipment
    ( ) Pay to retailers to dispose it when purchasing a new product
    ( ) OTHERS (Please Specify): _____

11. How do you dispose **small** electrical and electronic appliances (eg: handphone, laptop, camera) during end of its operational life? ***(Multiple Answer)***
    ( ) Dispose as household waste ( ) Send to recycling /collection centre
    ( ) Store in own premises ( ) Send to collection boxes in the public places
    ( ) Sell to scrap collector ( ) Sell as second hand equipment
    ( ) Donate to charity centre
    ( ) Trade-in when purchasing a new product
    ( ) OTHERS (Please Specify): _____

Please tick (√) or ranking on the relevant questions.

Part C: Survey of View on E-waste Collection Infrastructure

(*E-waste = Electrical and electronic waste ; EPR = Extended Producer Responsibility)

12. Are you aware of any collection/buy-back centres around your residential area to collect
    E-waste?
    (Single Answer)
    ( ) Yes ----*Proceed Q13*
    Please specify the collection/buy-back centre location:_____

    ( ) No----*Proceed Q14*

13. If yes, how do you know for the collection/buy-back centres around your residential area to collect E-waste? ***(Multiple Answer)***
    ( ) Mass media ( ) Campaign / Exhibition
    ( ) Family ( ) Internet
    ( ) OTHER (Please Specify):_____

14. Which of the following is your preferred **small appliances** of E-waste collection infrastructure? ***(Ranking Answer: Please rank from 1-4)***
    ( ) Collection boxes in the public places ( ) Collection by retailers
    ( ) Collection/buy-back centres ( ) Post to manufacturer
    OTHERS (Please Specify): _____

Part D: Survey of View on E-waste Recycling Fee

(*E-waste = Electrical and electronic waste ; EPR = Extended Producer Responsibility)

15. Are you willing to pay extra for the E-waste recycling fee when you buy a new electrical and electronic appliances? ***(Single Answer)***
    ( ) Yes ----*Proceed Q16*

    ( ) No ----*Proceed Q18*
    Please specify the reason for not willing to pay recycling fee :
    _____

16. If do, how many percentage of E-waste recycling fee can you accept to pay? ***(Single Answer)***
    ( ) 1% - 5% of the product selling price
    ( ) 6% - 10% of the product selling price
    ( ) 11% -15% of the product selling price
    ( ) 16% - 20% of the product selling price

17. Which of the following is your preferred payment pattern for E-waste recycling fee?
(Ranking Answer: Please rank from 1-3)

( ) Deposit system ( ) Embedded in product price
( ) Paid during disposal
OTHERS (Please specify):_____

18. In your opinion, which party/parties is/are responsible to pay for the E-waste recycling fee?
(Multiple Answer)

( ) No idea ( ) Manufacturer
( ) Government / Stakeholder ( ) Consumer

19. In your opinion, what are the factors that motivate you to bring the small appliances of E-waste to the authorized collection / buy back centres?
(Ranking Answer: Please rank from 1-4)

( ) Gift voucher ( ) Environment concern
( ) Cash ( ) Law enforcement
OTHERS(Please specify): _____

Part E: Survey of Online Purchasing Electrical & Electronic Appliances

(*E-waste = Electrical and electronic waste ; EPR = Extended Producer Responsibility)

20. Do you purchase electrical and electronic appliances via online shopping? ***(Single Answer)***

( ) Yes ----*Proceed Q21* ( ) No----*Proceed Q23*

21. If yes, which of the following electrical and electronic appliances are your preferred to purchase via online shopping? ***(Multiple Answer)***

( ) Small household appliances eg: hair dryer, clock,vacuum cleaners,coffee machine, etc.
(Please specify):_____

( ) Large household appliances, eg: TV,washing machine, refrigerator, air conditioner, etc
(Please specify):_____

( ) Lighting equipment, eg: fluorescent lamp, bulb
(Please specify):_____

( ) Leisure and toy equipment, eg: video game, toys
(Please specify):_____

( ) IT and telecommunication equipment, eg: laptop, computer, handphone, telephone, printers, etc
(Please specify):_____

( ) OTHERS (Please specify):_____

22. What are the factors that encourage you to purchase electrical and electronic appliances via online shopping? ***(Ranking Answer: Please rank from 1-4)***

( ) Convenience ( ) Price
( ) Wider selection ( ) Saving time
OTHERS (Please specify): _____

Part F: Survey of View on Environment Awareness
(*E-waste = Electrical and electronic waste ; EPR = Extended Producer Responsibility)

23. Are you aware of the **social consequences** of the improper disposal of E-waste? ***(Multiple Answer)***

( ) No idea ( ) High cost of proper disposing E-waste
( ) Visual pollution ( ) Community exposed to health hazards

24. Are you aware of the **environmental consequences** of the improper disposal of E-waste? ***(Multiple Answer)***

( ) No idea ( ) Soil / water contamination
( ) Reduce landfill capacity ( ) Depletion of natural resources

25. Are you aware of electric and electronic appliances with 3R (reduce, reuse and recycle) can conserve natural resources? ***(Single Answer)***

( ) Yes ----*Proceed Q26* ( ) No----*Proceed Q27*

26. If yes, what is/are the valuable resources can be conserved from recycling E-waste? ***(Multiple Answer)***

( ) Metals ( ) Glass
( ) Plastic ( ) Energy

27. Have participate any E-waste awareness/ recycling programme before? ***(Single Answer)***

( ) Yes ----*Proceed Q28* ( ) No----*Proceed Q29*

28. If yes, where do you get the information? ***(Multiple Answer)***

( ) Education ( ) Mass media
( ) Family ( ) Campaign / Exhibition
( ) Company training ( ) Internet
( ) OTHERS (Please Specify):_____

29. In your opinion, what are the most effective ways to encourage proper collection of E-waste in Malaysia? ***(Ranking Answer: Please rank from 1-5)***

( ) Education ( ) Mass media
( ) Law enforcement ( ) Campaign / Exhibition
( ) Internet
OTHERS(Please Specify): _____

30. In your opinion, what are the factors that hinder proper collection & recycling of E-waste in Malaysia? ***(Ranking Answer: Please rank from 1-4)***

( ) Awareness ( ) Insufficient of regulation enforcement

( ) Insufficient of recycling facilities ( ) Inconvenient of collection point

OTHERS (Please Specify): _____

----------End of Questionnaire----------

THANK YOU FOR YOUR PARTICIPATING IN THIS SURVEY