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IMPACT ASSESSMENT OF THE EXTENDED PRODUCTION RESPONSIBILITY IMPLEMENTATION IN VIETNAM: A STUDY ON ELECTRONIC WASTE MANAGEMENT

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ABSTRACT

The electronic waste is now raised in Vietnam as emerging issue, not only by its impact on the environment and public health, but also the chance to utilize the natural resources. In order to sustainable management of major urban-mine sources, including e-waste, an Extended Producer Responsibility (EPR) system is proposed under the Decision 16/QĐ-TTg dated 22, May, 2015, to extend the responsibility of producers to the end-of-life product. In this study, the Material Flow Analysis and Policy assessment tool are applied to assess the impact of the EPR system, in case of large home appliances and to find the obstacles on the implementation of the system. Among the experimental appliances, air conditioner has the highest rate of valuable materials and also the highest rate of recyclable materials, then follows the refrigerator, washing machine and desktop computer. On the opposite, Cathode Ray Tube (CRT) monitor has the highest rate of hazardous compounds, where washing machine has no hazardous matter. Three scenarios were developed and assessed based on the obtained benefit–cost from dismantled material and hazardous waste. It is shown that the role of intermediate stakeholders, the infrastructure for e-waste treatment and monetary distribution flows under the pressure of legislation are the main factors that caused failure in the application of the EPR system in Vietnam.

Keywords: e-waste, Extended Producer Responsibility, Material Flow, policy assessment

1. INTRODUCTION

The electronic waste (e-waste) is now raised in Vietnam as an emerging issue, due to not only the increasing rate, but also the social and environmental impacts from the flow of e-waste [1]. Up to present, e-waste is mostly under the control of the informal sector, and thus, causes a lot of concerning issues on the environmental risk [2, 3], the loss of natural resource [1, 4] and the trans-boundary flow of e-waste, where Vietnam is pointed out as an entre-port [4, 5].

In 2013, the Prime Minister's Decision No. 50/2013/QĐ-TTg dated 9th, August, 2013 (then is replaced by the Decision No. 16/2015/QĐ-TTg dated 22, May, 2015) on Prescribing Retrieval and Disposal of Discarded Products has been issued as the first legislation in Vietnam that

defined the application of Extended Producer Responsibility (EPR) system for the discarded products, including e-waste. The Decision have been defined the responsibility of producers/importers to the retrieve and treat of their discarded products. Thus, the collection network and treatment/recycling center should be reformed to handle the generated e-waste all over the country. Nevertheless, it is found many difficulties in the system that cannot be overcome in the present, due to the infrastructure needed to manage the collection, treatment, or the recycling of e-waste [1].

It is very important to reveal the material flow in the e-waste system of developing countries as well as its benefit. For the obsolete recycling system in the developing countries, Streicher-Porte et.al [6] mentioned that process – based Material Flow Analysis (MFA) was a possible approach. Widmer et.al [7] also suggested the possibility of the MFA in assessing the recycling system. This research aimed to assess the dynamic pressure of Decision 16 for the operation of EPR system and then, the impact of the EPR system on the flow of e-waste by using Material Flow Analysis.

2. MATERIALS AND METHODS

2.1. Field Survey Information

The field survey is needed to clarify the flow of the discarded large home appliances including desktop computer (with Cathode Ray Tube monitor), refrigerator, washing machine and air conditioner. In this research, the survey information is obtained from our previous work on e-waste inventory in the urban area of Hanoi in the period 2012-2013 [6]. There were 401 households, 20 small companies, 20 service shops (junk shops), 20 collectors and 20 dismantlers were personally interviewed. The major investigated information is focused on the number of using home appliances and discarded appliances in households, the ways to discard large home appliances, the situation of the dismantling process, the way to treat with different parts of e-waste as well as the financial flow of e-waste (input and output price of materials).

2.2. Experimental work

The sampling large home appliances were collected from households in Hanoi area during the period 2012-2014. The experiment was conducted in the pilot system for e-waste dismantling and recycling that is installed in the School of Environmental Science and Technology (INEST), Hanoi University of Science and Technology at the same time. The system is equipped with multi-size air screw-driving and rolling table, when the appliances are dismantled. Besides, weighing instrument, nipper, cutter machine, brushing, protective clothing and plastic containers are also used.

Considering the capacity of recycling technology in Vietnam at the present time, it is aimed to dismantle the experimental appliances into printed circuit board (PCB), glass, plastic, rubber, copper, iron, aluminum, magnetic, cellular, concrete and lamination parts/devices. Besides, the hazardous materials from these appliances are also recovered, including CRT glass (from CRT monitor), coolant, insulating oil and the PCB in each appliance.

2.3. Material Flow Analysis

To date, the flow of discarded home appliances in Vietnam is described in detail by Huynh et.al (2015) [1]. At the present time, only copper, iron/steel, aluminum and some kinds of plastic are evidently recycled in Vietnam and the rest, including CRT glass, PCB, coolant/insulating oil and other small part/device are disposed or exported after dismantling.

3. RESULTS AND DISCUSSIONS

3.1. Material contain of large home appliances

The experimental results are shown in Table 1. In this research, the small part is not counted and classified into other material group. In fact, this type of material is normally discarded into the domestic waste due to its small volume. It is very difficult for recycling, due to the fact that Vietnam is lacking of fully treatment line for the whole appliance at the moment and in the near future.

Table 1. Material contain of major large home appliances.

Materials	Desktop Computer		Refrigerator		Washing Machine		Air Conditioner	
	Weight, kg/unit	Rate, kg/kg	Weight, kg/unit	Rate, kg/kg	Weight, kg/unit	Rate, kg/kg	Weight, kg/unit	Rate, kg/kg
Plastic case*	1.95–2.35	0.1	-	-	-	-	-	-
Other plastic**	0.04–1.23	0.03	13.7–24.2	0.38	4.26–9.4	0.22	4.06–8.6	0.20
CRT glass	9.05–11.35	0.47	-	-	-	-	-	-
Glass	-	-	0–3.8	0.02				
Copper	0.11–0.35	0.01	1.86–2.34	0.06	1.88–2.56	0.08	2.9–5.40	0.12
Aluminum	0.44-0.83	0.03	0.67–3.43	0.03			2.14–4.0	0.10
Iron/steel	2.77-4.12	0.17	14.58–56.33	0.47	11.67-21.1	0.52	8.76-26.20	0.52
PCB	1.1–1.9	0.08	0.02–0.03	<<	0.24–0.94	0.02	0.33–0.6	0.01
Coolant /Insulating oil	-	-	0.63–0.93	0.02	-	-	0.35–0.76	0.02
Defrost timer (Hg)	-	-	0.05	<<	-	-	-	-
Concrete	-	-	-	-	0–5.08	0.07	-	-
Balance solution	-	-	-	-	1.14–1.82	0.04	-	-
Electronic element	1.46-1.77	0.07						
Solid waste***	0.63–1.08	0.04	0.48–1.47	0.02	0.63–1.92	0.05	0.53–1.73	0.03

: Including ABS, HIPS, ABS/PC, PPO, BFR, etc.; **: Including PU, ABS, PC, PPO; *: Including rubber, paper, plastic, tape, cloth, tin, glass and other un-usable small parts/devices*

Among the experimental appliances, air conditioner has the highest rate of valuable materials and also the highest rate of recyclable materials, then following the refrigerator and washing machine. On the air conditioner, there is a large volume of iron/steel, then following

plastic, copper and aluminum. For the washing machine, iron/steel is the highest volume, then following plastic and copper. The PCB in a washing machine has lowest weight and wt. %. Where iron/steel and plastic are the most abundant materials of refrigerators, it is also contained remarkable volume of copper and small volume of aluminum. The desktop computer has lowest rate of recyclable materials, which is composed of iron/steel, plastic, then follows aluminum and copper. For the related stakeholders such as dismantlers or exporters, the PCB and CRT glass also can be counted as valuable material (since they are exported illegally). On the opposite, CRT monitor has the highest rate of hazardous compounds, mostly come from leaded – glass (funnel glass), plastics that contain brominated flame retardant and PCB, where washing machine has no hazardous matter. The air conditioners and refrigerators have a coolant (old version that used CFC) and insulating oil that is needed to collect and treat safety, but in small volume. Besides, it is needed to take into account the defrost timer in refrigerator that contained mercury, even the weight is very small. Among the recyclable material, copper has the highest value, then following aluminum, iron and plastic, as seen in Table 2. Certainly, if the element/device or part of these appliances can be reused in the remanufacturing or refurbishing process, their value could be increased much higher.

3.2. Benefit estimation from e-waste dismantling

Since in Vietnam, the major process for e-waste handling is mostly dismantling [1], and based on our previous work [8], a simple material flow is drawn to describe the kinetic of existing systems as seen in Fig. 1.

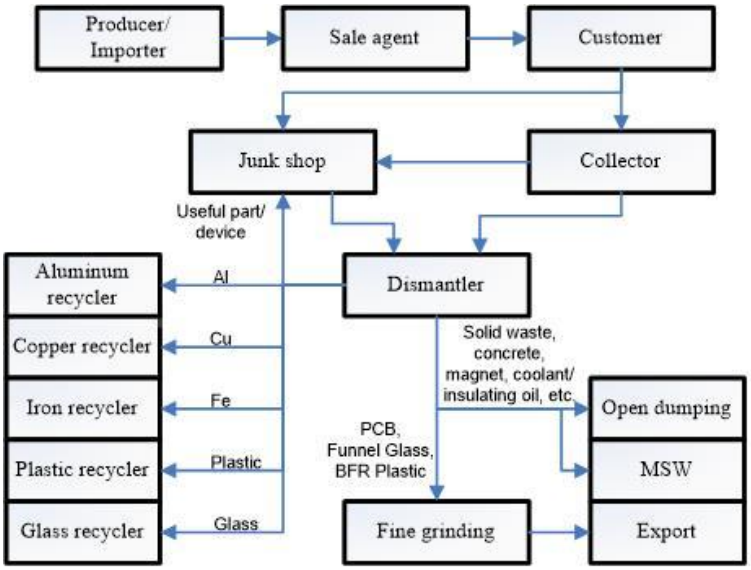

Figure 1. Current material flows from discarded home appliances.

The common benefits of the dismantling process are summarized in Table 2 where the values are just adopted for the end-of-life appliance. Due to the volume of material, it is found that the dismantlers can obtain the highest benefit then follow the exporter, collector and customer. We did not take into account the junk shop, where the higher benefit can be obtained from the reassembling discarded appliance.

Table 2. Benefit value of the dismantling process of large home appliances,

Material	**Price (VND/kg)**	**Total benefit (VND/kg unit)**			
		Desktop computer	**Refrigerator**	**Washing Machine**	**Air Conditioner**
Other plastic	6,000	64.38	2,273.41	1,321.06	1,232.64
White glass	500		10.67		
Copper	120,000	2265.21	6,702.93	9,013.73	14,350.98
Aluminum	30,000		913.16		2,958.70
Iron/steel	5,000	213.91	2,358.3	2,610.53	2,599.63
Sub selling (1): recyclable materials		***2,543.5***	***12,258.47***	***12,945.32***	***21,141.95***
PCB*	20,000	1,455.83	11.65	415.96	282.46
BRF plastic*	3,000	565.80			
CRT glass*	300	193.13			
Sub selling (2): exported materials		***2,214.76***	***11.65***	***415.96***	***282.46***
Sub cost (1): input cost **		-2,000	-8,000	-8,000	-10,000
Sub cost (2): solid waste treatment		0	0	0	0
Sub cost (3): hazardous waste		0	0	0	0
Total (sub selling – sub cost		**2,758.26**	**4,270.12**	**5,361.28**	**11,424.41**
Scenarios 1: the operation of dismantlers and exporters are under the control of legislation. In this case, BFR plastic, CRT glass and PCB should be considered as hazardous waste, and should be treated by the licensed enterprise					
Sub selling		***2,543.5***	***12,258.47***	***12,945.32***	***21,141.95***
Sub cost (1)		2,000	8,000	8,000	10,000
Sub cost (2)	0	<<	<<	<<	<<
Sub cost (3)	10,000,000	***-4,880,000***	**<<**	**<<**	**<<**
Total		**-**	**4270.12**	**5361.28**	**11,424.41**
Scenarios 2: the operation of dismantlers and exporters are under the control of legislation. In this case, BFR plastic, CRT glass and PCB should be considered as recycled materials					
Sub selling		***2,543.5***	***12,258.47***	***12,945.32***	***21,141.95***
Sub cost (1)		-2,000	-8,000	-8,000	-10,000
Sub cost (2)	<<	<<	<<	<<	<<
Sub cost (3)					
PCB	120,000	***14,849***	***118.81***	***4,242.77***	***2,881.12***

Material	Price (VND/kg)	Total benefit (VND/kg unit)			
		Desktop computer	**Refrigerator**	**Washing Machine**	**Air Conditioner**
BRF plastic*	5,000	***943***	-	-	-
CRT glass*	500	***321.88***	-	-	-
Total		**16,657.38**	**4,377.28**	**9,188.09**	**14,023.07**

*: for export; ** maximum estimation, depending on the weight and type of appliances.

3.3. Impact assessment of EPR system

The Decision 16/2015/QĐ-TTg allows keeping the operation of informal sectors, including the collectors and dismantlers, but takes control the operation of waste disposal and exporting. It means that the export flow should be abandoned, and the waste disposal must be accompanied the legislation. In case of e-waste, if there is no formal recycling process for CRT glass, BFR plastic that contained PBDE/PBDD and the PCB, they should be treated as hazardous waste in the licensed treatment enterprise. According to our previous work [1] these wastes are still cannot be recycled in Vietnam at the moment due to the actual benefit. That is also the reason to explain why the electronic waste from industry can be handled by these enterprises, since they are paid to treat the waste. Thus, if the government does not have sufficient legislation to control the operation of the dismantlers, the Decision 16 cannot be successfully applied.

In this study, 3 scenarios are developed and assessed based on the obtained benefit, which is supposed to be a major dynamic factor for the system, as summarized in Table 2. It is found that, despite of the hazardous waste, the obtained benefits from electronic appliances are almost similar in case of large home appliances excluding the desktop computer. The situation is found similar to China and Thailand [9] as described by Kojima *et.al.* Nevertheless, when Vietnam cannot recycle the hazardous waste, it is found that the desktop computer cannot be collected and recycled due to the high cost of hazardous waste treatment by the collection and dismantling, which is similar to the case of Cathode Ray Tube Television – CRT TV [10]. Considering that at the present time, the operation of exporter and informal dismantlers will be banned and the dismantlers has still keeping the benefit for large home appliances without environmental cost (related to the hazardous waste), there will be no change of the management system as seen on the scenarios 2. On the other hand, when the proper recycling technology can be applied in Vietnam as pointed out by [1], the benefit will be raised without the interference from environmental cost, and thus, make the dynamic sector pushing on.

4. CONCLUSION

This is very first data on the assessment of recycling rate and benefit for large home appliances in Vietnam. It is found that under the impact of benefit, the role of intermediate stakeholders, the infrastructure for e-waste treatment and monetary distribution flows under the pressure of legislation are the main factors that caused failure in the application of the EPR system in Vietnam. It is needed to develop a better technology for utilizing the PCB and CRT glass, as well as the plastic cabinet in Vietnam, for the increase of benefit from the recycling

process and reducing the cost of hazardous treatments, thus, allows Vietnam to successfully control the e-waste as a secondary resource instead of waste.

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