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Tóm tắt

Trong bối cảnh bùng nổ công nghệ trên toàn thế giới, rác thải điện và điện tử đã trở thành một vấn đề cấp bách bởi nó gây ra những mối nguy hại lớn đối với sức khỏe con người và môi trường, từ đó thúc đẩy các quốc gia xây dựng một giải pháp quản lý nguồn rác thải này một cách có hệ thống. Thụy Sĩ là quốc gia tiên phong xây dựng quy trình quản lý toàn diện về thu gom, phân loại, vận chuyển, tái chế, xử lý và báo cáo rác thải điện tử với sự phối hợp chặt chẽ của khu vực chính thức. Trong khi đó, tại Việt Nam, với sự tham gia chủ yếu từ khu vực phi chính thức, quá trình xử lý rác

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thải điện tử còn kém hiệu quả và tồn đọng những tác động tiêu cực đến môi trường. Vì vậy, thông qua phân tích hệ thống quản lý rác thải điện tử ở Thụy Sĩ và Việt Nam, nhóm tác giả đề xuất một số khuyến nghị nhằm nâng cao hiệu quả quản lý rác thải điện tử tại Việt Nam.

Từ khóa: Rác thải điện tử, thiết bị điện và điện tử, hệ thống quản lý

ANALYSIS ON E-WASTE MANAGEMENT SYSTEM IN SWITZERLAND AND LESSONS FOR VIETNAM

Abstract

In the context of the technology boom around the world, electrical and electronic equipment disposal has become one of the most critical issues worldwide that causes enormous threats to human health and the environment, which pushes countries worldwide to build a systematic method to manage it. Among them, Switzerland has been a pioneering nation to develop a comprehensive management process of collecting, sorting, transporting, recycling, disposing, and reporting e-waste with the harmonized coordination of formal sectors. On the other hand, Vietnam mostly just includes informal sectors in the process of e-waste handling, which appears to be less effective and still causes negative impacts on the environment. Therefore, by thoroughly analyzing the e-waste management system in both Switzerland and Vietnam, the authors propose some recommendations for Vietnam to enhance the effectiveness of e-waste management.

Keywords: E-waste, electrical and electronic devices, management system

1. Introduction

Electrical and electronic waste, or "e-waste," has increased due to the growing usage of electronic gadgets around the world, creating a severe risk to both the environment and human health. The World Health Organization (WHO) claims that improper e-waste disposal has resulted in harmful substances being released into the air, water, and land, endangering both human health and the ecosystem. As a result, a suitable managing procedure must be implemented to safeguard both current and future generations.

To examine a comprehensive e-waste management system, Switzerland is chosen as a case study in this research for several reasons. First, Swiss e-waste management program offers a simple, and transparent system that is well designed and defined in terms of history, roles and responsibilities of all stakeholders, system financing, performance and performance indicators, policy, and other factors. Second, in terms of performance in an international comparison, Switzerland not only meets minimum collection and recycling targets set by the EU, but also performs better. Third, Switzerland is particularly active in providing information about e-waste including latest news, and events.

On the other hand, in Vietnam - a developing country with a rapidly growing economy, e-waste management is still in its infancy and there is a lack of proper regulations and infrastructure in place. This has resulted in e-waste accumulation and illegal dumping, resulting in serious environmental pollution. As a result, identifying opportunities and barriers in the implementation of an effective e-waste management system in Vietnam has become an urgent issue for sustainable economic development and improved living standards.

Recognizing these concerns, the objective of this research is to assess the Swiss e-waste

management system and identify any lessons that Vietnam can apply. It will present recommendations for improving e-waste management in Vietnam by looking at policies, regulations, and infrastructure in both countries, such as implementing effective regulations, establishing proper disposal channels, and developing awareness campaigns to promote effective e-waste disposal.

The findings of this study can help Vietnam develop effective e-waste management systems, reducing the environmental and health risks associated with e-waste disposal. This study may serve as a helpful material for policymakers, academics, and industry professionals in both Switzerland and Vietnam, as well as other developing countries who wish to enhance their e-waste management systems.

2. Literature review

2.1. Research on e-waste management system in Switzerland

A study of T-Dashkova (2012) said that a pioneer in tackling e-waste issues and developing strict environmental programs is Switzerland. Since 1990, Switzerland has been involved in the deployment of e-waste management solutions and has gone through a process of trial and error to do so (Bandyopadhyay, 2010). Switzerland is the first nation to have formalized a system to manage electronic trash (Khetriwal et al., 2005).

The Swiss e-waste management program offers a straightforward and transparent system that is well designed and defined in terms of history, the roles and responsibilities of all stakeholders, system financing, performance indicators, legislation, and other factors (Bandyopadhyay, 2010; Khetriwal et al., 2005). The government has set up a network of collection points across the country where consumers can drop off their old electronic devices for recycling.

Several studies have examined the effectiveness of the Swiss e-waste management system. For example, one study by Widmer et al. (2005) found that the system was effective in reducing the amount of e-waste that ends up in landfills. The study noted that the collection and recycling of e-waste had increased significantly since the introduction of Swiss e-waste management system.

2.2. Research on e-waste management system in Vietnam

In contrast, Vietnam's e-waste management system faces several challenges, including a lack of awareness among the public, inadequate infrastructure for e-waste collection and recycling, and insufficient regulations to control the import and export of e-waste. According to a study of Duc-Quang Nguyen (2017), the Extended Producer Responsibility (EPR) application in Vietnam is a process to formalize the dismantling and recycling sector and contribute to the utilization of natural resources, but there are obstacles related to the financial responsibility and capacity of the recycling system. He also stated that illegal actions such as smuggling of appliance and waste, or the refurbishing of appliance should be affected to the operation of the EPR system.

Overall, the research indicates that Vietnam and other nations looking to solve the issues of e-waste management can learn a lot from Switzerland's e-waste management system. The Swiss e-waste management program is regarded as a comprehensive program because to its long history and track record in managing e-waste, performance rate, widely accessible and trustworthy information, and high consumer awareness of e-waste. As a result, the Swiss program offers many insightful lessons that can help Vietnam's program.

3. Overview on e-waste management

3.1. Definition of e-waste

E-waste is a new category of waste brought about by the rapid creation of electrical and electronic equipment. This waste has advanced electronic technology and increased product availability (Van de Merwe, 2009). In the world, e-waste makes up 8% of municipal solid garbage (Babu et al., 2007).

E-waste doesn't have a common definition (Widmer et al., 2005). The term "e-waste" refers to a variety of electrical and electronic devices whose owners no longer want them (Widmer et al., 2005). Any electrically powered gadget that has reached the end of its useful life is considered e-waste (OECD, 2002). E-waste is defined as all parts and subassemblies of electrical and electronic equipment at the time of disposal under the EU's WEEE Directive (EU, 2003a). The EU member nations as well as other nations in Europe, including Switzerland, recognize this definition (UNEP, 2007). In Ontario, "e-waste" is defined as electrical and electronic equipment that needs a battery or an electric current to operate and has reached the end of its useful life (OES, 2008; Whitney and Webb, 2008). Electrical and electronic equipment that has been abandoned by its original users is referred to as "e-waste" (Puckett et al., 2002).

3.2. Principles of of e-waste management

The principle of e-waste management is to responsibly manage the disposal and recycling of e-waste in a way that minimizes the impact on the environment and human health as follows:

Firstly, reduce: to reduce the amount of electronic waste generated in the first place.

Secondly, reuse: to reuse electronic products that are still functional.

Thirdly, recycle: to recycle electronic waste that cannot be reused.

Fourthly, responsible disposal: to dispose of electronic waste that cannot be recycled in an environmentally responsible manner.

Overall, the principles of e-waste management aim to reduce the amount of electronic waste generated, promote the reuse of functional devices, recover valuable materials through recycling, and ensure the safe and responsible disposal of waste that cannot be reused or recycled. Two popular fundamentals that e-waste management is based on are circular economy and Extended Producer Responsibility (EPR).

3.3. Current situation of e-waste management worldwide

Electrical and electronic equipment has emerged as the most important component of our daily lives. Global demand for these equipments is surging by the year and huge quantities of outdated equipment are being dumped in landfills, that caused enormous threats to our health and environment due to unsustainable methods of treatment. According to the most recent reports by the United Nations in 2021, worldwide e-waste generation is predicted to reach a massive amount of 57.4 million metric tonnes. This is expected to increase to 74.7 million metric tonnes by 2030.
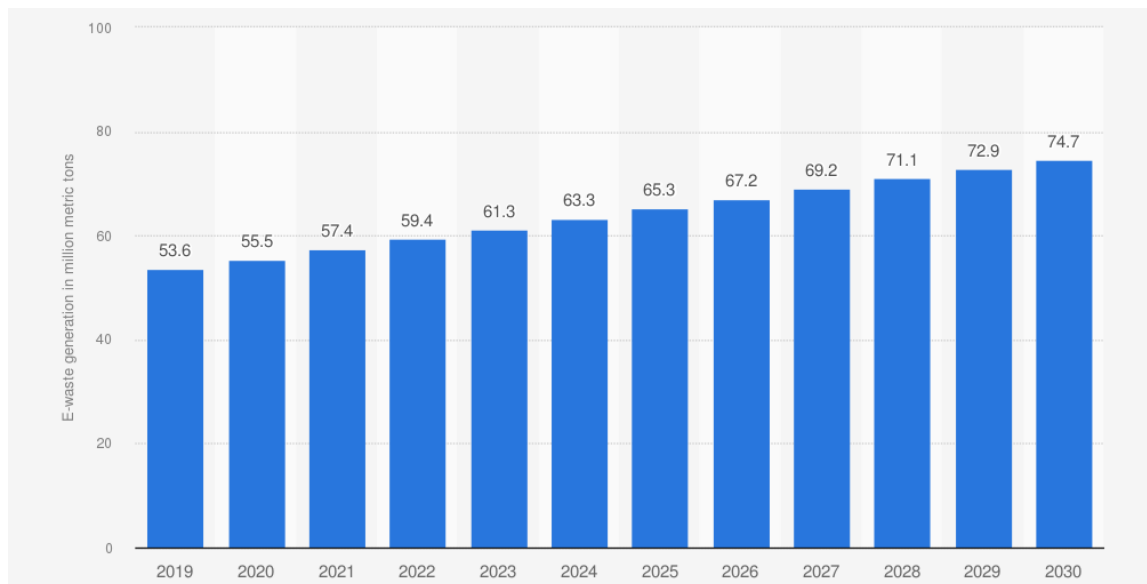
Figure 1. Projected electronic waste generation worldwide from 2019 to 2030

Source: United Nations University (2023)

Many countries, especially in low- and middle-income regions, have poor e-waste management practices which can lead to serious environmental and health risks. For example, a study conducted in Ghana found that 85% of e-waste was informally recycled, often using methods that release toxic chemicals into the environment. Informal recycling practices, such as burning or dismantling e-waste, can release toxic chemicals into the air and water, and expose workers to harmful substances.

Besides, many governments lack the regulatory frameworks to manage e-waste effectively. According to a report by the World Health Organization, only 78 out of 193 countries have e-waste legislation in place. In addition, enforcement of existing legislation is often weak, and there is a lack of funding for e-waste management activities.

It should also be noted that there is a significant lack of infrastructure for e-waste management in many countries. According to the Global E-waste Monitor, only 17.4% of the e-waste generated in 2019 was collected and properly recycled. In addition, many countries lack the necessary facilities for safe e-waste disposal and recycling, which can lead a significant amount of e-waste being exported to other countries, often illegally, where it is processed in unsafe conditions.

On the bright side, there has been some progress in e-waste management in certain regions with the development of recycling facilities, the establishment of e-waste collection programs, and the introduction of regulations to control e-waste. For example, the EU has implemented a comprehensive e-waste management framework that requires producers to take responsibility for the disposal of their products. In addition, some countries, such as Japan and South Korea, have implemented successful e-waste recycling programs. However, progress is slow, and there is a need for more investment in e-waste management infrastructure and regulatory frameworks.

Overall, the situation of e-waste management worldwide is a significant challenge that requires a concerted effort from governments, the private sector, and civil society to address. The

problem is likely to continue to grow as electronic products become more prevalent, and urgent action is needed to address this issue in a sustainable and responsible manner.

4. Analysis on e-waste management system in Switzerland

4.1. Main responsible organizations of managing e-waste

In Switzerland, several organizations are responsible for managing the e-waste system. The Swiss Federal Office for the Environment (FOEN) is the main government agency responsible for developing and implementing policies and regulations related to waste management, including e-waste. The FOEN works closely with other federal agencies, such as the Federal Office of Energy and the Federal Office of Public Health, to coordinate e-waste management efforts. They also provide guidance and support to other organizations involved in e-waste management.

Secondly, Swiss Association for the Collection and Recycling of Electrical and Electronic Waste (SENS) is a non-profit organization that operates a national collection system for e-waste in Switzerland. It works with municipalities, retailers, and other stakeholders to ensure that e-waste is properly collected and transported to authorized treatment facilities, and also works with the government to develop and implement policies and regulations related to e-waste management.

Thirdly, Swico Recycling is a subsidiary of Swico - the Swiss Association for the Information, Communications, and Organizational Technologies. Swico Recycling is responsible for the recycling of electronic devices and IT equipment that are collected through the national collection system operated by SENS. It works with authorized treatment facilities to ensure that e-waste is properly processed and recycled, and also provides data security services to ensure that personal and confidential data is properly handled and destroyed.

In addition, the Swiss Association for the Recycling of Electrical and Electronic Equipment (Senserec) is a non-profit organization that manages the collection and recycling of e-waste in Switzerland. It works with retailers, manufacturers, and other stakeholders to ensure that e-waste is properly collected, transported, and processed. Senserec operates a network of collection points throughout Switzerland, making it easy for individuals and businesses to dispose of their e-waste in a responsible manner. Senserec also provides educational materials and resources to help raise awareness about the importance of e-waste management.

Another important organization is Swiss Recycling. It is a non-profit organization that promotes sustainable waste management practices in Switzerland. It works to increase public awareness about the importance of recycling and proper disposal of e-waste, and encourages the use of recycling programs offered by municipalities and private companies.
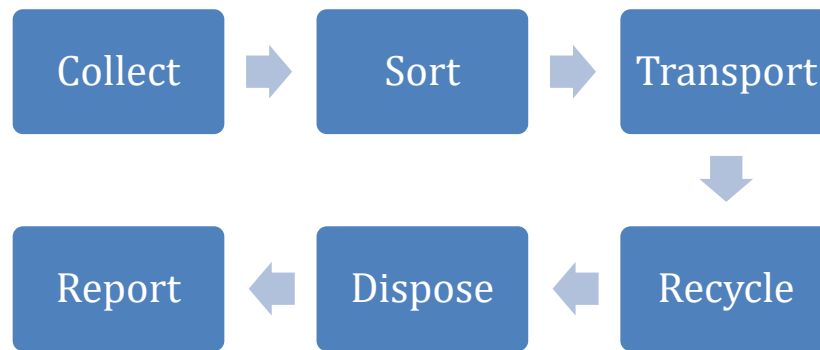
4.2. Process of e-waste management

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Collect  →  Sort  →  Transport
                          ↓
Report   ←  Dispose  ←  Recycle
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Figure 2. Process of e-waste management in Switzerland

4.2.1. Collection

In Switzerland, e-waste is collected via a variety of sources such as municipal collection stations, specialized recycling centers, collection sites, on-demand collection services and take-back programs run by producers and merchants. The e-waste at this stage is usually separated by kind as many collection locations provide bins and boxes for different items. This is crucial for e-waste, including batteries, which require further processing and can result in serious harm if mixed with other waste.

4.2.2. Sorting

The gathered e-waste next goes through a manual sorting phase where different items (such as batteries and lights) are removed to be processed further. The waste is then classified into different categories according to the materials it contains such as metal, plastic, glass, and hazardous waste. For example, metals such as copper, aluminum, and gold are separated from plastics, glass, and potentially hazardous materials such as lead and mercury.

As regards sorting technologies, the sorting process of e-waste in Switzerland is carried out with the utilization of cutting-edge technologies such as X-ray fluorescence (XRF) and optical sensors, which enhance precise and efficient separation of various types of materials. These technologies help to increase the recovery of valuable materials and reduce the amount of waste that is sent to landfill.

4.2.3. Transportation

The sorted e-waste is then delivered to specialized recycling facilities where it is handled. The transportation of e-waste takes place to specialized recycling centers in Switzerland that are supplied with modern equipment to process and manage various kinds of e-waste.

4.2.4. Recycling

Mechanical and thermal treatment (MTT) is the primary method used in Switzerland to recycle e-waste. This approach is the combination of mechanical shredding, sieving, and separation of materials followed by thermal treatment of the remaining waste. The e-waste is first shredded into small pieces and then separated into different materials such as metals, plastics, and glass by various methods such as magnetism or eddy current separation. These materials are then recycled or reused in the manufacturing of new products. The separated materials are then treated

further to extract valuable metals and other resources that can be reused in the manufacturing of new products. This process is highly efficient and enables the recovery of valuable metals and other resources from e-waste.

4.2.5. Disposal

Requirements for disposal facilities are specified in the Technical Ordinance on Waste. It specifies stringent requirements for waste that is to be landfilled. Today, three different types of landfill site exist in Switzerland, corresponding to different types of waste:

Firstly, landfills for inert materials: only rock-like wastes may be disposed of, from which virtually no pollutants will be leached out by rainwater. These include materials such as construction waste and uncontaminated soil that cannot be used elsewhere.

Secondly, landfills for stabilized residues: are designed for the disposal of materials of known composition, with high concentrations of heavy metals and only a small organic component, and which cannot release either gases or substances readily soluble in water.

Thirdly, bioreactor landfills: chemical and biological processes are expected to occur. At these sites, drainage controls are also required. In addition, any gases emitted are to be captured and treated. Given the unpredictable composition of their contents, bioreactor landfills are at greatest risk of requiring expensive remediation at a later date.

4.2.6. Reporting

The Swiss Federal Office for the Environment (FOEN), which oversees and controls the national e-waste management system, receives reports from the recycling companies about the quantity of e-waste they process. This information is used to monitor the amount of electronic trash produced in Switzerland and evaluate the efficiency of the e-waste management system.

4.3. Responsibilities of each sector

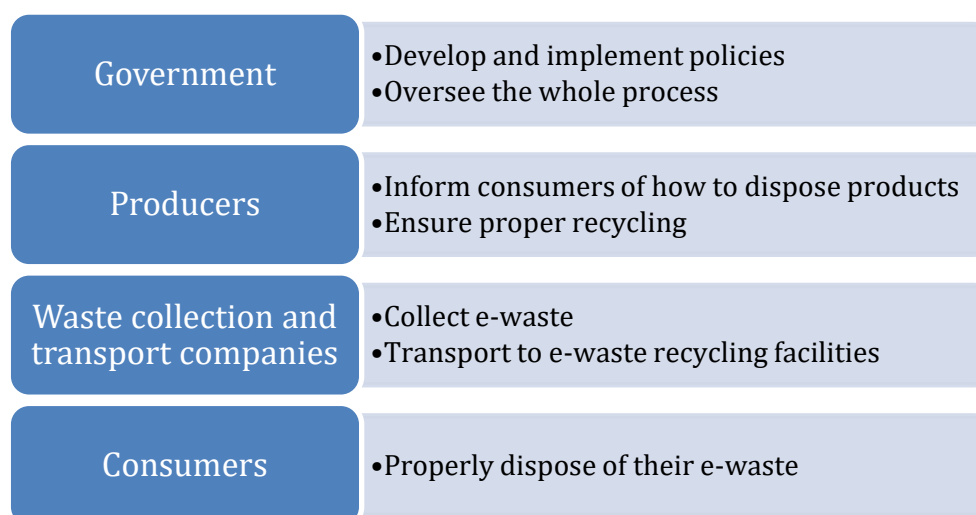| Government	•Develop and implement policies •Oversee the whole process
Producers	•Inform consumers of how to dispose products •Ensure proper recycling
Waste collection and transport companies	•Collect e-waste •Transport to e-waste recycling facilities
Consumers	•Properly dispose of their e-waste

Figure 3. Responsibilities of each sector in e-waste management in Switzerland

The Federal Government, in particular The Swiss Federal Office for the Environment (FOEN), is responsible for developing and implementing policies and regulations related to waste management, including e-waste, as well as overseeing the whole process. The government sets up

and enforces regulations on e-waste management, ensuring that waste is collected and recycled in an environmentally responsible manner. This includes setting targets for the collection and recycling of e-waste, ensuring that e-waste is properly sorted and processed before being sent for recycling, and monitoring compliance with regulations.

Producers and manufacturers are responsible for taking back their own e-waste and ensuring that it is properly recycled. They must register with the Swiss Association for the Recycling of Electrical and Electronic Equipment (Senserec) and pay a fee for the collection and recycling of their products. Producers and manufacturers must also provide information on the proper disposal of their products to consumers. This includes information on where and how to dispose of their products, as well as advice on how to delete personal data from their devices before disposal.

Waste collection and transport companies are responsible for collecting e-waste from consumers and transporting it to e-waste recycling facilities. These companies must be authorized by the FOEN and comply with regulations regarding the collection, transport, and storage of e-waste. They must also ensure that e-waste is properly sorted and processed before being sent for recycling. This includes separating hazardous materials from non-hazardous materials and ensuring that e-waste is transported in a way that minimizes the risk of environmental harm.

Consumers are responsible for properly disposing of their e-waste. They can either bring their e-waste to collection points, or return their e-waste to retailers or manufacturers when purchasing new products. It is important that consumers delete all personal data from their devices before disposing of them.

By working together, these sectors can ensure that e-waste is properly managed and recycled in a way that protects the environment and human health.

4.4. Strengths and weaknesses of the process

Regarding the strengths, Switzerland has a well-established and efficient e-waste recycling system. The country has high recycling rates and advanced technologies in place to properly handle electronic waste. Secondly, the e-waste management process in Switzerland focuses on resource recovery. Valuable materials such as gold, silver, copper, and rare earth metals are extracted from electronic waste, reducing the need for mining and conserving natural resources. Thirdly, proper e-waste management helps prevent the release of hazardous substances into the environment. By safely disposing of and recycling electronic waste, Switzerland minimizes soil, water, and air pollution, thus protecting the ecosystem and human health. In addition, Switzerland promotes a circular economy approach to e-waste management. The recycled materials are used to manufacture new products, contributing to a more sustainable and resource-efficient economy.

On the other hand, their e-waste management process can be expensive due to the advanced technologies and strict regulations involved. The costs are typically borne by consumers, manufacturers, and the government, which can sometimes lead to increased product prices or additional fees. Secondly, despite having well-established collection points and systems, ensuring widespread participation and awareness among the public can be a challenge. Encouraging individuals and businesses to properly dispose of their electronic waste requires ongoing education and awareness campaigns. Moreover, Switzerland, like many other countries, faces challenges related to the export of e-waste to developing countries. Despite stringent regulations, there is still

a risk of illegal export or improper handling of electronic waste, leading to environmental and health risks elsewhere. Lastly, the rapid pace of technological advancements poses a challenge to e-waste management. Newer devices with shorter lifecycles and complex components require constant adaptation of recycling technologies and processes to effectively handle the changing nature of electronic waste.

5. Recommendations for Vietnam on e-waste management

5.1. Overview of e-waste management situation in Vietnam

5.1.1. Current situation of e-waste in Vietnam

EEE disposal, the importation of used EEE and e-waste, as well as industrial activities at electronic companies are all sources of e-waste in Vietnam. Honda et al.'s research indicates that in 2015, our nation produced an estimated 115,000 tons of e-waste at a 1.34-kilogram emission rate per person. According to Forti et al., with a per capita generation of 2.7 kg, the amount of e-waste produced in 2019 climbed to 257,000 tons. Emerging solar photovoltaic (PV) panels and electric vehicle (EV) batteries are significant issues for Vietnam as solar power and transportation, in addition to conventional e-waste. In our nation, electric running is advised for use. As well as this, a significant amount of e-waste is imported in the form of scrap or used machinery and equipment, particularly after the import of garbage into Vietnam was outlawed. The uncountable volume of e-waste from this source is a result of these unlawful operations.

o Products imported into the domestic market

EEE is imported into Vietnam both new and used. Vietnam-based electronic businesses also create fresh EEE. The number of products made available on the domestic market for the targeted EEE has been calculated in the URENCO study, as shown in Table 1 below. The figure excludes exported units and includes both newly made and used EEE that are produced and imported.

Table 1. The estimation of targeted domestic EEE in Vietnam from 2015 to 2020 (thousand units)

	2014	2015	2016	2017	2018	2019	2020	Annual growth rate (%)
TV	14,848	17,800	21,338	25,609	30,756	36,960	44,442	20
PC	2132	2540	3030	3619	4326	5177	6200	20
Mobile phones	3498	3533	3569	3604	3641	3677	3714	1
Refrigerator	3481	4127	4900	5826	6937	8269	9869	19
Air conditioner	1367	1653	1998	2416	2921	3533	4272	21
Washing machine	3140	3674	4307	5060	5955	7022	8294	18

Source: Analysis of recycling structures for e-waste in Vietnam - Journal of Material Cycles and waste management (Tran, C.D. and Salhofer., 2016)

The annual growth rate for six different categories of appliances is shown in Table 1, with air conditioners having the highest rate (21%) of increase. Computers and Televisions both have a 20% rate. Mobile phones are notable for having the lowest annual growth rate (1%). The low annual growth rate of mobile phones and the few mobile phones offered by URENCO on the domestic market can be attributed to the high cost of mobile phones and mobile service in comparison to the income of residents at the time the study was done. It's also possible that it was due to Vietnamese people's actions that cell phones were passed from one person to another.

New EEE is created locally by producers and imported from elsewhere (Japan, Taiwan). During a time, some types of used EEE can mostly be imported from one nation. For instance, old freezers were primarily exported from Japan to Vietnam. Between 1996 and 2006, used TVs came dangerously close to entering Vietnam.

o E-waste domestically produced

The majority of the used EEE in Vietnam that is being disposed of as e-waste comes from TVs, mobile phones, refrigerators, PCs, air conditioners, and washing machines, with the e-waste from used EEE discarded per capita was calculated as shown below. This rate of e-waste generation should be higher if other sources of e-waste can be counted.
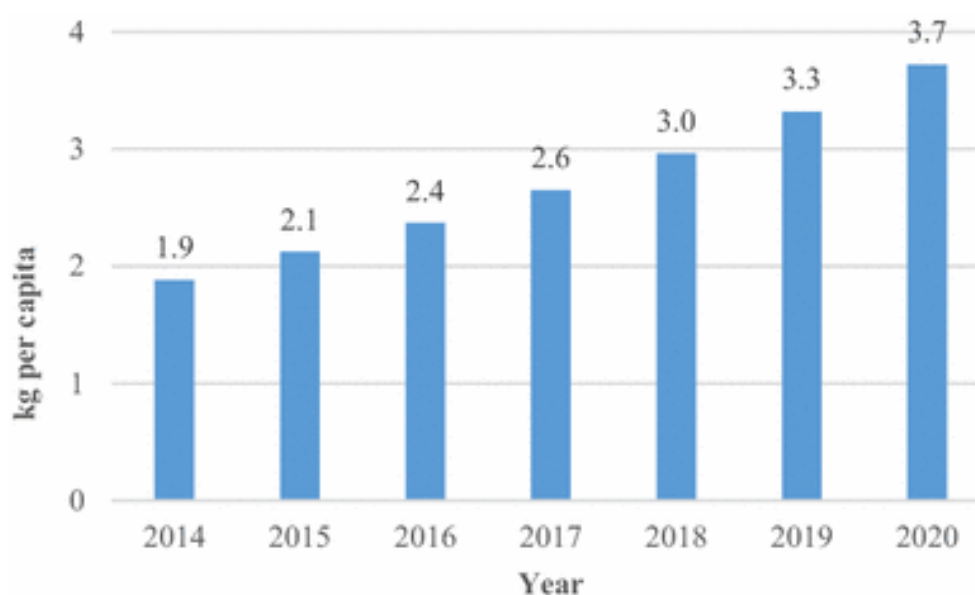

Figure 4. E-waste generated from used EEE per capita in Vietnam from 2014 to 2020

o E-waste from transboundary movement

The illicit import-export activities between adjacent nations are another source of e-waste. Both China and Vietnam forbade the import of e-waste, however both nations permit import for re-export, and China permits the import of used EEE, rebuilding it, and then re-exporting it. E-waste can thus be brought into Vietnam, sold to China for rebuilding, and then brought back into Vietnam for reasons that are unknown.

Secondhand EEE and e-waste that are imported through the Sihanoukville International Port (Cambodia) are smuggled into Vietnam through the border between the two nations in the south of the country. Used EEE is partially eaten in the Mekong Delta River, then shipped to Ho Chi Minh City for sale. The remaining used EEE, together with other e-waste, is then carried to the North for export to China.

Authorities and used EEE importers only have a realistic legal framework on which types of used EEE are not allowed to be imported after the Vietnam Ministry of Information and Communication issued guidelines about the export and import of used information technology products. Nonetheless, used EEE can still be brought into Vietnam illegally (e.g., claiming as belongings of travelers in exceeded numbers of used EEE allowed per traveler, smuggling activities between the borders).

5.1.2. Process of e-waste management and involved sectors

5.1.2.1. Formal sector

Businesses having permits from the Vietnam Environment Administration, which deal with hazardous waste, represent the official sector. TV, computer, and other EEE e-waste contain a number of dangerous materials. Some urban environmental businesses exist in major cities like Hanoi and Ho Chi Minh City. The units authorized to collect, transport, and treat hazardous garbage, including e-waste, in Ho Chi Minh City, Da Nang, and elsewhere have solely paid attention to the waste stream from the electronics industry. With a capacity of roughly 1,500 thousand tons/year in 2020, there were 117 hazardous waste treatment plants (including e-waste) licensed by the Ministry of Natural Resources and Environment.

5.1.2.2. Informal sector

The e-waste collection process in Vietnam is still mainly based on the informal sector, who can deal with the larger amount of e-waste and is involved in all steps of the recycling chain.
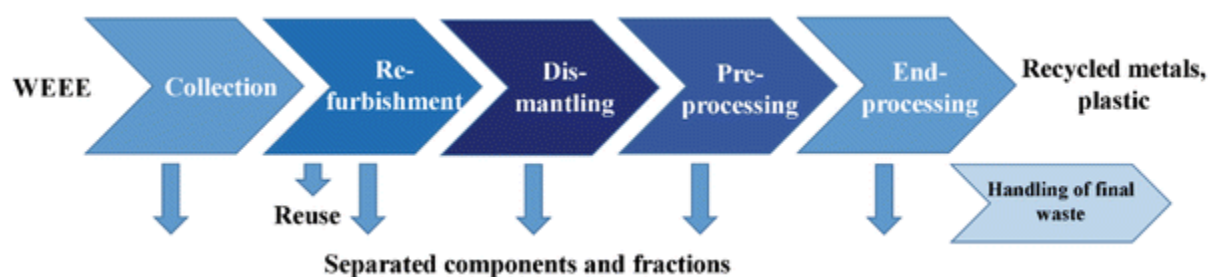

Figure 5. E-waste recycling chain in Vietnam

Source: Analysis of recycling structures for e-waste in Vietnam - Journal of Material Cycles and waste management (Tran, C.D. and Salhofer., 2016)

i. Collection and transportation:

In Vietnam, there are countless peddlers who collect used appliances from consumers and deliver them to repair businesses, dealers, or collectors. They are revered as "saviors" for the handling of e-waste in Vietnam because they can ensure that nearly all domestic e-waste is sent to recycling facilities and collectors. The unofficial system for handling e-waste is quite active and effective.

ii. Reuse and refurbishment:

Appliances are categorized by collectors, repair businesses, and service centers after being collected. After a quick repair or refurbishment, the discarded device might be marketed as if it were brand-new or used in secondhand marketplaces. Up until it becomes impossible, the broken EEE can be fixed numerous times at repair facilities. Only damaged EEE that is beyond repair or does not cover the cost of repair will be sent to workshops for dismantling. The repairers and service centers can disassemble the usable pieces from e-waste for reuse. Reusable parts are gathered at these workshops and sold to repair and service businesses for use as part replacements during repairs.

iii. Dismantling and pre-processing:

Separating the materials and getting ready for more treatment are the goals of this step. The development of manufacturing craft villages, or "villages with a profession that is separated from agricultural activities for an independent/processing and that profession attracts the workforce of the village and creates the main income for the inhabitants," is a characteristic of rural areas in Vietnam. In these villages, residents engage in both agricultural production and industrial activities. Out of 90 trash recycling villages, most of which are in the North, about 30 craft villages that handle e-waste recycling were counted. Materials or components from recyclable e-waste are primarily recycled in plastic recycling craft villages, and iron and steel. By categories of appliances, e-waste disposal craft villages have specialized their workshops. As an illustration, some workshops only purchase and disassemble refrigerators and washing machines, others only gather CD and DVD players, and yet others are responsible for collecting and grinding plastic. The tradeable pieces are categorized for future processing or sale after deconstruction. Common procedures include chipping and melting plastic components, burning copper wires in the open to recover copper, and dumping leftovers into ponds, fields, and riverbanks.

The existing practice of pre-processing and disassembling e-waste has resulted in numerous major problems with the environment and human health of both workshop employees and nearby people. For instance, unusually high amounts of polychlorinated biphenyls and brominated flame retardants have been found in the breast milk of women who live near an e-waste recycling facility (Bui Dau in the province of Hung Yen). Flame retardants have also contaminated the soil near these facilities.

iv. End processing:

The metal recovery/recycling from the pre-processing step and the final treatment of the residues make up the final processing step. The products of the pre-processing and dismantling processes are currently primarily exported to China. Even if only a tiny portion of the output is processed on Vietnamese soil, it is still important to highlight the infrastructure that is available for final processing. Pre-processing output recycling will soon be required due to the severe execution of both Decree No. 187/2013/ND-CP on the ban of used EEE imports and Decision No. 16/2015/QD-TTg on the regulation of retrieval and disposal of rejected products.

5.1.3. Implemented e-waste management policies in Vietnam

Up to now, Vietnamese government has remarkably shifted their focus to the issue of waste in circular economy in general.

Firsly, Vietnam has established legal frameworks and regulations to address e-waste management. The Law on Environmental Protection and related regulations provide guidelines for the collection, treatment, recycling, and disposal of e-waste.

Secondly, Vietnam has implemented EPR policies for e-waste management. This means that producers and importers of electronic products are responsible for the collection, treatment, and recycling of e-waste generated from their products.

Thirdly, the government has encouraged the establishment of collection and recycling facilities for e-waste. These facilities aim to properly handle and recycle e-waste to minimize its environmental impact.

Furthermore, Vietnam has been focusing on raising public awareness about the proper management of e-waste. This includes educational campaigns, workshops, and information dissemination to promote responsible disposal practices among individuals and businesses.

Lastly, Vietnam has collaborated with international organizations and partners to address e-waste management. This includes sharing best practices, receiving technical assistance, and participating in initiatives to improve e-waste management practices, such as The Consultation Workshop on Establishment of Product and Package Recycling Cost Norms (FS) and Supporting Administrative Cost (March 23, 2023).

5.2. Challenges and opportunities for e-waste management in Vietnam

5.2.1. Challenges

a. The lack of legislation and policies in the realm of e-waste management:

The biggest challenge for Vietnam in e-waste management is the lack of government policies. Although there are many documents and policies issued to tighten the collection and treatment of e-waste, such as the Prime Minister's Decision No. 16/2015/QD-TTg and Decision No. 491/2018/QD-TTg on e-waste collection and treatment disposal, there is still a lack of clear and efficient frameworks on the whole process of e-waste management.

The inadequacy in e-waste collection is also due to loopholes in current regulations & the absence of strict law enforcement. According to Dr. Tran Van Mieu, although the Government has issued legal documents that require manufacturing enterprises to be responsible for their products, there hasn't been an implementation of specific regulations on the number of points of collection, and the proportion of products that the manufacturers are responsible for. The current implementation mainly depends on the self-discipline of enterprises.

The lack of specific legislation has resulted in the domination of the informal sector in e-waste management collection, which makes situation harder for the authority to manage e-waste. After being collected by peddlers, EEE is usually brought to the "secondhand market", or sent to craft villages for dismantling and pre-processing. This has created a network of vague markets where it is impossible for the government to control business information, price, and taxes from the subjects involved. Moreover, evidence shows the illegal importation and exportation activities at craft villages.

b. Public health threats and negative environmental consequences:

Another e-waste management challenge for Vietnam is the weak labor condition for informal e-waste collectors. Most e-waste collecting, transporting, and processing work are done by peddlers and workers at craft villages. At these so-called villages, e-waste is dismantled and sorted manually into components by workers working with no or with a low level of protective equipment.

This has led to many serious risks related to the environment and human health, not only for the workers at those workshops but also for residents living close to the workshops. Research conducted on women who lived in e-waste recycling sites in Hung Yen province has shown evidence of breast milk being highly contaminated with poisonous substances. Another study discovered that the presence of pollutants in indoor dust and air at informal e-waste recycling sites was considerably greater compared to that in the household dust of urban areas. Furthermore, the soil in the vicinity of e-waste recycling workshops and open burning spots was found to be tainted by flame retardants.

These toxic chemicals can lead to detrimental diseases. Improper handling of electronic waste can lead to the release of toxic substances such as lead, mercury, cadmium, barium, and flame retardants, which can cause disruptions in normal biochemical reactions when they enter the human body. Exposure to these toxic chemicals can increase the risk of various diseases including cancer, respiratory and cardiovascular diseases, and neurological disorders. Furthermore, these substances can also pollute the environment, including land, water, and air.

5.2.2. Opportunities

a. <u>Lessons from international effective e-waste management frameworks & initiatives:</u>

The Government of Vietnam can learn from international directives & initiatives to develop an effective & efficient e-waste management framework. The EU's world's first law on solar waste (which treats solar waste as e-waste) is one of the best practices. The law, named as Waste Electrical and Electronic Equipment Circular (WEEE Circular), includes regulations for collecting, managing, recycling, and reusing materials for new PMT panels. All PMT manufacturers and importers are responsible for collecting, managing, and recycling their products. Leading countries, such as the UK, Germany, Italy, and the Republic, have implemented the WEE circular & also added their own specific mechanisms and regulations to best enforce waste management. Another example that Vietnam's Government can learn from is the Swiss Association for the Recycling of Electrical and Electronic Equipment (Senserec), which has been described in detail above.

b. <u>The approval of impactful e-waste management legislation:</u>

Another opportunity for Vietnam in e-waste management lies in the approval of new legislation to ensure the proper recycling and treatment of electronic products. On January 10, 2022, the Vietnamese government passed this decree which provides detailed regulations on the recycling of discarded products and packaging materials under the Extended Producer Responsibility (EPR) scheme as stipulated in Articles 54 and 55 of the Law on Environmental Protection 2020. Articles 77–86 of the Decree set out a list of regulated products and compulsory recycling rates while also providing rules on the Environmental Protection Fund, and producers' obligations to formulate recycling plans, disclose product information, and report recycling performance. However, Vietnam's Government won't be implementing the decree until 2024.

Additionally, on the same day, the Ministry of Natural Resources and Environment (MONRE) introduced Circular No. 02/2022/TT-BTNMT which outlines the implementation rules for certain articles of the Law on Environmental Protection. The Circular specifies the formats of application and report forms that must be used to perform treatment responsibilities.

c. A good opportunity for raising awareness on e-waste management:

Lastly, Vietnam should take advantage of the high media usage rate to raise awareness of e-waste management. In 2023, the active social media usage penetration rate in Vietnam is 71% of the population. Vietnam's Government can make use of it to raise citizens' awareness of the impact of unsafe e-waste processing methods on public health & the environment. In addition, the authority should pass more incentives for both the business sector & consumers to be more engaged in the collection of e-waste. Vietnam's Government can learn from the Chinese 'Old for New' scheme, which aimed to increase the appeal of formal e-waste collection systems through two methods. Firstly, electronics retailers and other formal collection entities were offered subsidies to incentivize consumers to return their e-waste through formal channels. Secondly, recyclers received high subsidies that allowed them to compete with informal collection systems. As a result of the 'Old for New' program, the Chinese government saw growth in collection rates.

5.3. Lessons for Vietnam in managing e-waste

i. Setting up a national e-waste management system by officially establishing a legal framework

In Vietnam, only a few incoherent organizations in formal sectors are registered with the government to deal with e-waste. However, most of them can not take care of the complete process of e-waste treatment due to operation cost and collection ability. The informal sector, despite being in charge of most e-waste, can bring unpredicted new issues since it is not fully legally controlled.

Looking at the Switzerland, a group of formal associations is in charge of e-waste management. Each party plays a different role and connects with each other effectively. They are all registered and certificated thoroughly by the government before being put to work.

Each stage of the e-waste management process can be improved as follows:

The collection stage should be held responsible by manufacturers instead of mass collection performed mostly by peddlers which leads to a considerable volume of untrackable e-waste. Formal sectors also build a network of collection points for residents and organizations to dispose of their waste in a responsible manner. The government should also introduce financial incentives in this stage to promote every party's commitment.

At the transportation stage, in Vietnam, peddlers often sell the e-waste to facilities and collectors. However afterward, it is impossible for the government to control whether the waste is sent to workshops and facilities for dismantling and pre-processing, or the secondhand market where transactions are vague and unrecorded. It is the government's effort to make sure recycling facilities are legally registered and have a record of e-waste journey.

The activities of dismantling and pre-processing in those craft villages have brought more environmental and health problems to people around. This comes from their lack of awareness and inadequate budget to apply more safety measures. Knowing these workshops' crucial role in

this stage, governments and environmental organizations should guide them to the most effective procedure without damaging their own health and the surroundings.

For the final processing, Vietnam is heavily dependent on China, since the level is not adequate. As a result, efforts should be made considering the short-term and long-term objectives to minimize the dependency on other countries in processing e-waste.

ii. Implementing strict regulations on e-waste imports

Vietnam can adopt stringent regulations similar to those of Switzerland to prevent the import of hazardous e-waste and protect the health and safety of its citizens. Considering Switzerland's regulations on the export of e-waste, the Vietnamese government should implement a ban on the import of hazardous e-waste from other countries and require importers to obtain permits for the import of non-hazardous e-waste.

In addition, Vietnam can work with the international community to promote responsible e-waste management practices and prevent the dumping of e-waste in developing countries.

iii. Encouraging manufacturers to take responsibility for e-waste

Vietnam can enforce an extended producer responsibility (EPR) system that encourages manufacturers to take responsibility for the e-waste generated by their products, which requires producers to fund the collection and recycling of e-waste. This can help to reduce the burden on local governments and taxpayers, and ensures that manufacturers take responsibility for the environmental impact of their products.

iv. Educating the public about the importance of e-waste management

Vietnam can launch educational campaigns, or can be worked with non-government organizations and private companies as the Swiss government has done, in order to educate the public about the risks of improper e-waste disposal and the benefits of responsible e-waste management. Gaining long-term benefits from well-informed citizens in the future, and active participation from both the government and people will be the foundation of building an effective formal sector's e-waste management system.

v. Crucial role of Vietnam's government in the regional and international exchange and cooperation

Vietnam's government plays the most crucial role when it comes to recycling e-waste. Alongside Vietnam's own issues, such as being a developing country that heavily relies on the informal sector, weak e-waste management system etc., the Vietnamese government must be able to consult and also innovate to create the most effective system for Vietnam. Although the e-waste management system in Vietnam started later than most, this also means there is more room for learning and improvement from existing frameworks.

6. Conclusion

E-waste is a growing environmental and health hazard worldwide. To address this issue, Switzerland's e-waste management system provides an effective model for other countries looking to address the challenges of e-waste management. The Swiss system involves all stakeholders and provides a comprehensive framework that covers e-waste collection, transportation, and recycling.

The Swiss model has led to positive social and environmental impacts, including job creation, reduced pollution, and increased resource conservation.

On the other hand, Vietnam's e-waste management system faces several challenges, including the lack of legislation and policies in the realm of e-waste management, the lack of awareness among the public, inadequate infrastructure for e-waste collection and recycling, and insufficient regulations to control the import and export of e-waste.

By looking into Swiss practices, this report recommends that the Vietnamese government should develop a national e-waste management plan that involves all stakeholders and introduces financial incentives to encourage the collection and recycling of e-waste. The government should also work to improve public awareness of e-waste management, implement strict regulations on e-waste imports and exports, and actively participate in regional and international cooperation. On the other hand, manufacturers should take responsibility for the e-waste generated by their products, which requires producers to fund the collection and recycling of e-waste. In addition, the public need to be better informed about the risks of improper e-waste disposal and the benefits of responsible e-waste management. By taking these steps, Vietnam can move towards a more sustainable and effective e-waste management system, benefiting both the environment and public health.

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