



E-Waste Management in Nam Theun 2 Power Company Limited: A Review of Issues, Challenges and Solutions

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Abstract

This paper reviews the e-waste management practices of Nam Theun 2 Power Company (NTPC), one of the leading power generation companies in Laos. The study focuses on the company's use of Total Environmental Solutions – Asset Material Management (TES-AMM), a leading e-waste recycling company, to manage their e-waste. In this paper, a mixed-methods research design has been applied, including a survey of employees and interviews with key stakeholders at NTPC, as well as document analysis to assess the company's compliance with the relevant regulations and standards. The results of the study indicate that NTPC has an effective e-waste management system in place that is compliant with the relevant regulations and standards, but it also highlights opportunities for improvement. The study also provides an overview of TES-AMM's e-waste recycling process, which is found to be in line with international standards. The study contributes to the existing literature by providing insights into the specific challenges and opportunities for improving e-waste management in the power generation industry part in Laos.

Keywords: *E-Waste Management, Environmental Impact, Recycling, Hazardous Waste Management, Life Cycle Assessment.*

1. Introduction

E-waste management includes the collection, transportation, and disposal or recycling of electronic devices, such as computers, cellphones, and televisions. It is important to ensure that e-waste is handled and disposed of properly to prevent the release of hazardous materials into the environment and to recover valuable materials for reuse. The rapid advancement of technology and the increasing use of electronic devices have resulted in a growing amount of e-waste, which poses a significant threat to the environment and human health. E-waste contains a range of hazardous materials, such as lead, mercury, and cadmium, which can be harmful if not handled and disposed of properly. E-waste has become a pressing global issue due to the rapid advancement of technology, while it poses challenges in terms of hazardous materials and inadequate infrastructure, it also presents opportunities for resource recovery and job creation. By implementing effective e-waste management

strategies, we can mitigate the environmental and health risks associated with e-waste while harnessing its potential benefits (Shahabuddin et al., 2023)

In 2016, a global analysis of e-waste generation by continent revealed that Asia produced the highest amount of e-waste, followed by Europe and the Americas. Surprisingly, despite being the second most populous continent, Africa generated one of the lowest amounts of e-waste. This can be attributed to slower technological growth and limited access to energy compared to other continents (Andeobu, Wibowo, & Grandhi, 2021).

In 2019, the world generated a striking 53.6 Mt of e-waste, an average of 7.3 kg per capita. The global generation of e-waste grew by 9.2 Mt since 2014 and is projected to grow to 74.7 Mt by 2030 – almost doubling in only 16 years. The growing amount of e-waste is mainly fueled by higher consumption rates of Electrical and Electronic Equipment (EEE), short life cycles, and few repair options (Adrian et al.)

The Asia Pacific region is currently facing significant challenges in managing electronic waste, or e-waste. With the rapid growth of technology and electronic devices in the region, the volume of e-waste generated has also increased exponentially (Ghosh, 2019). This has led to environmental and health concerns, as well as economic challenges for countries in the region. Overall, managing e-waste in the Asia Pacific region requires a multi-faceted approach that involves the development of infrastructure, education, and international cooperation. By addressing these issues and implementing effective solutions, the region can mitigate the environmental and health risks associated with e-waste and promote sustainable development (Tončev et al., 2019; Herat, 2021)

Nowadays, the rapid growth of technology adoption has led to a significant increase in e-waste generation in Laos. This includes discarded electronic devices such as mobile phones, computers, televisions, and other electronic appliances. E-Waste Management is a big challenge in Laos PDR for management and E-waste management is an important aspect of waste management, as electronic devices often contain hazardous materials and can be difficult to recycle or dispose of safely, not any specific legislative document on e-waste management only article 39 of Law on Environmental Protection presents a provision on the management of toxic and hazardous wastes (National Assembly, 2012) and defines regulations and measures related to the management and monitoring of treatment and disposal of toxic and hazardous chemical wastes in order to allow such treatment and disposal of wastes to comply with methods and techniques aiming to mitigate impacts on lives, human health, animals, plants and ecosystems contributing to the socio-economic development and environmental protection following green and sustainable directions (MoNRE, 2021). Furthermore, TES-AMM Thailand is a leading electronic waste management company based in Thailand. They specialize in the collection, recycling, and disposal of electronic waste in an environmentally friendly manner. TES-AMM Thailand is a subsidiary of TES-AMM, a global e-waste recycling company in Thailand.

In Laos, the specific information about waste management practices, including policy

control and management, are still under consideration, to define how to handle e-waste. However, Nam Theun 2 Power Company (NTPC) must have a policy in place to handle and dispose of e-waste in an environmentally friendly manner and in compliance with the relevant regulations and standards, especially ISO 14001:2015 Requirements (ISO, 2015) in order to demonstrate responsibility.

This study focuses on the e-waste management recycling practices of NTPC (Nam Theun 2, 2023), one of the leading power generation companies in Laos. The study aims to investigate the company's e-waste management system, its compliance with the relevant regulations and standards, and its use of TES-AMM, a leading e-waste recycling company, to manage its e-waste. The study also aims to provide an overview of TES-AMM's e-waste recycling process. The study is significant as it contributes to the existing literature by providing insights into the specific challenges and opportunities for improving e-waste management in the power generation industry in Laos, region and it also provides an overview of a specific e-waste recycling company's process (TES-AMM, 2023)

It would be interesting to investigate whether the company has an effective e-waste management system in place that is compliant with the relevant regulations and standards such as ISO 14001 and what the challenges they are facing in implementing such a system are.

2. Research Methodology

In this paper, the researcher performs an exploratory study a review, an interview with key persons, and an analysis of process e-waste management, treatment, and disposal in NTPC Comparative with ISO 14001:2015 Requirements with identifies the issues, challenges, solutions, and opportunities with the aim of contextualizing and making sound recommendations on how to address emerging issues in e-waste management.

This study identified two research gaps. Firstly, although the literature presents the results of various studies on e-waste generation, recycling, treatment, and environmental management, few studies have focused on the impact of e-waste generated in NTPC. Secondly, we have noticed that many companies in Laos, do not sufficiently manage e-waste, and greater

effort is needed to ensure smarter and more sustainable global production, consumption, management, and disposal of e-waste.

The six-phase approach includes (a) Defining the scope of the research, (b) Problems Identification, (c) Research Design, (d) Data Collection and Process, and (e) Data Analysis, and (f) Result in Issues, Challenges and Solutions.

3. Results

3.1 E-Waste Generation

In NTPC, the E-Waste Recycling program was implemented in 2018 which gathered 285 participants with 139 items of e-waste collected and disposed of. The objective is to reinforce the awareness of the staff regarding e-waste management for the separation and disposal of obsolete appliances i.e., obsolete mobile phones, phone batteries, used power banks, and used chargers, etc.

From operation, there are 433 items of e-waste from the Information and Communication Technologies (ICT) device replacement process which included 194 computers (desktop and laptop), 63 projectors, 112 printers, and 46 routers/switches collected and disposed process by TES-AMM (Thailand). At the end of the process, a certificate of destruction and recycling was issued to NTPC for reference.

The E-Survey was conducted in NTPC in which 48 staff of 272 staff (including 38 male and 10 female) have answered, the results showed the hazardous waste generation in 5 sub-categories in 2022 are as Bio-Hazardous 118 Pcs, E-Waste 110 Pcs, Batteries 85 Pcs, Chemical Container 82 Pcs, and Lamp 72 Pcs, all waste collected in red waste bin are provide and disturbing in sites. On average, the generation of hazardous waste is 9.72 pcs per person. The percentage of hazardous waste generation has been plotted in Figure 1. E-waste is generated from household waste, with an average of 3.006 pcs per person, as depicted in Figure 2.

3.2 E-Waste Management

The most preferred option for waste hierarchy consists of the Prevention level which shows the idea of avoiding things from becoming waste. The evidence suggests that the best waste management options for the environment must be kept within the waste hierarchy as shown in Table 2. All 6 programs of waste reduction plan

in the Waste Hierarchy Utilizes, NTPC shows the reduction plan to reach the target of preventing waste from arising in the first place is simply less waste for reuse products, less disposal, and most importantly, less waste to disposal at landfill sites.

NTPC is specifically concerning E-waste Generated from operation, The E-Waste recorded and collected in the proper storage in the Landfill follows the ISO 14001:2015 requirement as NTPC certificated, the management follows the diagram depicted in Figure 3. The transfer of e-waste from Laos to Thailand needs to follow the guidelines and regulations set by both countries and ensure compliance with the Basel Convention. The general steps that would need to be taken are represented as following details:

- Research and understand the regulations: Familiarize us with the e-waste regulations in both Laos and Thailand. Check if there are any specific requirements or restrictions for the transboundary movement of e-waste.
- Obtain necessary permits and documentation: Contact the relevant authorities in both countries to obtain the required permits and documentation for the export and import of e-waste. This may include obtaining prior informed consent and completing necessary customs paperwork.
- Choose a licensed e-waste transporter: Select a licensed transporter who specializes in the transportation of hazardous materials, including e-waste. Ensure that they have experience in handling e-waste and comply with all relevant regulations.
- Packaging and labeling: Properly package the e-waste in accordance with international standards, ensuring that it is secure and protected during transportation. Label the packages clearly to indicate that they contain e-waste and include any required hazard symbols or warnings.
- Arrange for transportation: Coordinate with the licensed transporter to arrange for the transportation of the e-waste from Laos to Thailand. Ensure that the transporter has the necessary permits and complies with all safety and environmental requirements during transit.

- Monitor and track the shipment: Keep track of the shipment throughout the transportation process to ensure that it reaches its destination safely. Maintain communication with the transporter and authorities to ensure compliance with all regulations.

- Ensure environmentally sound disposal: Once the e-waste reaches Thailand, it should be properly managed and disposed of in accordance with the country's regulations for e-waste recycling or disposal. Work with authorized recycling facilities or waste management companies to ensure the environmentally sound treatment of the e-waste.

It is important to note that these steps are general guidelines, and specific requirements may vary depending on the regulations of both countries. It is advisable to consult with the relevant authorities or seek professional assistance to ensure compliance with all legal and environmental obligations. The different steps of the E-Waste recycling process with TES-AMM are represented in Figure 4.

The Electronic waste and equipment recycling service at TES-AMM Thailand is shown in Figure 5. They committed to doing a necessary part to close the loop. From pick-up to repurposing, process the electronic waste using sustainable recycling techniques. Every step of the process has security embedded to protect consumer's brands from reputational damage, whilst ensuring environmental impact is minimized, following the requirements of certification of TES-AMM are ISO 9001:2015, OHSAS 18001:2007, ISO 27001:2013, and ISO 14001:2015. The details of the de-manufacturing and destruction process are depicted in Figure 6.

There is no specific legislative document on e-waste management in Lao PDR. The country's key national legislation such as Environmental Protection also does not mention this type of waste. However, there are several national legislations in relation to the management of general and hazardous waste. This legislation is listed in Table 3.

3.3 E-Waste Awareness

The result of the E-Survey (Souttiphong Keovongsa, 2022) demonstrated the awareness of hazardous waste management. 83.3% of them known the impact and definition of hazardous waste, 16.7% were not aware and understand

hazardous waste or toxic waste, and 100% of them desired to provide the activities/awareness campaign about hazardous waste to increase the awareness and understanding of hazardous waste and impact in communities and environment and 100% of them are willing to support and cooperate in the hazardous waste separation.

- In the practice section, they separate of them did and collected the waste in corrective waste 64.6%, sometimes separated 27.1%, 8.3% no separated the hazardous waste and mixed in general waste; 58.3% of them used to bring the hazardous waste to collection in hazardous waste collection point, and 41.7% them no used to do in this practice.

- In groups separated and collected the waste have 79.2% to collected and waiting to the disposal service for final disposal and 93.7% want to the collection point in their community for convenience to collect the hazardous waste.

- In case after separated the hazardous waste 79.2% collection in collecting points, 6.3% collect and mixed in general waste, 4.2% dumped and burn the hazardous, and 10.4% is other methods for waste management after their separation.

4. Discussion

Referring to this study, E-waste poses many challenges and problems in the real implementation in private companies due to low awareness and practice in separation, as well as inadequate local infrastructure to support the recycling and disposal process in Laos PDR. Based on these major challenges and problems, the E-Waste challenges and solutions can be drafted as follows, the detailed framework in ISO 14001:2015 requirement (Will, Brauweiler, & Zenker-Hoffmann, 2021) and Basel Convention(UNEP, 1999).

- Procurement requirements of electronic items ordering
- Inventory Register of the ICT Equipment
- Avoidance and minimization of E-waste
- Temporary Storage of E-waste

- E-waste recycling and Disposal
- Training and Awareness Raising

In NTPC, the e-waste generation is multifaceted, encompassing various sources such as the E-Waste Recycling program, operational ICT device replacements, and household waste. The E-Survey (Souttiphong Keovongsa, 2022) conducted among NTPC staff revealed specific hazardous waste generation categories, with an average of 9.72 pieces per person, including bio-hazardous, e-waste, batteries, chemical containers, and lamps.

In comparison with the review of issues, challenges, and solutions in Asia Pacific region: (Herat, 2021) the case study of NTPC reveals specific challenges and solutions within a localized context. While both studies acknowledge challenges related to weak regulatory frameworks, your study delves into a tailored examination of the NTPC's challenges, emphasizing the absence of a formal e-waste management policy, inadequate infrastructure, and limited employee awareness. The proposed solutions include policy development, infrastructure improvement, and awareness programs targeted at the specific needs of the company. On the other hand, the Asia Pacific study takes a broader regional perspective, addressing challenges related to financing and the consideration of Extended Producer Responsibility (EPR) concepts in the regulatory framework. Both studies collectively contribute to a more comprehensive understanding of e-waste management challenges, offering insights from a localized case study and a regional perspective.

Comparing this with the systematic review of e-waste management in Asia Pacific countries (Andeobu et al., 2021), common challenges emerge, such as the lack of workable e-waste management strategies, inadequate infrastructure, and the informal sector causing environmental and health issues. Both studies stress the significance of formal recycling and recommend future research expansion.

A case study from Vietnam (Nguyen et al., 2019) to show the stress the importance of environmental awareness, positive attitudes, and adherence to regulations in promoting e-waste management. While one examines practices within NTPC in Laos, the other focuses on residents' recycling intentions in Vietnam. Both

offer valuable insights into promoting sustainable e-waste practices, albeit from different perspectives: corporate vs. individual behaviors.

One of the major challenges identified in this study is the absence of a formal e-waste management policy within the company. Without clear guidelines and regulations in place, the proper handling and disposal of electronic waste is often overlooked, leading to potential environmental pollution and health hazards. It is imperative for NTPC to develop and implement a robust e-waste management policy that outlines the responsibilities of employees, the procedures for e-waste collection and disposal, and the promotion of sustainable practices. In compare with the "Sustainable Guideline for Developing the E-Waste Sector in Egypt" (Tarek & El-Haggar, 2019) identify challenges such as regulatory gaps and the prevalence of informal handling methods. Despite these distinctions, both studies emphasize the need for sustainable practices and regulations to tackle e-waste challenges effectively.

Furthermore, the study highlighted the insufficient infrastructure for e-waste collection and recycling within the company. The lack of designated collection points and recycling facilities makes it challenging for employees to dispose of their electronic waste responsibly. To address this issue, the company should consider establishing e-waste collection centers on-site and partnering with certified e-waste recycling facilities to ensure proper disposal and recycling of electronic devices.

Another critical aspect that emerged from the findings is the limited awareness among employees about the environmental and health impacts of improper e-waste disposal. Many employees may not fully comprehend the potential harm caused by e-waste, including the release of toxic chemicals and heavy metals into the environment. Therefore, it is essential for NTPC to conduct educational and training programs to raise awareness about the importance of proper e-waste management and the potential consequences of improper disposal practices.

In addressing these challenges, several potential solutions can be considered. First and foremost, the company should prioritize the

development and implementation of a comprehensive e-waste management policy that aligns with international best practices and standards. This policy should encompass guidelines for the proper handling, collection, and disposal of e-waste, as well as strategies for promoting a culture of sustainability and environmental responsibility among employees.

Additionally, NTPC should invest in the establishment of e-waste collection points and recycling facilities within its premises, making it convenient for employees to dispose of their electronic waste in an environmentally responsible manner. Collaborating with certified e-waste recycling partners will ensure that the collected e-waste is safely and ethically recycled, minimizing its impact on the environment.

Furthermore, the company should prioritize educational and awareness programs to inform and educate employees about the importance of e-waste management. By fostering a culture of environmental stewardship and responsibility, employees can be empowered to contribute to the sustainable management of e-waste within the organization.

In conclusion, addressing the issues and challenges related to e-waste management within NTPC requires a concerted effort to develop and implement a comprehensive e-waste management policy, improve infrastructure for e-waste collection and recycling, and raise awareness among employees. By implementing the suggested solutions, the company can mitigate the environmental and health risks associated with e-waste and demonstrate its commitment to sustainable business practices.

5. Conclusion

E-waste management in NTPC has shed light on the significant issues and challenges associated with the proper disposal and recycling of electronic waste. The company, like many others, faces obstacles such as lack of awareness, inadequate infrastructure, and high costs in implementing effective e-waste management programs. However, it is evident that there are potential solutions available, including raising awareness, implementing government regulations, and forming partnerships with e-waste management companies. By addressing these challenges and implementing sustainable e-waste management practices, NTPC can contribute to environmental protection, human

health, and sustainable development in the region.

It is imperative for the company to take proactive steps in managing e-waste responsibly, and by doing so, it can set an example for other organizations in the industry. Overall, the review emphasizes the importance of prioritizing e-waste management and encourages the company to take the necessary actions to address these critical issues.

6. Conflict of Interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Table 1 E-waste generated around the world and per continent in 2016.

Indicator	Africa	America	Asia	Europe	Oceania	World
Number of countries with sufficient data availability	47	32	44	39	12	174
Population (millions)	1,064	932.8	4,295	737.9	39.29	7,068
WEEE Total (Mt)	2.23	11.08	18.23	12.26	0.68	44.49
WEEE per Capita, an average of continent (Kg/inh)	2.09	11.89	4.24	16.61	17.36	6.29
GDP Total	2,309,676	24,061,119	26,870,635	21,347,978	1,552,169	76,141,597
GDP per capita, Average of continent (USD/Inh)	2,170.5	25,819.7	6256.2	28,929.1	39,496.4	10,772.4

Table 2 NTPC Waste Reduction Plan in the Waste Hierarchy Utilizes

	Reduction of the plastic bag	Reduction of the foam box	Paper Reduction	E-Waste Recycling Program	Ban Single Use	Compost at Home	Donation Clean Waste
	Preventive	Preventive	Preventive	Preventive	Preventive	Preventive	Preventive
			Re-use				
				Recycling			
						Recovery	Recovery
	Disposal	Disposal	Disposal	Disposal	Disposal	Disposal	



Table 3 The National legislation in relation to the management of general and hazardous waste (Ministry of Finance, 2023)

No	National Legislation	Date	Status
1	The Ministerial Decision on Landfill Management, No521/PWT	23 Feb 2007	In force
2	Law on Environmental Protection, No.29/NA	18 Dec 2012	In force
3	Ministerial Instruction on Hazardous Waste Management	13 Jun 2015	In force
4	Industrial Waste Discharge Regulation No.180/MIH	3 Nov 1994	TBC
5	The Decree on the Control of Import, Export and Consumption of Ozone Depleting Substances, No. 162/PMO	13 Oct 2003	In force
6	The Regulation on the Control of Import, Export and Consumption of Ozone Depleting Substances, No. 2358/TEA-PMO	16 Nov 2004	In force

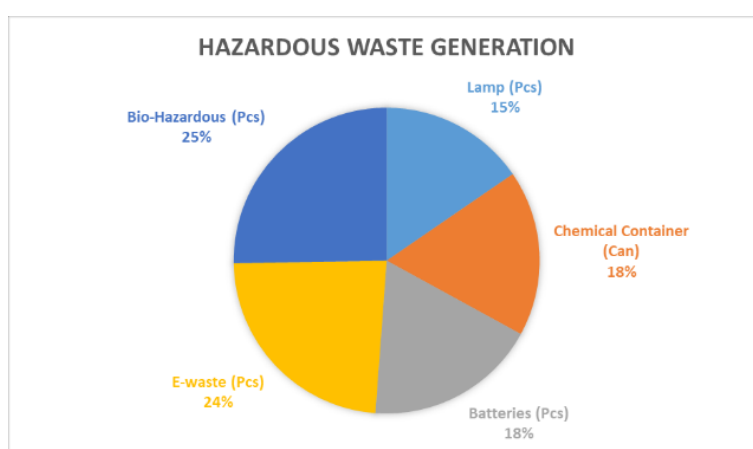


Figure 1 Hazardous Waste Generation

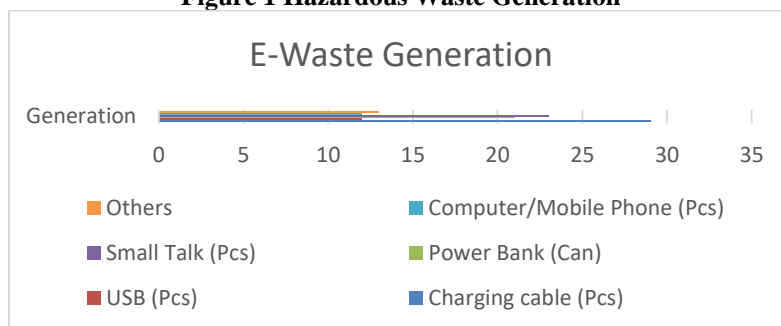


Figure 2 E-Waste Generation

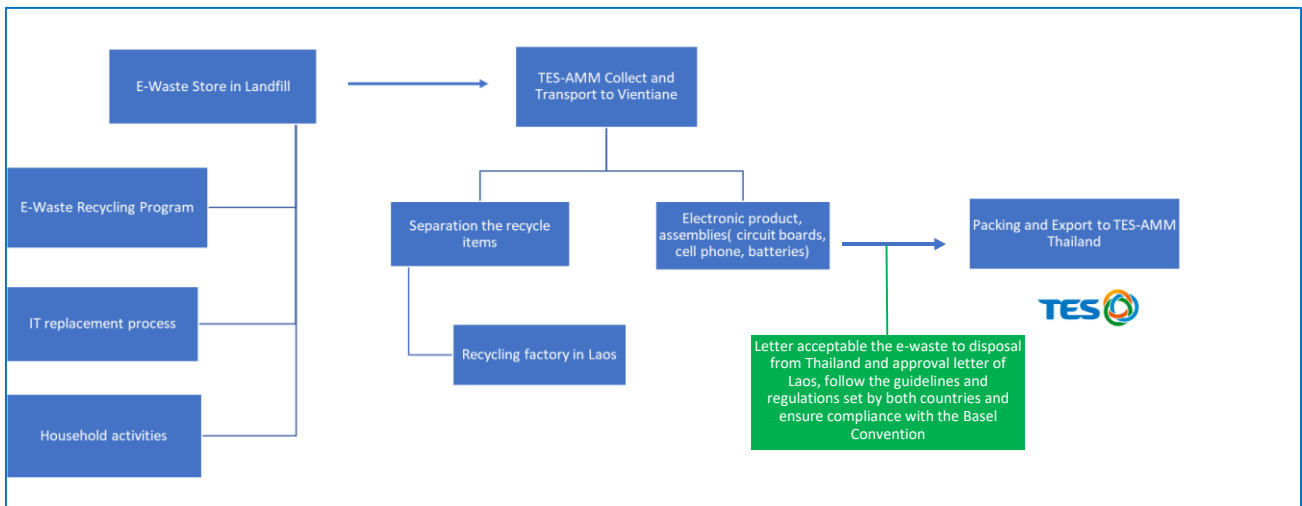


Figure 3 The E-waste Management and Disposal Diagram

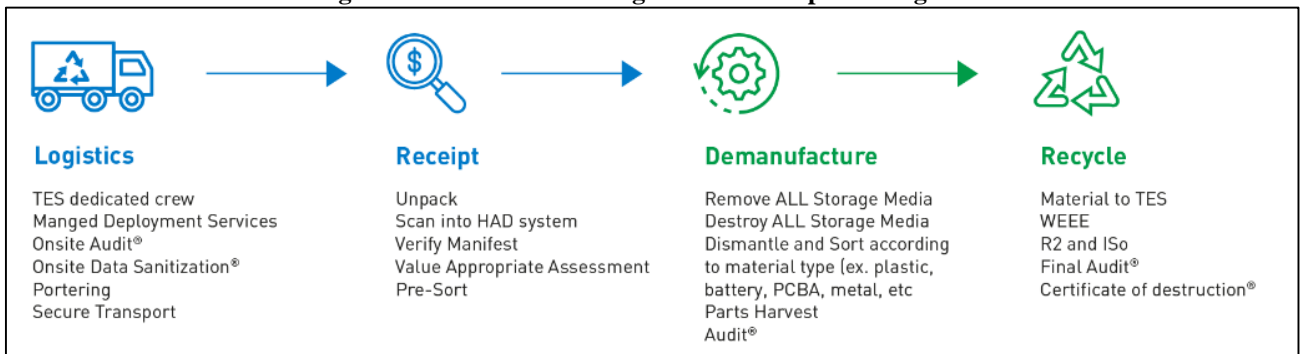


Figure 4 The E-Waste recycling works with TES-AMM

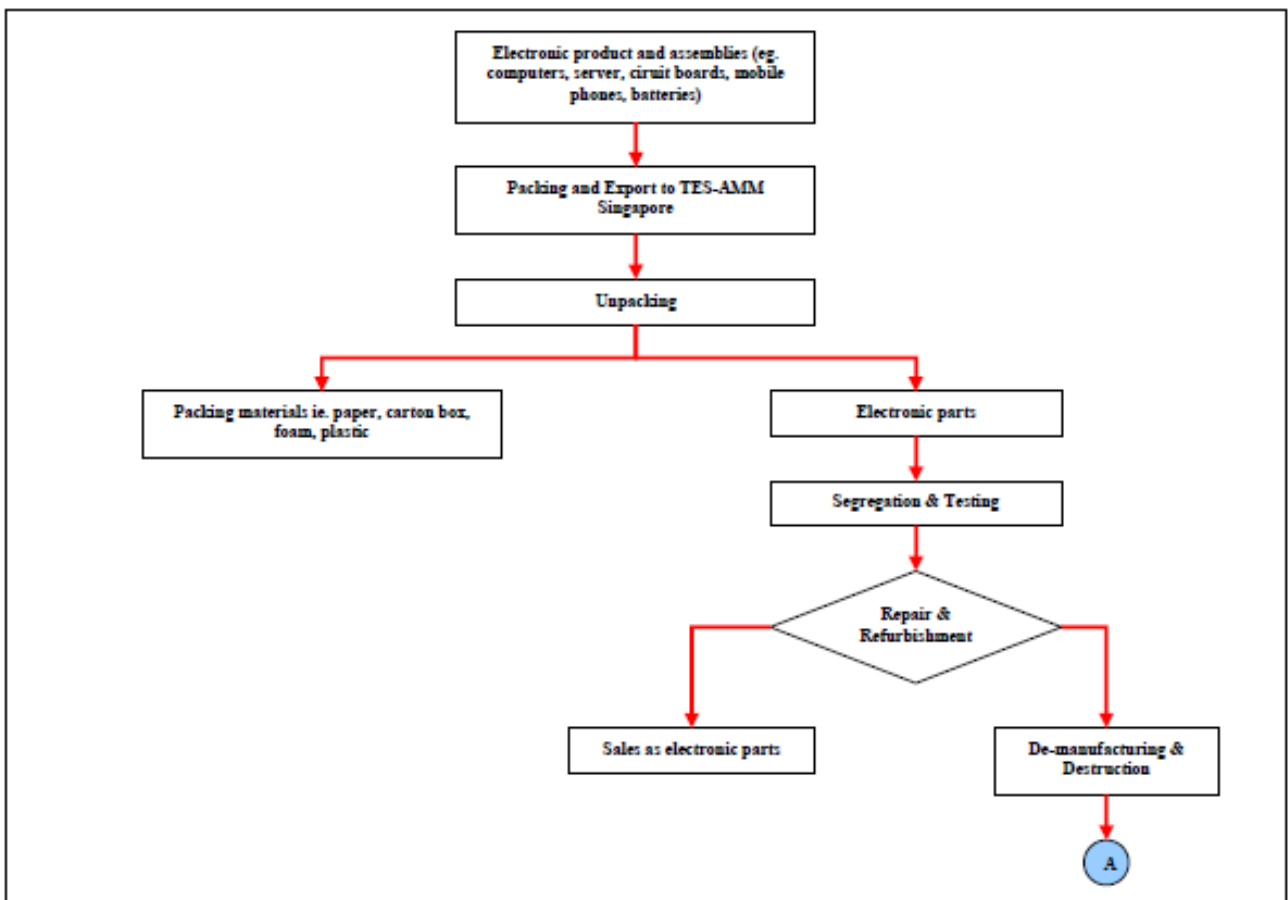


Figure 5 Receiving, Repair & Refurbishment Process Flowchart of TES-AMM

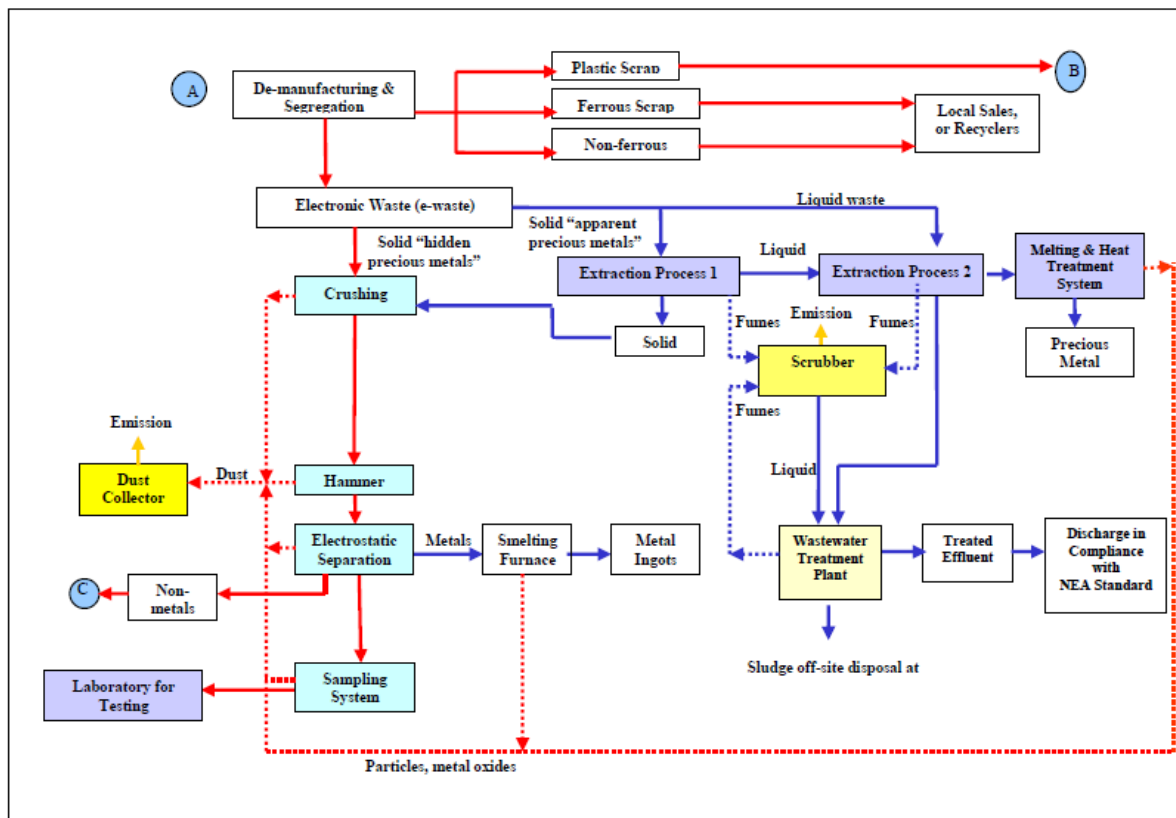


Figure 6 The De-Manufacturing & Segregation Process Flowchart of TES-AMM

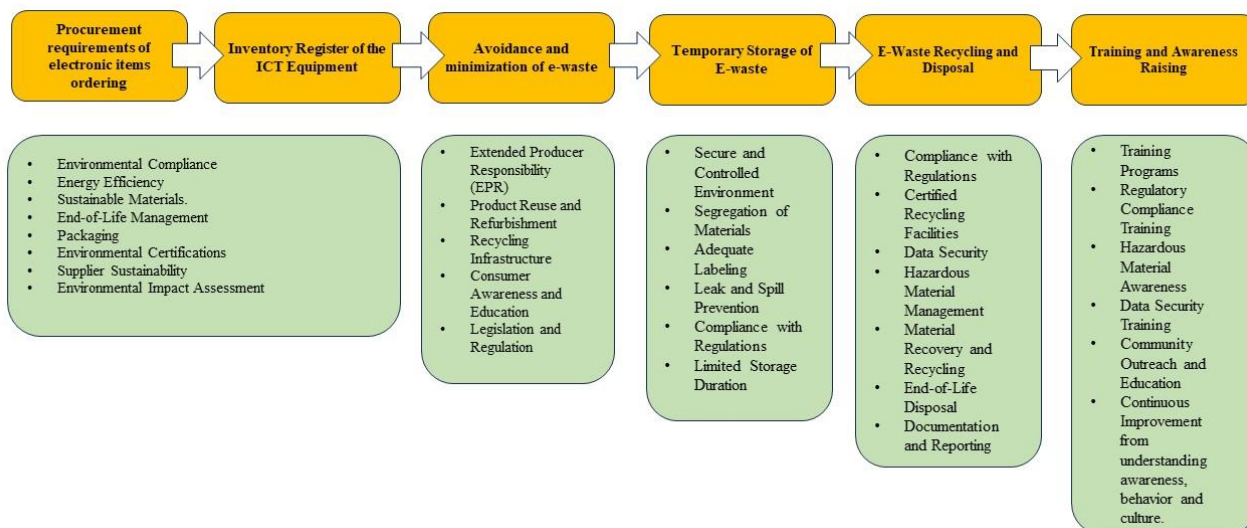


Figure 7 Requirements Framework of E-Waste Challenges and Solution