



**THE DETERMINATION OF THE RECYCLERS PREFERENCE INDEX  
(RPI) FOR RECYCLING THE END-OF-LIFE WASTE ELECTRICAL  
AND ELECTRONIC EQUIPMENT (WEEE) IN MALAYSIA**

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka  
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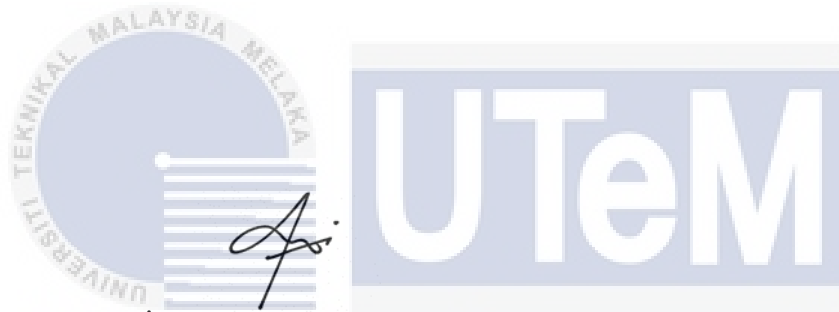
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## DECLARATION

I hereby, declared this report entitled “The determination of the Recycler Preference Index (RPI) for recycling the end-of-life Waste Electrical and Electronic Equipment (WEEE) in Malaysia” is the result of my research except as cited in the reference.

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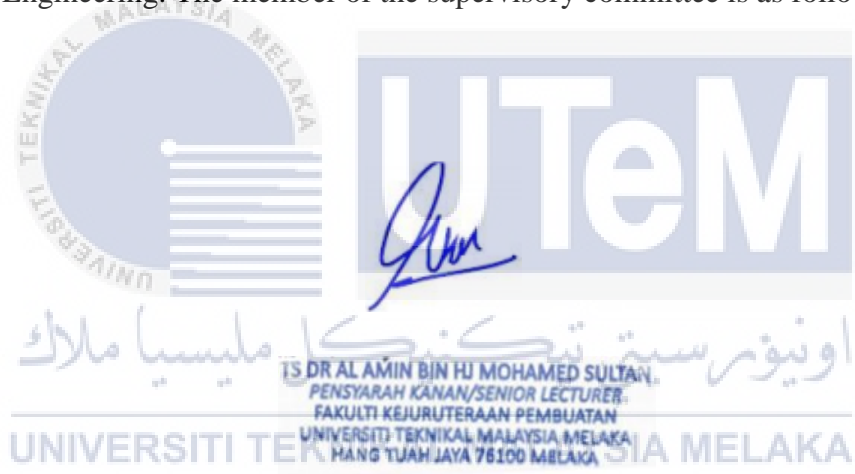
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## APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfilment of the degree of Bachelor of Manufacturing Engineering. The member of the supervisory committee is as follow:



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## ABSTRAK

Sisa barang elektrikal dan elektronik merujuk kepada semua barangan atau peralatan elektrik dan elektronik yang telah dibuang oleh pemiliknya sebagai sampah tanpa tujuan untuk menggunakannya semula. Sisa barang elektrikal dan elektronik telah meningkat sebanyak 44.7 juta metrik tan setiap tahun. Daripada jumlah tersebut hanya 20% sisa barang elektrikal dan elektronik dikumpulkan untuk dikitar semula. Di samping itu, masalah ini juga terjadi di dalam Malaysia. Hal ini kerana, Malaysia masih kekurangan atau ketiadaan faktor-faktor utama seperti pemangkin, penghalang dan cabaran semasa untuk mengitar semula Sisa barang elektrikal dan elektronik, peranan pemilikan sisa barang elektrikal dan elektronik yang tidak jelas, analisis terhadap mengenai aktiviti kitar semula di Malaysia, dan ketiadaan kerangka terkini dalam menentukan perjalanan sisa barang elektrikal dan elektronik telah menjadikan aktiviti kitar semula sisa barang elektrikal dan elektronik sukar ditangani dengan baik di Malaysia. Untuk mencapai objektif kajian, borang soal selidik dibina dan diulas terlebih dahulu oleh pakar untuk memastikan isi kandungannya mudah difahami oleh responden. Borang soal selidik telah diedarkan kepada pusat kitar semula di Selangor dan Johor dengan menggunakan kaedah kuantitatif. Hasil daripada kajian mendapati bahawa aspek keuntungan merupakan factor responden menjalankan aktiviti kitar semula, manakala aspek dasar kerajaan dan perlesenan merupakan cabaran semasa yang dihadapi mereka untuk terus kekal di dalam industri kitar

semula. Seterusnya, aspek permintaan pasaran yang tinggi terhadap barangan kitar semula merupakan faktor mereka terus kekal di dalam industri kitar semula di Malaysia. Selain itu, kerangka perjalanan sisa barang elektrikal dan elektronik berjaya dilakar dan dirujuk oleh pegawai di jabatan alam sekitar serta membina satu model kaedah untuk menentukan keutamaan sesuatu Sisa barang elektrikal dan elektronik untuk dikitar semula di Malaysia. Kesimpulannya, mengendalikan sisa barang elektrikal dan elektronik merupakan satu tugas yang sukar dan amat mencabar bagi sesebuah negara. Oleh itu, beberapa tindakan komprehensif perlu diambil untuk mengatasi cabaran semasa untuk menghidupkan kembali industri kitar semula di Malaysia dengan mengambil hasil penemuan ini sebagai satu gambaran awal untuk meneruskan usaha penambahbaikan di masa akan datang.



## **ABSTRACT**

Waste Electrical and Electronic Equipment (WEEE) refers to all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of reuse it. WEEE has grown to 44.7 million metric tonnes annually. But only 20% of the e-waste generated is documented to be collected and recycled. Locally, the problem is significant too. The missing of critical factors particularly on the drivers, current challenges and consideration factor for recycling WEEE, the unclear roles of the waste ownership, limited analysis on the current state of the recycling practices in Malaysia, and the absence of the related recycling framework all together have made the recycling of those WEEE could not be adequately addressed. In order to achieve the research objectives, questionnaires are developed and reviewed by the experts to ensure it is understandable by the respondent. The survey is using quantitative method and is distributed to recyclers in Selangor and Johor. The research findings found that critical factors for the recyclers to sustain in the recycling industry are profit as main consideration factor, government policy and licensing as the current challenges faced, high demand for recycled materials are the drivers for the recycler to sustain in the recycling industry. Besides, local recycling supply chain framework in managing WEEE in Malaysia is developed based on the findings and reviewed by the Department of Environment (DOE) representative, and the models of decision-making measure to boost the end-of-life WEEE from the recycler perspectives for Malaysia are constructed. To summarize, making the best choice to tackle end-of-life waste was one of an organisation's most difficult challenges. Therefore, some comprehensive action needed to be taken to counter the current challenges to revive the recycling industry in Malaysia by looking at this finding results as the initial illustration for the future improvement.

## DEDICATION

Only,

My beloved father,

My appreciated mother,

My adored siblings,

My supportive academic supervisor,

For giving me moral support, financial support, cooperation, encouragement, and understanding.

Thank You So Much & Appreciated Your Kindness



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I also want to take this opportunity to express my heartfelt thanks to the recyclers in Johor and Selangor for their willingness to help throughout the journey. At the same time, those who did not cooperate showed me how the real-world works. I shall cherish every bittersweet throughout the journey of completing this study.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Over the years, demand for Electrical and Electronic Equipment (EEE) products, especially household appliances such as refrigerators, air conditioners, washing machines, computers, televisions and mobile phones has continuously increased. As the world's population continues to grow, these products' production is maximized to meet the current demands. The continuous demand for the EEE products could be seen from the report produced by the MIDA shows that EEE industry in Malaysia has gained approximately RM166.2 billion of total gross outputs and was able to provide job opportunities for over 336 thousand of people to meet higher demands of EEE products in 2010 (MIDA, 2020). However, EEE products' increment demands have simultaneously increased the volumes of Waste Electrical and Electronic Equipment (WEEE) where Suja et al. (2014) reported that 10% to 15% of the scheduled waste generated in Malaysia is WEEE. WEEE refers to discarded EEE products that have reached their lifespan or have failed to operate and cannot catch up with advanced technology.

The Department of the Environment (DOE) estimates that the total WEEE volume produced in 2020 will reach up to 21,38 million tons. Television and cell phones are the key contributors (Department of Environment, 2017; B. Lim, 2019). Out of the total waste generated, it is reported that only 25% of the WEEE is discarded sustainably. Simultaneously, the remaining are either burned or mixing along with the residual waste to be disposed of in

landfill (B. Lim, 2019). This, however, has contributed to the massive waste as the WEEE contains many valuable materials that could be processed to be other's product resources. This situation led to a discussion of the experts in resource sustainability issues. Factors that contribute to the development of the crisis can be identified into two, a) linear model that is currently practised causes huge consumption of resources and b) barriers in handling end-product waste (Breivik et al., 2014; Habib et al., 2015).

The linear model has monopolized the industry for over 150 years and is defined as 'take-make-use-destroy' model where the products are following a linear cycle, which contributes, to the increment numbers of waste in landfill (Jawahir and Bradley, 2016; Ghisellini et al., 2016). The current model's continuities practice has resulted in the massive waste generated, and the current waste is expected to be doubled by 2045 (Parajuly et al., 2019). WEEE is rapidly becoming a leading source of waste due to ever-changing technological era. Through this era, manufacturers make the consumer buy more products through planned obsolescence. The product is purposely designed to break down over time so that the consumer has no choice besides replacing a new one. According to Balde et al. (2017), approximately 44.7 million tons of WEEE produced worldwide in 2016, of which 20% was reported had been collected and appropriately recycled while another 80% of WEEE was unidentified. Those unidentified products may be disposed of inappropriate ways.

Proper waste management needs to be implemented as the political leaders criticize the number of products being thrown in the landfill. (Balde et al., 2017; IA. Jereme et al., 2014). Through this limitation of the current model, Circular Economic (CE) has been continuously promoted as an economic model in substituting a linear economy due to its idea of prioritizing environmental protection, social well-being, and economic development. CE is defined as a model that proposes reformation on the existing linear process flow to a circular flow that retains products' economic and environmental value over time (Nußholz, 2017). (Cavallo et al., 2017; Nancy et al., 2016) state that CE's implementation is to achieve several objectives; a) Reduction of waste in landfills and pollution, and b) Ensure the continued usage of resources.

The implementation of CE helps preserve and maximise the resources due to this model is a closed-loop system where reuse, remake, repair, remanufacturing and recycling are practised. Circular economy could save money and contribute to the big boost for the European Union (EU) economy (Mac Arthur, 2013). In 2014, the European Commission announced that the CE transformation could produce EUR 600 billion economic gains for the EU countries' EU manufacturing sector (Valavanidis, 2018). Through CE model, European Economic will contribute to innovation and job growth and help the environment by preserving our precious natural resources.

The previous study has shown that Malaysia is starting to implement the circular economy approach (Shamee and Shamsuddin, 2019) reported that several Malaysia companies are taking part in remanufacturing industries. These companies focus more on the ICT sector, where both companies remanufacture products such as cartridge and toner. Nevertheless, Shamee and Shamsuddin (2019) state that Malaysia is still in the commencement stage in the remanufacturing industries and faced several challenges; 1) No standardized framework for the raw material collection system, 2) lack of design factor consideration in the current product, and 3) lack of remanufacturing business analysis.

To fully adopt the CE approach in Malaysia, the government should emphasize more deliberate action to encourage and overcome the barriers in remanufacturing industries. As stated by Shamee and Shamsuddin (2019), the remanufacturing sectors could be a starting point for adopting the recycling culture. The government plays an essential role in ensuring the continuity of the effort by providing an official framework for waste management and amended more regulations.

## 1.2 Problem Statement

The EEE products have become a necessity of life, as the advent of such products has made life simpler in several ways. However, every EEE products have its lifespan, which in a certain period, the product could no longer be used or unable to catch up with technological advancement. As the demands for the EEE products increases, it will simultaneously increase the numbers of WEEE generated. According to Department of Environment (2017), the WEEE generated amount increases with an average of 14% every year in Malaysia and is expected to have 21.4 million tons of WEEE by 2020. Lim (2019) stated that out of total WEEE generated in Malaysia, only 25% are recycled and managed sustainably. The WEEE remaining might be mixing along with the residual waste or illegally dumped or burned in an unsustainable manner. This unsustainable manner in handling WEEE impacts the environment and human health due to the hazardous substance contained in electrical and electronic waste.

In Malaysia, WEEE is reported that the current WEEE regulations in Malaysia apply only to industrial waste where an authorized recycling centre must handle the generated WEEE (DOE, 2019; Yong et al., 2019). As for the household sector, the WEEE Regulation is still under consideration. However, due to poor law enforcement in Malaysia, Shumon and Ahmed (2013) highlighted that the manufacturers and importers do not take any responsibilities to manage their end waste. This irresponsible action has contributed to the rise in illegal recyclers who take advantage of the absence of WEEE ownership. These informal sectors are typically dismantled the WEEE using two techniques, illegally burned or dismantled without wearing proper personal protective equipment in extracting the valuable materials contained inside the products. Later, the unwanted part will be illegally dumped or burned in the open space. However, these techniques are risky to the employee and people living nearby due to illegally burning, and dumping could affect the human's health and trigger the pollution.

The missing critical factors (drivers, current challenges and consideration factor) for recycling WEEE, the unclear roles of the waste ownership, limited analysis on the current state of the recycling practices in Malaysia, and the absence of the related recycling framework all together have made the recycling of those WEEE could not be adequately addressed. Without strategic decision tools to respectively address the management of the end-of-life WEEE, especially to prioritise the types of product or materials for recycling, Malaysia is still at the infancy stage towards recycling practices compared with other developed countries.

The linear economy uses a 'take-make-dispose' model, where the raw material will be extracted and processed to be a functional product. In a certain period, the products will be disposed of, and the cycle goes on. The sequences from this action led to the degradation of natural resources and increased the numbers of WEEE. Hence, the call for the circular economy approach. The life cycle of the CE approach products holds the services in operation for as long as possible, extracting the full benefit. At the same time, recycling plays an essential role in ensuring the circle are continuously circulated. However, Malaysia's low recycling rate, the lack of critical factor recycling initiatives and the lack of an official WEEE management system have made it a shortcoming for Malaysia to implement the circular economy approach.

Simultaneously, the surge in population growth as rising demand for electrical and electronic products would ultimately decrease natural resources. Therefore, these compounds' refining is necessary as WEEE contains valuable materials such as iron, aluminium, copper, gold, silver (Heacock et al., 2016). The WEEE products should not be mistreated to be used to other product's resources through recycling. The 75% of unrecycled WEEE has proven that Malaysia has failed to educate the people on the urgency of securing and preserving these materials for the future generation. Measurement of the recycler preferences index is essential to help the government or other parties take a deep action and control the WEE waste at the local recycling centre.

### 1.3 Objectives

1. To determine the critical factors and the current practices of the end-of-life WEEE recycling in Malaysia
2. To develop the local-recycling supply chain framework in managing WEEE in Malaysia
3. To models the decision-making measure to boost the end-of-life WEEE from the recycler perspectives for Malaysia

### 1.4 Scope

This study is measured by several factors, including the critical factors for the execution of WEEE recycling initiatives by determining the driver and barrier for recycling initiatives in Malaysia from the recycler's perspectives. The measure of these critical factors is crucial in strengthening the recycling culture among recyclers as recycling is one of the significant CE approaches. Identification critical factors of drivers and barriers for the execution of WEEE recycling initiatives are based on recycler's perspectives. The outcome may be varied for the recyclers in a different state (Selangor and Johor). The determination of WEEE ownership is measure through the recycler's initiatives in promoting the recycling culture. These measures are crucial to determine their responsibilities in managing WEEE. The demonstrated local-recycling supply chain framework focuses on the WEEE only from recyclers perspectives and is critical for monitoring the movement of WEEE until its end route. The constructed local-recycling supply chain framework of WEEE are solely based on the recyclers that have been visited. The Recycler Preference Index (RPI) are developed mainly based on the recyclers in the targeted area and may be also applicable to others with some relevant modification.

## 1.5 Report Outline

Chapter 1: The chapter summarises the study, including the background to the study, the current study issue, and the goals of the analysis and the area to be covered.

Chapter 2: The chapter discusses and analyzes various literature to have a clear view of the study. This provides a comprehensive analysis of the current linear economy, the transition to a circular economy, the circular economy as a resource for sustainable growth, relevant WEEE problems and the emerging problem of recycling WEEE.

Chapter 3: The chapter illustrates the method used for the study, including study design, data collection method, the timeline of the study (Gantt chart), general view of data analysis and study plan.

Chapter 4: The chapter will present the finding based on the objectives. This includes discussing the current practices of the WEEE recycling, ownership of the products, WEEE management framework, the recycling industry's critical factor, and the recycler preference index.

Chapter 5: The chapter will present the study's conclusion and propose several suggestions for the future works.



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Sustainable Development**

The economic development and industrial revolution have led to an improved standard of life; however, it has resulted in more natural resources being depleted, which placed pressure on Earth's life support system. The effect of the industrial revolution since the mid-18<sup>th</sup> century has affected the capability of the environment to sustain social and environmental development. This has led to the possibility of compromising future needs. Therefore, there was an immediate call for a transformation towards balance environmental consideration, sustainable social and economic growth.

Brundtland (1987) had introduced sustainable development (SD) in The Brundtland Commission Report of 1987. He defined the SD as a development that satisfies current human needs without compromising future needs. The authors emphasize that the over-exploitation of resources in the present time will lead to difficulties in the future. Nevertheless, Hák et al. (2016) and Mensah (2019) stressed that adopting a sustainable development approach is necessary to ensure that the supply of natural resources and population growth is adequate. The concept of sustainable development is built based on the development (progress on social and economical must be in line with environmental constraint), current needs (equality on resources distribution) and future demands (securing the resources for next-generation) (Klarin, 2018).