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 (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons)

by

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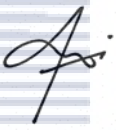
DECLARATION

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.

Signature : 

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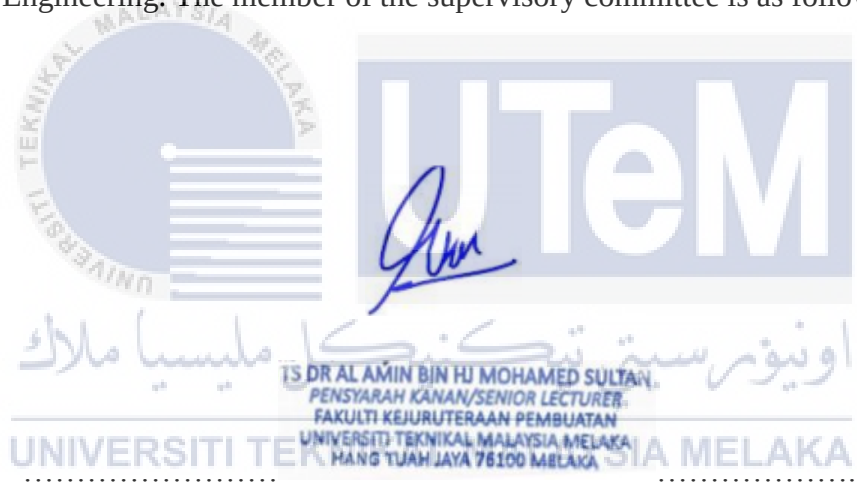
Date : 9th February 2021

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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(Principal Supervisor) – Signature & Stamp

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 terhad mengenai aktiviti kitar semula di Malaysia, dan ketiadaan kerangka terkini dalam menetukan 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 tugasan 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

ACKNOWLEDGEMENT

Alhamdulillah, To Allah the Almighty belong to all praises and glory. I would like to express my gratitude to the Universiti Teknikal Malaysia Melaka (UTeM), and the individuals whose kind assistance, concern, and motivation help me throughout this journey of completing the study.

I would like to express my love and appreciation to my parents and siblings for their prayers, supports, sacrifices, inspiration, financial, understanding, and blessings. These have always given me the strength and encouragement to give my best in this study. I would like to take this opportunity to extend my sincere thanks to my supervisor, Ts. Dr. Al Amin, for his wisdom, necessary supervision, dedication, support, and encouragement has always been the inspiration for completing this research. I would like to express my gratitude and appreciation to friends who have helped me in many ways.

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.

Thank You.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

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-18th 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).

In her view of sustainable development, Cobbinah et al. (2011) highlighted that the sustainable development is a possible direction to steer growth into a more equitable model to establish a balanced relationship between the three pillars; economic, social and environment. Punjab (2013) stressed that the social and economic development are related to the environment in which each socio-economic transition will lead to environmental consequences and vice versa. This relationship between the pillars is seen in the concentric circle model, as shown in Figure 2.1. The concentric circle model comprises a multi-level subsystem; the environment circle encompasses the human social process, and the human society circle contains the economy circle. This model describes the interdependence and inter-reliance relationship between the environment, social and economic (Thakshila et al., 2019).

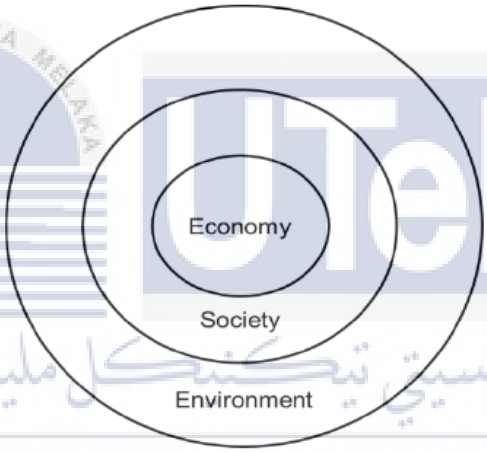

Figure 2. 1 : Main pillar of sustainability [Derived from (Thakshila et al., 2019)]

Baker (2007) highlighted that sustainability is perceived only from an economic point of view. The economy would undoubtedly be improved profitably. Still, the consequences will be on the environmental and social aspect. For instance, human rights concerns will be raised on a social level, and environmental degradation occurred on environment aspect. The purpose of the SD approach is to ensure the human can live comfortably by keeping on supplying the human needs, preserving natural resources without compromising future needs, conservation of the environment, and preserving the quality of human lives (Prasad, 2018). The three pillars of SD should be inter-reliant and interdependence for a nation to be a fully sustainable developed.

2.1.1 Economic Sustainability

Economic sustainability refers to approaches that foster long-term economic development without having a detrimental effect on the social and environmental aspects. Economic sustainability requires the upholding of competitive advantages and efficient market orientation while conserving resources and increasing life quality (Stock et al., 2018). According to Kandachar (2013), the present evolving global economy reveals that a country's economy and prosperity depends solely on its technical capacity to add value in its natural resources. Competencies in product design offer the opportunity to transform natural resources into marketable domestic and foreign markets.

In Malaysia, the EEE industry gained RM 166.2 billion of total gross output, RM249.8 billion of exports, and jobs for 336 thousand people in 2010. The EEE industry has been a significant contributor to Malaysia's economy where the industry is reported managed to attract foreign investment, including Singapore, Netherland, Japan and Germany (MIDA, 2020). Jute is a biodegradable natural fibre. Most of the part is useful because its leaves can be eaten, and its husks can be used for firewood. Frequently, jute is used to manufacture a reusable bag that may replace a plastic bag that has a detrimental effect on the environment due to its non-biodegradable properties (Kandachar, 2013).

2.1.2 Environment Sustainability

Human activities in the past decade have caused detrimental effect towards the environment, such as, increase in the concentration of greenhouse gases (GHGs), climate change, degradation of land, pollution of air water and soil, depletion of non-renewable resources and loss of biodiversity (Arora et al., 2018). Sustainable environmental development focuses on the restoration of the ecological system, which is the primary source of natural

resources and human survival (Stock et al., 2018). Several alternatives could be made to address end-product waste, which is the leading cause of environmental degradation, particularly when it is disposed of in landfills.

Goetzman (2019) highlighted that the EEE industries strive to greener system where these industries seek safer alternatives in processing EEE products that do not harm the environment and human health. These industries are starting to adopt a more efficient design that could reduce energy consumption during the processing and EOL phases. For instance, European countries are beginning to develop bio-composite plastic to be used in EEE product's part. This bio-composite is used for wire-coating and housing to enhance the product's durability and reduce vibration damping and flame retardance. The transition from plastic to bio-composite is a safer alternative as its mechanical properties are more rigid and bend-resistance due to its natural trait. Biogenic material processes have significantly reduced the uses of fossil carbon. Using this material to replace plastic is a better option as it could conserve the long-term environment (Wilson, 2019).

Nokia corporation is a multinational telecommunications company that is founded in 1865. SCRC (2012) stated that Nokia has sold millions of handset globally, and throughout its operation, the company has been striving to produce sustainable devices. The Nokia product is made from the biodegradable material or made from the recycled material that lasts for a long time. Each part of the handset from this brand are 100% could be reused again for other application. This company ensures the products to be environmentally friendly in which at EOL of this product, parts could be reused and eliminate the needs for newer natural resources.

2.1.3 Social sustainability

Social sustainability includes the equitable inclusion of human resources, taking into account social classes, gender, age group, and cultural and regional identity. The aim is to achieve social stability and individual freedom, combined with solidarity and social justice (Stock et al., 2018). While most countries are transitioning between developing and developed nations, the gap between rich and poor widens. Prasad (2018) stressed that sustainable social development could only be accomplished if the country can provide equal opportunities for jobs, education, food security and good health services to its citizens.

The EEE has become one of Malaysia's leading sectors for the past fifty years and has been a part of the job's provider ever since. Hirschmann (2020), 533 thousand people are employed in the electrical and electronic industries in 2015 and continue to increase to 575 thousand employment in 2019. As demand for the EEE product rises, the job rate is rising to meet demand. Figure 2.2 below demonstrates the statistical data on the job employment rate in EEE industry in Malaysia.

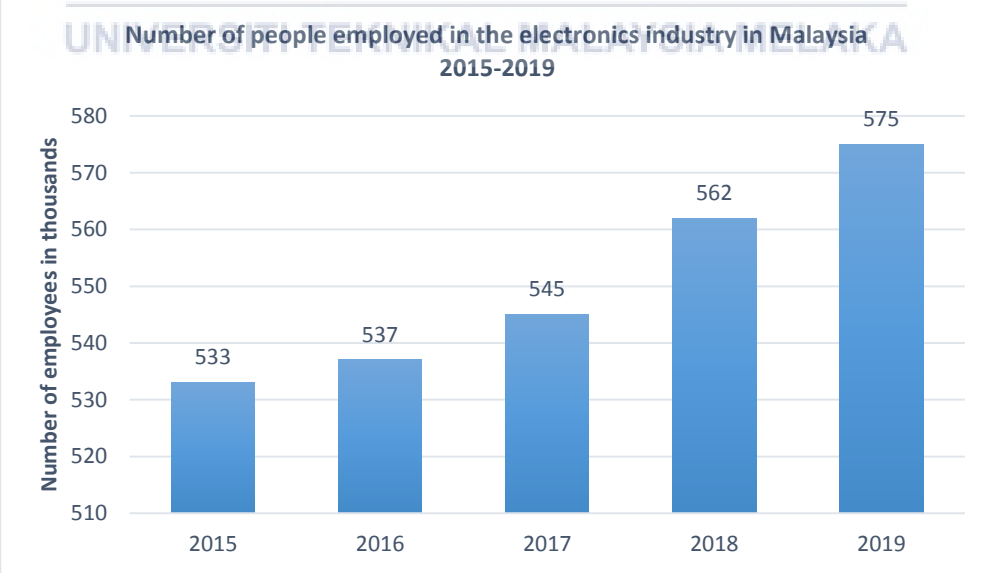

Figure 2. 2 : Statistic of job employment in Malaysia electrical and electronic industry (Hirschmann, 2020)

2.2 The limitation of Linear Economy

For the last 150 years, the linear economy has been monopolized by industry in which products follow a linear cycle starting from material exploitation, manufacturing, consuming and lastly, the disposing phase (Jawahir and Bradley, 2016). The linear approach is an obstacle for the nation to be fully sustainable developed due to the world's often focusing on the economy and social growth. As demonstrated in Figure 2.3, the approach operates throughout a linear flow where resources are extracted from the parent system (environment), manufactured and consumed. After a while, waste of the products is disposed of in the landfill, causing pollutions (Korhonen et al., 2018). These linear economies are introduced as the 'take-make-dispose' model (Ghisellini et al., 2016).

Figure 2. 3 : Material Flow in Linear Economy [Derived by (Korhonen et al., 2018)]

Previously, there is an abundance of raw natural resources sold with a lower price and excellent accessibility. The uses of the raw natural resources in many manufacturing sectors have become compulsory without thinking of preserving for future needs and long-term consequences on the environment. However, this mindset has led to unnecessary waste losses, especially in the production chain and disposing of phase (Kormut'ák et al., 2013). A significant volume of resources is reported lost during the initial and final phases of the production. The operator tends to take a newer part whenever one part is missing. Most consumers tend to mix the discarded products with other residual waste or dumped in the landfill illegally during the disposing phase. This has caused unnecessary waste because most of the discarded product is still valuable and needs to be disposed of sustainably. Most valuable material could be derived from the discarded product and could be used for other purposes.

Jawahir and Bradley (2016) emphasized that resources are scarce, and the persistence of depletion resources for never-ending human needs will cause harm the earth in the future, as shown in figure 2.4 below. As projected by Bastein et al., (2013) and Reh (2013), the natural resources will surge up to eightfold along with the population growth estimated to hit 9 billion by 2050. As the population numbers increase, the demand for the EEE product will increase simultaneously. If the manufacturer continuous using the linear approach, the current resources will inadequate for future uses. Hence, the linear economy is no longer acceptable and fall short to endure the sustainability challenges in the future due to the lack of consideration in social welfare, economic growth and environmental preservation.

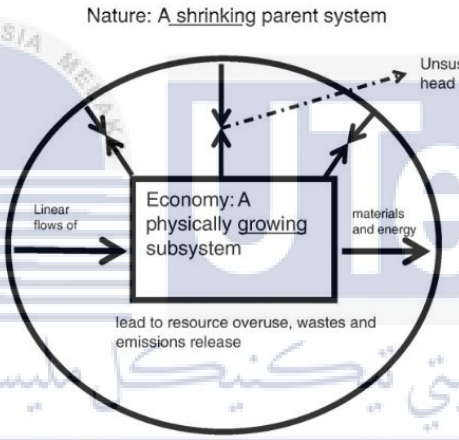

Figure 2. 4 : Shrinking system of Linear Economy [Derived from (Korhonen et al., 2018)]

Although recycling behaviour is practised, actions that consider finite resources have not been addressed by (Jawahir and Bradley, 2016). Reusing, recycling, or incinerating the discarded product saves significantly more energy than the disposed of the product in the landfill, which the product loses its residual energy. Foundation (2015) point out that waste is viewed solely as environmental threats despite being recognized as a source of valuable material. Consequently, redesign, recover, reuse or even trading faced a legal obstacle and significantly limit these activities. This view is supported by EMF (2015), who argues that the economies of continuous exploitation since the mid-20th century lead to negative externalities.

Reducing resources and fossil fuel consumption in this situation will not preserve the finite nature of material stocks but will only delay the depletion of existing resources.

The Sustainable Europe Study Institute (SERI) reported that the OECD country manufacturer generates over 21 billion tons of waste material not incorporated into the products each year. From the EOL perspective, the recycling rate is said to be competitively lower than manufacturing rates. In Europe, out of 2.7 billion tons of EOL waste are generated in 2010, only 40% are reused and recycled. In the point of view of energy usage, this model's energy resource usage is most concentrated in the upstream parts of the supply chain, where materials need to be extracted from the earth and converted into a commercially available form.

The significant limitations of the current linear model are it causes the degradation of the natural system. The linear economy approach has placed extra pressure on the ecosystem that threatens the core environmental services: water, air and soil. The three taglines of take-make-dispose approach have affected the environment in many ways. Deriving natural resources and turning these materials into usable products requires high energy intakes, increasing pollution and demolishing natural capital. When the WEE product is disposed of in the landfill, the toxic substance will be discharged from the discarded product and emerged into the soil, water and atmosphere. These approaches continuously manage the good in an unsustainable manner if the manufacturer considers the economy and social aspect. It will significantly harm the environment aspect and future generations. Therefore, the scholar has encouraged the manufacturer to concentrate on the three foundations of sustainability through the circular economy.

2.3 The rise of The Circular Economy

The economic model, also known as the Circular Economic, is a pragmatic response to the emerging global resource crisis. This model has been an incentive to overcome a linear economy's constraint by addressing economic growth, environment conservation, and social well-being. The academic literature on circular economy has revealed the needs for a change from the current model. For instance, Nußholz (2017) defines CE as a concept that attempts to restructure the existing model primarily on the framework of a linear flow into a closed-loop flow that can sustain the environmental and economic value of products over time. The author points out that the CE model can increase resource efficiency and generate environmental benefits through reduced raw material extraction and waste generation compared to the current economy. This argument is backed by (Babbitt et al., 2018; Hofmann, 2019) where the excessive exploitation of natural resources over the years in the current economy has resulted in severe environmental and social impact. Thus, the CE approach is aimed at the efficient system by minimizing the waste produced and long-term conservation of value. CE is a closed-loop system within the context of environmental conservation and socio-economic benefits.

Sauvé et al. (2016) demonstrate the difference between the linear economy cycle and the circular economy, as seen in Figure 2.5. The linear economy imposed a 'Take-make-use-dispose' approach which causing the negative externalities, especially towards the environment and social concern. This paradigm's implications have resulted in the intense exploitation of the earth's resources, pollution, and the development of a volume of waste in landfills. The beginning and end phase of the linear economy creates a lot of waste in the chain, where the eventual return to Earth is lost due to pollution. Nevertheless, CE approaches consider the environmental impact where the products' life cycle is circulating in the close loop, reducing the numbers of waste generated. The CE framework is demonstrated in figure 2.6.

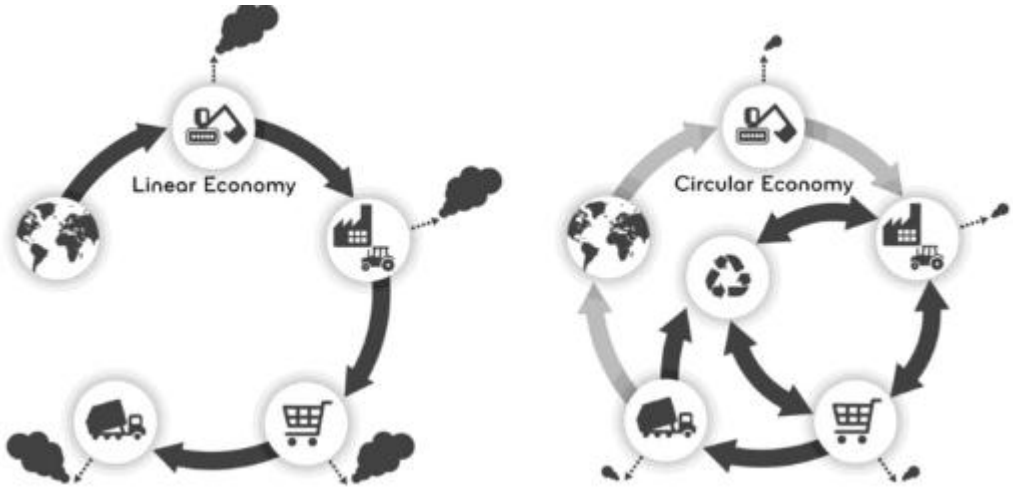

Figure 2. 5 : Differentiation between Linear Economy and Circular Economy (Sauvé et al., 2016)

The life cycle of the products circulates in holding the services in operation for as long as possible, extracting the full benefit while in use, recycling and regenerating the products and materials at the end of each service period. Jawahir and Bradley (2016), CE strategies are efficient in increasing resource efficiency and eliminating the waste of useful resources in the products usually disposed of in the landfill. The closed-loop framework in CE helps to recycle resources from the consumption phase useful for production use. The author claimed that the CE model's goal is to optimize virgin resources and reduce emissions and waste.

Figure 2. 6 Closed-loop framework, (Jawahir and Bradley, 2016)

Amui et al. (2017) stressed that the material should be kept available rather than disposed of in such a way as to create a closed-loop for the material to circulate within the product lifecycle to reduce the use of resources and energy demand. Nevertheless, Ritzén & Sandström (2017) argues that CE's transition requires a structural change that affects the whole organization and its stakeholders. The author points out that the transformation may be disruptive, needing new approaches where the existing working processes need to be modified. However, to address these changes, it is necessary to consider the barriers and the drivers that the organisation faces in implementing CE. Stewart et al. (2016) points out a study on barriers and drivers in CE implementation are typically focused on case studies surveys as primary sources of empirical evidence. Although the CE approach is continuously emphasized and implemented, several environmental and economic content barriers are addressed in these journals and are demonstrated in Table 2.1.

Table 2. 1 : Barriers in implementing CE

Category	Barriers	Bechtel et al., 2013	Gumley, 2014	Ilić & Nikolić, 2016	Rizos et al., 2015	Xue et al., 2010	Adams et al., 2017	Liu & Bai, 2014	Ecorys, 2011	Stewart et al., 2016
Economic	Lack of tool and method to measure long term benefit of CE	√	√	√	√	√				
	High costs and lack of financial flexibility and supports	√	√	√	√	√				
Social	Lack of social awareness and uncertainty of consuming responsiveness and demand	√				√	√	√	√	
	Lack of market mechanisms for recovery	√				√	√	√	√	
	Lack of clear incentives	√				√	√	√	√	
	Complex and overlapping regulation	√	√	√		√			√	√

Institutional	Lack of governmental support	√	√	√		√			√	√
	Lack of CE know-how of political decision-makers	√	√	√		√			√	√
Technological and informational	Lack of information and knowledge	√			√		√		√	
	Lack of technologies and technical skills	√			√		√		√	
Supply chain	Lack of network support and partners	√	√		√					√
	Lack of collaboration and resources	√	√		√					√
Organizational	Conflicts with existing business culture and lack of internal cooperation	√			√		√	√		√
	Heavy organizational hierarchy and lack of management support	√			√		√	√		√
	Lack of CE knowledge and skills	√			√		√	√		√

From the Table 2.1 above, many prominent researchers listed out several limitations on the context of economic; a) Lack of measuring tool in CE approach, b) Lack of financial stability support and c) Higher cost of emerging technology (Bechtel et al., 2013; Gumley, 2014; Ilić and Nikolić, 2016; Rizos et al., 2015; Xue et al., 2010). From the social aspect, Lack of social awareness and uncertainty of consumer responsiveness and demand, lack of a market mechanism for recovery and lack of clear incentives are addressed in the (Adams et al., 2017; Bechtel et al., 2013; Ecorys, 2011; Liu and Bai, 2014; Xue et al., 2010) in a context of social. Complex and overlapping regulations, lack of government support and lack of CE know-how of political decision-maker are addressed in the (Bechtel et al., 2013; Ecorys, 2011; Gumley, 2014; Ilić and Nikolić, 2016; Stewart et al., 2016; Xue et al., 2010) in a context of institutional. Lack of information, knowledge, technologies and technical skills are addressed in (Adams et al., 2017; Bechtel et al., 2013; Ecorys, 2011; Rizos et al., 2015) in a context of technological and informational. Lack of network support, lack of collaboration and resources are addressed in (Bechtel et al., 2013; Gumley, 2014; Rizos et al., 2015; Stewart et al., 2016) in a context of the supply chain. Lastly, Conflicts with existing business culture and lack of internal cooperation, heavy organizational hierarchy and lack of management support, lack of CE

knowledge and skills are addressed in (Adams et al., 2017; Bechtel et al., 2013; Liu and Bai, 2014; Rizos et al., 2015; Stewart et al., 2016) in a context of organizational.

However, of all these obstacles, many papers discuss the guiding force behind the CE approach's development, as seen in Table 2.2 below. (Andrews, 2015; Ghisellini et al., 2016; Linder and Williander, 2017; Moreno et al., 2014; Murray et al., 2017) points out limitation or a constraint in Earth's resources and avoiding the negative impact on the environment are the driver in implementing CE approach in a context of the environment. Because of the economy, the CE approach is seen as an economic booster as this model provides the potential for new value development, market growth, improved margin and income as addressed in (Dong et al., 2016; Ghisellini et al., 2016; Linder and Williander, 2017; Liu and Bai, 2014; Murray et al., 2017; Rizos et al., 2015; Schulte, 2013).

Futhermore, with standardized and strict environmental regulations are one of the motivating forces for the organization to adopt CE approach, as the competition among stakeholders encourages the search for alternatives to the linear economy model. With subsidies and supportive taxes, it motivates the companies to adopt the CE approach (Bai et al., 2015; Dong et al., 2016). Lastly, (Andrews, 2015; Ghisellini et al., 2016; Linder and Williander, 2017; Moreno et al., 2014; Schulte, 2013) points out that through the supply chain, the CE approach has the effect of reducing supply dependency as well as preventing higher and unpredictable resource prices over time. Throughout this META analysis, it can be concluded that the CE approach can be used as a tool for sustainability as this model considering environmental, social and economic aspect.

Table 2. 2 : Drivers in implementing CE

Category	Drivers	Ghisellini et al., 2016	Moreno et al., 2014	Murray et al., 2017	Andrews, 2015	Linder & Williander, 2017	Liu & Bai, 2014	Rizos et al., 2015	Dong et al., 2016	Schulte, 2013	Bai et al., 2015
Environment	Limitation on Earth's resources	√	√	√	√	√					
	Potential to avoid adverse environmental risks	√	√	√	√	√					
Economic	Opportunities for enhancing cost-efficiency	√		√		√	√	√	√	√	
	Discovering new revenue sources	√		√		√	√	√	√	√	
Institutional	Regulations and uniform specifications								√		√
	Supportive funds, taxation and subsidy policies								√		√
Supply chain	Possibilities in reducing supply reliance and eliminating high and unpredictable prices	√	√		√	√				√	
	Multi-disciplinarily, enhanced utilization of resources and capabilities	√	√		√	√				√	
	Management of (reverse) networks	√	√		√	√				√	

2.4. Waste Electrical and Electronic Equipment (WEEE)

As the world population numbers keep growing, EEE products' production is maximized to accommodate the demands. However, the increment of demand in these products has simultaneously increased numbers of WEEE. WEEE is the world's primary residue source due to a) technological innovation and b) shorter lifespan (Needhidasan et al., 2014; Terazono et al., 2006). According to Balde et al. (2017) report, they highlighted that 44.7 million tons (Mt) of WEEE was produced in 2016 and are expected to reach 52.2 (Mt) globally by 2021. Out of 44.7 Mt generated globally, Asia is reported to generate the highest amount of WEEE (18.2 Mt), followed by Europe (12.3Mt), America (11.3Mt), Africa (2.2Mt) and Oceania (0.7Mt).

However, only 20% of WEEE is reported to be collected and properly recycled. The rest of the WEEE is unidentified and is believed to be either mixed and residual waste, traded or recycled inappropriately. Nevertheless, the exact collection rate is challenging to measure, considering that only 41 countries have official WEEE statistics, while the rest of the 16 countries are measured from the collected study (Balde et al., 2017).

The rising amount of WEEE is becoming a primary global concern as it has adversely affected the environment and health through inadequate recycling and disposal techniques. The author points out that informal recycling is mostly taking place in developing countries where recycling practised is not highly developed. Much of the WEEE will end up either in a non-hygienic landfill or in an open dumpsite (Ikhlayel, 2018). Furthermore, StEP (2016) stressed that comprehensive data on WEEE, including the qualitative and quantitative aspects, must understand consumers and policymakers. Malaysia is estimated to generate 21.38 Mt of WEEE by 2020 (Department of Environment Malaysia, 2008) and generated 8.8kg of WEEE per capita in 2016 (StEP, 2016). Comprehensive quantitative data on WEEE are important for addressing WEEE challenges. Statistics help to assess trends over time, set and review goals and define best management practices. Enhanced WEEE data would help reduce its production, prevent illegal dumping and pollution, encourage recycling and create job opportunities (Balde et al., 2017).

2.4.1 Classification of WEEE

The classification system for WEEE is developed by UNU and are referred to as UNU KEYS. This system classified WEEE category by similar feature, equivalent material composition and attributes (Balde et al., 2015). Table 2.3 demonstrates 6 categories of WEEE.

Table 2. 3 : Six categories of WEEE [derived from (Balde et al., 2017)]

Category	Example
Large Equipment	Washing Machine, Clothes Dryer Space, heater, Photovoltaic panel, control panel, copying equipment, Central heating (household installed), Dishwasher, Kitchen equipment (large furnace, oven), professional monitoring & control equipment, professional tools (milling, turning)
Temperature exchange equipment	Air conditioners, Fridges, Freezers, cooler dispenser
Lamp	LED lamp, Special lamp, Compact fluorescent lamp, Straight tube fluorescent lamp
screen	Flat display panel, Cathode Ray Tube, Cathode Ray Tube monitor, Flat Display Monitor Panel
Small equipment	Microwaves, other small household appliance (iron, clocks, adapter) vacuum cleaner, electric kettles, personal care equipment (hair dryer, electric shaver), small consumer electronic (headphone, remote control), portable audio & video, (mp3, car navigation), cameras (camcorders), speakers,
Small IT	Mobile phone, Routers, Laptop, Printer, scanner, fax, Telephones, calculator, desktop, game consoles,

2.4.2 Projection Amount of WEEE Generation Based on Its Categories

WEEE project was carried out by the Department of Environment (DOE) in 2006 under the Basel Convention that is focused on 7 types of WEEE: Television, Personal Computer, Mobile Phone, Refrigerator, Air Conditioner, Washing Machine and Rechargeable Batteries. The data were collected in cooperation with DOE and the Ministry of the Environment, Japan (JICA, 2014). The estimated volume of WEEE generated is calculated based on the trend of consumption during the year 2006. The estimated amount of WEEE is as shown in table 2.4.

Table 2. 4 : WEEE Inventory Project with the recycling rate (%) in Malaysia [Derived from (JICA, 2014)]

Year	TV	PC	Mobile Phone	Refrigerator	A/C	Washing Machine	Rechargeable Batteries
2014	6923 (11.17%)	12 638 (20.4%)	17 256 (27.85%)	894 (1.44%)	2470 (3.98%)	624 (1%)	21 149 (34.14%)
2015	7481 (11.13%)	13 963 (20.76%)	18 915 (28.12%)	916 (1.36%)	2448 (3.64%)	663 (1%)	22 868 (34%)
2016	7115 (10.06%)	15 253 (21.56%)	20 040 (28.33%)	939 (1.3%)	2391 (3.38%)	756 (1.07%)	24 245 (34.3%)
2017	6154 (8.4%)	16674 (22.77)	20 779 (28.37%)	964 (1.3%)	2347 (3.2%)	996 (1.36%)	25 316 (34.57%)
2018	6222 (8.14%)	18 231 (23.86%)	21 363 (28%)	989 (1.29%)	2342 (3.07%)	1087 (1.42%)	26 161 (34.2%)
2019	6306 (8%)	19 745 (24.86%)	21 922 (27.6%)	1015 (1.27%)	2373 (3%)	1197 (1.5%)	26 870 (33.83%)

2.4.3 Recovery of Metal Components in WEEE

At the same time, the surge in population growth as rising demand for electrical and electronic products would ultimately lead to a decrease in natural resources. The need for the refining of these compounds is therefore necessary these days. In his view of WEEE, (Heacock et al., 2016), deriving valuable material from WEEE has resulted in securing several resources such as iron, aluminium, copper, gold, silver and other Earth metals. The retrieval and recovery of these metals from WEEE have potentially mitigated the global demand for new metal production and alleviate the volume of waste dumped in the landfill (Kumar et al., 2017).

According to Liou and Jheng (2018), the traditional approaches of managing WEEE are by repairing, reusing and removing the WEEE by incineration or in landfills. In his view, the other ways in which WEEE can be disposed of are by conversing WEEE towards a valuable nanomaterial that is deemed to be more a sustainable and effective method in implementing the circular economy. The idea of urban mining (UM) itself is seen as an efficient way in deriving natural resource that makes a massive difference to the global economy today (Jo et al., 2018). Pierron et al. (2017) argued that urban mining is an initiative involving landfill mining and recycling activities to integrate alternative resources flows into the circular economy.

The incineration and disposal system of WEEE causes environmental degradation and health consequences due to the release of polyhalogenated organic compounds and heavy metals into the atmosphere. For instance, a printed circuit board (PCBs) are responsible for establishing hardware-software interconnection. According to Tuncuk et al. (2012), PCB is a rich resource containing 20% of Cu and 250 g / ton Au, which are substantially high, i.e. 25–250-fold for gold and 20–40-fold for copper compared to gold ores (1–10 g / ton Au) and copper ores (0.5%–1% Cu) respectively. However, useful PCB materials are lost as PCBs are processed by uncontrolled and unsafe processes, including open acid washing, which causes health and environmental pollution. (Y. Lu and Xu, 2016). Table 2.5 demonstrates the processes and the potential material recovery that can be derived from WEEE.

Nonetheless, in most developing countries, the WEEE management framework is at an early stage far behind the evolution of technology. Such collection and recycling industry are often dominated by the informal sector, who dump or dispose of waste improperly, causing severe environmental and human health implications. These have become factors for developing countries to change for efficient waste management and implement proper recycling practices an immediate intervention (Borthakur and Singh, 2020).

Table 2. 5 : Type of WEEE and material composition

WEEE	Process	Metal Recovery	Reference
Light-emitting diodes	-Combination of pyrolysis -physical disaggregation methods -vacuum metallurgy separation	Rare metals; Indium (In), Gallium (Ga)	(Zhan et al., 2015)
Printed Circuit Board (PCB)	-Cupric chloride solutions	Copper (Cu), nickel (Ni) and iron(Fe)	(Tuncuk et al., 2012)
	-Bioleaching by acidithiobacillus ferrooxidans strain z1	Copper (Cu)	(Nie et al., 2015)
	-Bleaching process using ferric sulphate generated by leptospirillum ferriphilum dominated consortium	Copper (Cu), Zinc (Zn), Nickel (Ni)	(Shah et al., 2015)
	Acid leaching–electrowinning process	Indium (In), lead (Pb), zinc(Zn) and aluminium (AI)	(Guo et al., 2015)
	Moderate thermophiles	Lead (Pb), Stannum (Sn), Zinc (Zn), Copper (Cu	(Xia et al., 2017)
Liquid Crystal Display (LCD)	-Sing various solid:liquid (s/l) ratios and solvents (acid mixtures)	Indium (In), Arsenic (As), Stibium (Sb)	(Savvilotidou et al., 2015)
	-Non-crushing leaching method	Indium (In)	(K. Zhang et al., 2017)
Mobile Phone	-Acidithiobacillus ferrooxidans -Bioleaching	Uranium (U), Nickel (Ni)	(Arshadi & Mousavi, 2015)
Li-ion Batteries	-20% acorga m5640 in kerosene with agitation for 5 min at 30 °c	Lithium (Li), Manganese (mn), Cobalt (Co), and Nickel (Ni)	(Nayl et al., 2015),
	-Hydrometallurgical extraction of metals		(Vieceli et al., 2018)

Aluminium electrolytic capacitors	-Involving heating treatment, crushing sieving, and magnetic separation	Aluminium (AI), Iron (Fe)	(Wang & Xu, 2017)
Cigs photovoltaic cells	-Acid-resistant nanofiltration with liquid-liquid extraction	Indium (In)	(Zimmermann et al., 2014)

2.4.4 Hazardous Substance Contained in WEEE

The presence of electronic products makes our lives simpler. However, the possibility of a hazardous and toxic material being contaminated inside the products has become a threat to life, particularly in the event of improper waste management. WEEE produced from developed nations is most likely to be transported to developing nations (i.e. China and India) for the disposal phase due to; i) developed countries are faced with a strict environmental regulatory system, ii) higher waste disposal costs and iii) more profitable (Awasthi and Li, 2017). These developing countries, mainly China and India, are greatly affected by the illegal WEEE transition and are mostly managed by the informal sector. According to Awasthi et al. (2016), the WEEE management dominated by the informal sector are greatly expanding due to; i) simple set-up, ii) cheaper labour cost and iii) weak regulatory system.

The informal sector carries out the extraction process to retrieve the usable material in the WEEE using raw and crude methods. According to Awasthi and Li (2017), the dismantling process is done by informal sectors including; i) remove parts of WEEE manually by using screwdrivers, chisels and bare hands, ii) open-pit acid baths for metal extraction, iv) melted plastics part of WEEE without proper ventilation and v) open-burning cables. These primitive methods and lack of safety measures have led to a detrimental effect on the environment and human health, although the informal sector managed to derive valuable materials (Labunska et al., 2015).

The primitive method used by the informal sector releases volumes of toxic fumes, hazardous acids and organic pollutants (Pradhan and Kumar, 2014). These informal recycling practices WEEE pollute soil and water and pollute the air with excess amounts of heavy metals. The accumulation of heavy metals around the WEEE informal sector in India is caused by inadequate WEEE handling. As reported by Pradhan and Kumar (2014), The concentration of the substance in the water nearby informal recycling area in Mandoli was as follows; Cr: 0.60; Cu: 0.70; Cd: 0.05; Fe: 0.46; Pb: 0.04; Zn: 1.89; Al: 3.67 mg / kg. these contaminated waters become a poison that could cause a detrimental effect on humans.

The air can be polluted by the burning of electronic waste product. According to (Luo et al., 2015). they stressed that open burning used in the primitive method would release a wide variety of contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs) into the atmosphere that exposes people who live nearby to such toxic pollutants. The exposure to PAHs leads to the risk of carcinogenic effects due to its toxicity (Man et al., 2013). Long-term exposure to such compounds would affect the human body's physiological system, including the endocrine system, reproductive system and nervous system (Jaibee et al., 2015).

Soil contamination is a significant concern due to its toxicity, affecting both the environment and human health. Soil contamination happens when the concentration of soils is higher than before. The soil contamination has severely affected the ecosystem and causes food limitation to livings (Awasthi et al., 2016). Improper recycling and disposal practices have given these pollutants the ability to pass through the food chain, resulting in sustained and inescapable access to people living in the area of recycling site. Table 2.6 demonstrates the list of the hazardous substance in WEEE and its consequences that affected the recycling worker and the residents living nearby.

Table 2. 6 : Chemical Substance along with the health consequences

No	Type of substance	Health implication	References
1	Heavy metals: Cadmium (Cd), Lead (Pb), copper (Cu), Zinc (Zn)	Increased likelihood of adverse birth outcomes on a sex-dependent basis (Cd)	(Yuling Zhang et al., 2018)
		Effects in the immune system (Pb,Cd)	(Yu Zhang et al., 2017)
		Cardiovascular (Pb)	(X. Lu et al., 2018)
		Natural killer cell in children (Pb)	(Yu Zhang et al., 2016)
		Cancer risk (Heavy metal)	(Huang et al., 2016; Zheng et al., 2013)
		Ranging from minor upper respiratory irritation to chronic respiratory, urinary and reproductive disease (Heavy metal)	(Zeng et al., 2016)
		Changes in blood morphology, hemoglobin synthesis and CR1 expression (Pb)	(Dai et al., 2017)
2	Polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs)	DNA damage	(Alabi et al., 2012)
		Tyroid Hormone change	(Xu et al., 2014)

2.5 Waste Electrical Electronic Equipment (WEE) Directives

The Waste Electrical Electronic Equipment (WEEE) directive (Directive 2002/96/EC) was first introduced in February 2003. The directive provides the recycling scheme specifically for consumers to encourage recycling and reuse culture (Union, 2003). However, in December 2008, the European Commission proposed a Directive reform to tackle the increasing stream of waste. As a result, Directive 2012/19 / EU entered into force in August 2012 and effectively brought into force in February 2014. The Directive 2012/19 / EU emphasises conservation, protection, and preservation to protect human health and natural resources. (European Union, 2012) points out that the policy adopted is based on the precautionary principle. Environmental pollution should be handled as a priority at source and should be paid for by the polluter. The Directive 2012/19/EU has been used ever since.

2.5.1 Malaysia Scheduled Waste Regulations

Malaysia has continuously been regarded as one of the most environmentally sustainable countries where renewable and non-renewable resources can cover all living needs, including forestry, fisheries and livestock. Malaysia has been a supplier of natural rubber, hardwood, palm oil and tin globally and recognized as one of the fastest-growing economies in the ASEAN region. Since Malaysia has engaged in a wide variety of industrial activities, hazardous waste is unavoidable and defines Scheduled Waste (SW) (Mt et al., 2019). Without a proper long-term resolution, this threat positively would affect the nation in an aspect of environment, economy and society. Acknowledging these threats, the Government has enacted a range of legislation, including the Environmental Quality Act (EQA) 1974 that is administered by the Department of Environment (DOE) (Mohammad, 2011).

The EQA was first enforced in 1975 and was amended to conform with global norms in 1976, 1985 and 1996. Mt et al. (2019) highlight that the shortage of scheduled waste facilities has resulted in a rise in the amount of waste in open landfill sites in the 1980s. Inadequate waste facilities have resulted in the contamination and pollution that causes detrimental environmental and health effects. Nevertheless, the Government has demonstrated its efforts to resolve these issues by implementing the Sixth Malaysian Plan (1990-1995). Industries that abide by the law may receive a tax exemption, while non-compliance industries may earn fines. The sixth Malaysia plan (1990-1995) clearly outlined the policy statement to incorporate environmental issues into all national development processes, emphasizing sustainable development. Malaysia has established a comprehensive legal structure for scheduled waste management over the years. The previously based legislation on the principle of cradle to grave has been switched to cradle presently. According to Jamin and Mahmood (2015), a facilities that create, collect, handle, treat or dispose of scheduled waste is responsible to the following provisions;

- Section 34B, Environmental Quality Act, 1974
- Environmental Quality Regulations 1989 (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities)
- Environmental Quality Regulations 2006 (Revised) (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities)
- Environmental Quality Regulations 2005 (Scheduled Wastes)
- Environmental Quality Regulations 2007 (Revised) (Scheduled Wastes)
- Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989
- Environmental Quality (Prescribed Conveyance) (Scheduled Wastes) Order 2005
- Customs (Prohibition of Exports) Order 1998 (Amendment) 2008
- Customs (Prohibition of Imports) Order 1998 (Amendment) 2008.

Within this framework of environmental legislation, the Department of Environment (DOE) has been set up to manage, track and formulate environmental protection legislation. Ismail and Hanafiah (2019) stresses that DOE is responsible for assessing, approving and licensing the contractor for the treatment and disposal of scheduled waste in Malaysia. Under the Act, scheduled waste must be processed no longer than 180 days, and the weight must be less than 20 metric tons. Otherwise, the waste generator must report to DOE explicitly and transferred the waste to other facilities using the authorized transporters of DOE according to the Environmental Quality (prescribed conveyance) (scheduled waste) Order 2005 (Mt et al., 2019; Yong et al., 2019). Under Sections 34B(1)(b) and (c) of the Environmental Quality Act, 1974, written permission for cross-border movement of scheduled waste is necessary for importation and exportation of scheduled waste. The WEEE is also listed as code A1180 and code A2010 under Annex VIII, List A of the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their disposal 1989. Malaysia as the Basel Convention party, the importation and exportation of WEEE must follow convention procedures. The offender shall be punished with imprisonment for a term not exceeding five years and shall also be liable for a fine not exceeding five hundred thousand ringgit (*Transboundary Movement of Used Electrical and Electronic*, n.d.). The transboundary movement of used EEE must be first evaluated to determine whether it is suitable for direct reuse, reuse, repair or refurbishment. Used EEE suitable for these activities should be further tested for its functionality and appropriate documentation (Annex A) and the declaration of testing result, before any transboundary movement.

2.5.2 Malaysia WEEE Regulations

Previously, there was no specific regulation for WEEE management in Malaysia until the Environmental Quality Regulations 2005 (Scheduled Waste) reform took effect (Jaibee et al., 2015). WEEE is classified as the scheduled waste under the code SW110 which refer to "electrical and electronic wastes that contain components such as accumulator, mercury-switches, glass from cathode ray tubes and other activated glass or polychlorinated biphenyl-

capacitors, or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyls" (EQA, 2004). Nevertheless, Malaysia has established a legislative framework to ensure that scheduled waste, including WEEE, is appropriately managed. This can be seen where many regulations have been amended to ensure that the flow of scheduled waste is in the right direction. Under the Environmental Quality (Scheduled Waste) regulations 2005, the government has specifically amended the regulation in managing the scheduled waste. Table 8 shows that Regulation 3,4,5,6,9,11 are related to WEEE management in Malaysia and are tabulated in Table 2.7.

Throughout their study on the WEEE legislative framework in Malaysia, Yong et al. (2019) point out that WEEE is related to these regulations stated in Table 8 above. Regulation 3 and regulation 11 are referred to the documented and reported to the DOE on the WEEE generated. The generator needs to record numbers of WEEE generated in the premises and notify the DOE. Restriction of storage WEEE should not be more than 180 days with a weight of fewer than 20 tones (Regulations 9) otherwise it must be moved to other facilities using authorized DOE transporters under the Environmental Quality Regulation (prescribed conveyance) (scheduled waste) Order 2005. In the context of enforcement, WEEE is restricted from being disposed of in landfills as it has detrimental effects on humans and the environment. The recycling and recovery process of WEEE must be carried out in prescribed premises (partial or full recovery facilities). At the same time, disposal shall take place in prescribed premises. It should be carried out in an eco-friendly manner in compliance with Regulations 4, 5 and 6 of the Environmental Quality Regulations 2005.

These prescribed premises are then managed by placing the WEEE in several treatment, incineration or recovery processes before transfer to the final disposal facilities. Malaysia government have strictly prohibited the importation and exportation of WEEE unless it has written approval from the DOE (EQA, 2004). Under the transboundary movement regulations 2017, WEEE that are less than 5 years from the manufactured date and functional are not classified as SW110. These WEEE could be assured for direct reuse, repair and refurbishment.

However, these products are strictly prohibited from being dismantled unless with the DOE approvals (Yong et al., 2019). Nevertheless, these regulations are only implemented on the industrial sector and need to be amended or otherwise they could be fined.

Table 2. 7 : Regulations (Derived from (EQA, 2004)

Regulation 3	Notification of the generation of scheduled wastes
Regulation 4	Disposal of scheduled wastes
Regulation 5	Treatment of scheduled wastes
Regulation 6	Recovery of material or product from scheduled wastes
Regulation 9	Storage of scheduled wastes
Regulation 11	The waste generator shall keep an inventory of scheduled wastes

2.6 WEEE Flow in Malaysia

The direction of the WEEE management in Malaysia are as demonstrated in figure 2.7 and figure 2.8. Throughout their study on the WEEE management in Malaysia, (Ismail and Hanafiah, 2019; Yong et al. 2019) demonstrated their WEEE framework, which is similar to each other. As shown in Figure 2.6 below, the WEEE flow from the industrial sector and household sector differs. The industrial sector is bound to the Environmental Quality (Scheduled Wastes) Regulations 2009, while the household sector regulation is still in the drafting stage. According to Yong (2019), recovery facilities typically hold two licenses. One for an operating license and the other for a transport license. Presently, there is 743 offsite recovery facilities, 27 incinerator facilities, 46 offsite storage, 1 onsite treatment, 6 secured landfill and 339 licensed transportation registered under licensed scheduled waste facility/transporter in Malaysia (JAS, 2019). These licensed scheduled waste facility/transporters are listed in eSWIS official website.

These recovery facilities were responsible for collecting WEEE from the industrial sector using an approved transporter with a DOE permit. The WEEE will then be sent to Partial Recovery Facilities where segregation of reusable EEE and components from collected WEEE. The Partial Recovery Facilities' role is to encourage the 3R (Reduce, Reuse, Recycle) concept to minimize WEEE production by producing secondhand EEE to the market and supplying functional component for other industries. The rest will be sent to full recovery facilities where the precious metal is retrieved. Nevertheless, Yong et al. (2019) points out that there is no regulatory framework for managing household waste, yet formal and informal sectors dominate the WEEE collector. The waste generator including individual, commercial, institution, and household, is required to dispose of the WEEE through the authorized collector or collection centre including JPSPN, NGOs, JICA and MCMC (Yong et al., 2019). The Licensed Collector / Collecting Center are then pre-sorting the WEEE where the usable WEEE is sent to retailers, and the remainder is sent to approved recycling facilities. The approved recycling facilities can process WEEE to recover valuable materials safely and environmentally sustainable.

- Jabatan Pengurusan Sisa Pepejal Negara (JPSPN)

In his analysis of household WEEE, (Yong et al., 2019) JPSPN was responsible for collecting WEEE in the domestic area in compliance with the DOE agreement. Mixed with the solid waste current, the WEEE must be isolated and segregated upon collecting. Numbers of collected WEEE will then be updated through eSWIS and later will be sent to recovery facilities.

- Non-Governmental Organization (NGO)

Together with DOE, JICA and MCMC, NGOs such as The Tzu Chi Foundation are also involved in the WEEE collection project. The Tzu Chi Foundation initiated environmental conservation programs in 1995 and is a self-funded NGO with more than 250 recycling points in Malaysia (Yong et al., 2019). The Thu Chi Foundation is run by a volunteer who collects the WEEE from the recycling point and pre-sort the recyclables before sending the remainder to the recovery centre. Through his perspective, the author urged the NGOs to implement a redeemable

point collection scheme based on the weight of WEEE to motivate the community to recycle their EOL products than hoarding the products at home.

- Malaysian communications and multimedia commission (MCMC)

The collaboration of MCMC and other communication industry players including Celcom Axiata, U Mobile and Digi Telecommunications has launched the "Mobile WEEE: Old Phone, New Life" campaign in August 2015 as an initiative to collect unused and discarded mobile devices. Ministry of Communications and Multimedia gear the movement to advocate the public in fostering 3Rs (reduce, reuse, recycling) culture in Malaysia. Through this campaign, collection boxes set up by MCMC only accept the mobile devices placed at the selected Telco stores, institutions, and retail outlets where the user can drop by and hand over the WEEE. The collected WEEE is sent to full recovery facility afterwards where the recovery process is carried out (Yong et al., 2019). Nevertheless, the authors suggest that MCMC could improve its initiative by installing the collection box in a domain area, such as hypermarkets, and upgrading the collection box to have the same feature as the vending machine.

- Japan International Cooperation Agency (JICA)

The continuous partnership between JICA and DOE since 2011 has provided an effective solution in collecting WEEE from the household sector. Several projects such as "The Project for Model Development for WEEE Collection, Segregation and Transportation from Household for Recycling" (2011) and "The Project for Development of Mechanism for Household WEEE Management" (2015) could be evidence of its efficacy where the output of these projects has resulted in the establishment of WEEE collection points across Malaysia (Yong et al., 2019). In the meantime, DOE intends to adopt EPR schemes in Malaysia, where the electronics industry and the consumer are charged for the recycling fees. The industries will be charged for every product produced or imported. It goes vice versa with the consumer who bought the EEE (this scheme is similar to Japan, where the recycling fees will not be refunded as reported by (Sthiannopkao and Wong, 2013).

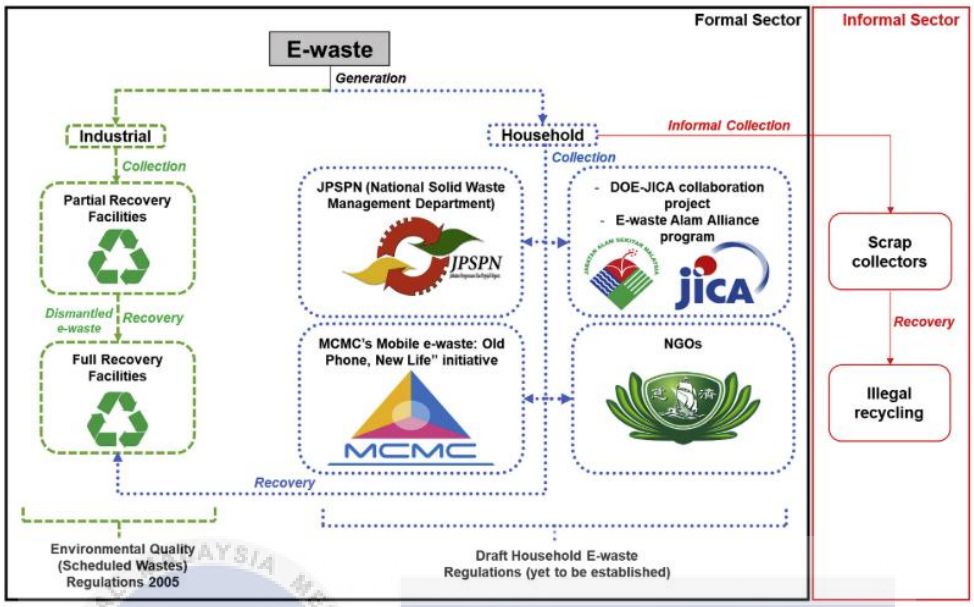

Figure 2. 7 : WEEE flow in Malaysia 1 [Derived from (Yong et al., 2019)]

The framework provided by the Ismail and Hanafiah (2019) are not that different from the (Yong et al., 2019) framework. As demonstrated in figure 2.8, the WEEE from the industrial sector are collected by the Material Recovery Facility (MRF) where the WEEE undergo the material extraction before it is transported to the integrated final treatment and disposal facility. The WEEE from the non-industrial sector such as household are collected by the formal sector and informal sector. Through the formal sector, the WEEE are collected by the NGOs, local authority or private company and are transported to the MRF from material extraction process. Later, the WEEE from MRF are transported to the integrated final treatment and disposal facility for final disposal. However, the WEEE that are collected by the informal sector underwent different process where the WEEE are either to be burned for material extraction process or mixing along with the other residual waste at municipal solid waste facility in which the both ways will causes a detrimental effect on the environment and the human's health.

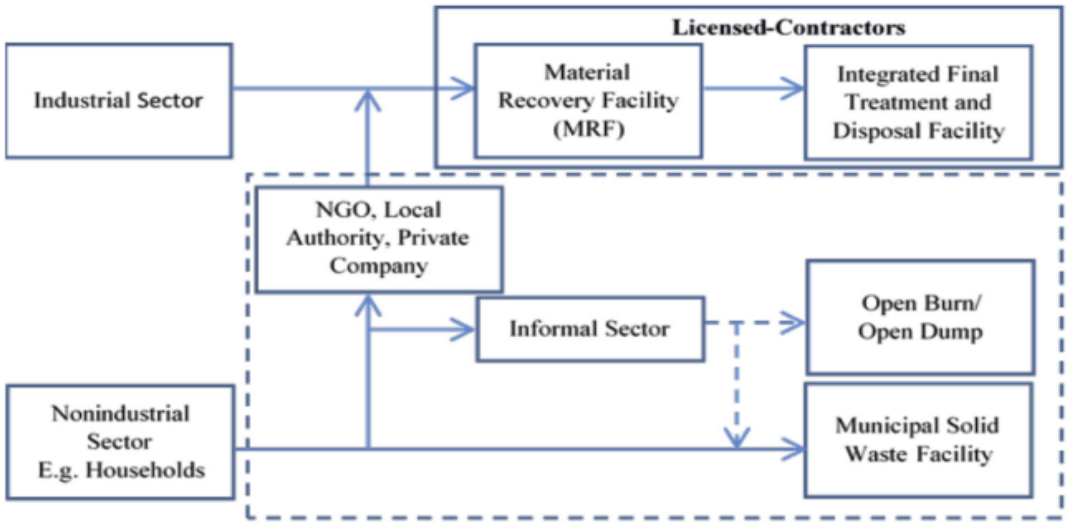

Figure 2. 8 : WEEE flow in Malaysia 2 [Derived by (Ismail and Hanafiah, 2019)]

2.7 Waste Ownership

Extended Producer Responsibility (EPR) is a product recovery scheme that suggests a zero-waste principle. The scheme promotes the product's design to be more earth-friendly, leaving a minimal impact on human health and the environment at any point in its life cycle. Perchard and Veit (2015) defines EPR as a strategy to promote the integration of the environmental costs associated with goods throughout their life cycles into the products' market price. The EPR seeks to engage the consideration of the environment at the early stage of product design. However, Agamuthu and Victor (2011) highlighted that the current practice of EPR in Malaysia is restricted by voluntary participation. The political developments of EPR in Malaysia suggest that Malaysia might be making progress on the road towards EPR via the implementation of the EPR Legislation.

In the perspectives of a local authority, Alam et al. (2010) highlighted that the local authority needs to raise public awareness and encourage the public's recycling culture. This is because the local authorities are representatives who are nearest to the people under their jurisdiction. However, to improve the recycling culture in the communities, there is a need for a range of public regulations, which are currently lacking. This statement is backed by Kamaruddin and Omar (2015) highlights that the local authorities are players in the waste management system and are also active in organising community activities, taking decisions and adopting policies that can support the communities environment. The authorities help foster recycling efforts hoping that this will raise public visibility and enable the public to participate in sustainable waste management.

2.8 Current Challenges of Recycling WEEE in Malaysia

Current problems and barriers for WEEE management in Malaysia are summarized in table 2.8 :

Table 2. 8 : WEEE recycling challenges in Malaysia

Challenges	References
Lack of proper disposal mechanism for the household sector • Currently, there is no adequate recycling system for the household sector. Recycling facilities only cater to industrial waste and are not suitable for households used due to the different processing line.	(Mt et al., 2019)
Lack of knowledge in disposing WEEE • Based on the survey conducted, the public is reported to have minimal knowledge of the right way to dispose of WEEE. It is reported that 43% of the Shah Alam (SA) community are unsure how to dispose of their WEEE. These communities tend to mix with other general waste or handed over to the unauthorized collector.	(Alam et al., 2010) (Jaibee et al., 2015)

Poor regulation and enforcement • The current guideline issued by the Department of Environment related to WEEE is more focusing on the industries sector rather than the household sector. Nonetheless, Malaysia is beginning to draft the Environmental Quality Policy (Recycling and Disposal of End-of-Life Electrical and Electronic Equipment) Regulations. According to the source, the government is beginning to enforce EPR policy through regulatory strategies such that the manufacturer held responsibilities in take-back of their goods. Malaysia's current WEEE policy does not provide the end-user with careful disposal management of WEEE.	(Mt et al., 2019), (Shumon and Ahmed, 2013), (Y. S. Yong et al., 2019)
The lack of an effective collection system • The industrial sector's WEEE is collected and properly managed by the licensed recycling centre due to the existing regulation. Nevertheless, up until today, there is an absence in the clear direction and responsibilities for the household sector. This has resulted in the informal sector's growth, taking advantage of the absence of waste ownership.	(Ismail and Hanafiah, 2019), (Y. S. Yong et al., 2019)
Unidentified WEEE ownership • Manufacturers and importers of WEEE in Malaysia do not hold any responsibilities in managing their end product. These end products are generally governed by the recycling centre or in the worst case, are dumped in the landfill. The unidentified ownership on the end product makes it difficult to ensure the WEEE generated in Malaysia is adequately managed sustainably. Also, become a barrier for Malaysia to adopt the CE approach.	(Shumon and Ahmed, 2013)
Consumer • The consumer is not bound to any regulations (that need the consumer to send back the WEEE to the manufacturer or recycler), and no recycling fees are charged on the consumer (when buying the EEE products)	(Shumon and Ahmed, 2013)

2.9 Product Recycling Desirability Model

According to their findings, Sultan et al. (2017) proposed recycling desirability model. Several parameters are identified throughout their study based on the findings, including simplicity of material separation, material security index, and recycling technology readiness level. These 3 parameters are calculated according to the equation (2.1 – 2.6) prepared by (Sultan et al., 2017). The complexity of the separating materials in the finished product will be calculated to determine how many steps are carried out to recover pure substances. On the left side of figure 2.9 illustrate below is the mass product (Mtotal). The square form is the separation process by which the material retrieves the pure substance (process 1, process 2, process 3, process 4 and process 5). The circular shape is the pure substance (M1, M2, M3, M4 and M5). In each separating tree, the evaluation of the material mixing is considered. This could be inferred that less separation tree corresponds to lower mixing content, whereas more separation tree corresponds to higher mixing content. Thus, the formulation of the complexity measure is established by equation (2.1) and (2.2).

$$Ci = \frac{Mi}{Mtotal} \quad \text{Equation 2.1}$$

$$H = K(Ci \log Ci) \quad \text{Equation 2.2}$$

In equation (2.1), Ci represents the mass fraction of the material in a component that enables the product to be assembled; Mi represents the material's actual weight in Kilogram (Kg) and Mtotal, representing the complete weight of the product to be assembled. Thus, this would represent the disassembly task. Then, the complexity of material separation is shown in equation (2.2). K represents the constant value of negative 1 so that the summation outcome would be positive.

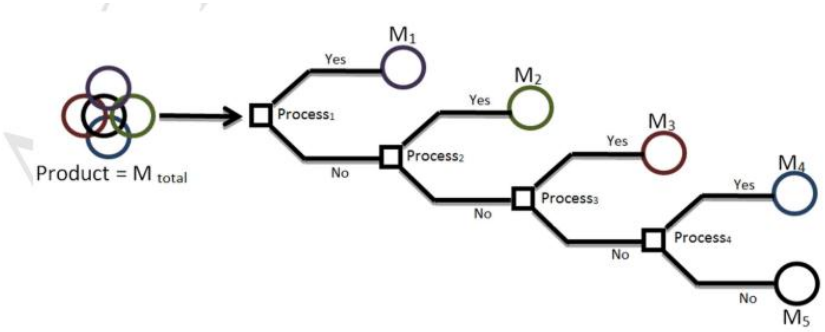

Figure 2. 9 : Material separation tree (Mohamed Sultan et al., 2017)

A range of steps needs to be taken to develop the recycling desirability index, including material simplicity in the product, the material security index of the product and the technological readiness level (TRL) in the materials' processing. The simplicity of the material separation (Dsimplicity) in the product or part is defined in equation (2.3), where the mass fraction and stage of the process are considered. H is the complexity index obtained from equation (2.2), and Htop is the top level of the material complexity index, which is 3.5.

$$D\ simplicity = 1 - \left(\frac{H}{Htop}\right) \quad \text{Equation 2.3}$$

Then, the calculation for the material security index ($Dmsi$) are shown in the equation (2.4) where n is the maximum number of discrete material type in the product, Mi are the mass material in a product, MT is a total product mass, SI is the material security index of pure substance of the materials and STOP is the top scale for the material security index. The STOP is obtained from the manufacturer's or stakeholder's own of listing for analysis purpose.

$$Dmsi = \sum_{i=1}^{n} \left(\frac{MiSi}{MTSTOP}\right) \quad \text{Equation 2.4}$$

Lastly, is the calculation for recycling technology maturity ($Dtrl$) as shown in equation (2.5) where n represents the maximum number of recycling technology used in a product , Mi is the mass of discrete materials in a product, MT is the total mass of a product, Ri is the technology readiness level assessment of recycling technology of particular materials, Rtop is the top TRL scale for electronic materials. Lastly, the recycling desirability (D desirability) will sum up equation (2.3), equation (2.4) and equation (2.5) as shown in the equation (2.6).

$$Dtrl = \sum_{i=1}^{n} \left(\frac{MiRi}{MTRtop}\right) \quad \text{Equation 2.5}$$

$$Ddesirability = Dsimplicity + Dmsi + Dtrl \quad \text{Equation 2.6}$$

CHAPTER 3

METHODOLOGY

Methods and procedures used to collect data for this study are discussed in this chapter. A proper approach is needed to obtain accurate results and to achieve the objective of this study. The goal of this study is to determine the critical factors and current practices of the end-of-life WEEE recycling in Malaysia, to develop the local-recycling supply chain framework in managing WEEE in Malaysia and to model, the decision-making measure to boost the end-of-life WEEE from the recycler perspectives for Malaysia. Therefore, the present study used existing literature to deduce the relationship between constructs and establish a strategy for testing the proposed theory with the ultimate goal of confirming and building on existing knowledge in the area. The study methodology shall set out a road map for the study, which will show the direction towards achieving the study objectives in several well-defined logical steps. The study process, study methodology, study design, and study technique will be found and explained in detail here.

3.1 Develop a Study Approach

The study approach is a strategy for how the study should be performed. One of the procedures consists of broad-based assumptions for comprehensive data collection methods, analysis, and interpretation. Data collection is a systematic method of collecting exact information based on the direction of the study. In this study, the author uses a quantitative study method with a deductive approach. The quantitative study method is used for data collection as the author aims to measure characteristics, attitudes, behaviours, and other identified variables with the intention of either supporting or opposing the hypothesis of a particular phenomenon by contextualizing the data obtained by the study sample.

3.1.1 Quantitative Method

The quantitative study is a study technique that focuses on the quantification of data collection and analysis. A quantitative study method deals with quantifying and analyzing variables to get results. It involves the utilization and analysis of numerical data using specific statistical techniques (Apuke, 2017). In this study, the author uses a statistical survey to make statistical inferences about the population being studied, the recyclers. As Malaysia moves towards implementing the circular economy, this study aims to determine the recycler's readiness to embrace new practices and provide a government roadmap to cover various recycling industry aspects.

3.1.1.1 Survey

A survey is a method of collecting information from a group of individuals, traditionally intending to generalize the findings to a broader population. Surveys offer a vital source of knowledge and perspective for more general topics. The survey method is appropriate for any studying approach, qualitative, quantitative, or mixed. Questionnaires with the Likert scale are generally used for a quantitative study. The surveys were distributed by mail and were intended to elicit opinions on which programs or goods should be tailored to a population or a group. The questionnaire survey is demonstrated in the appendix.

3.1.2 Deductive Study Approach

The study on the determination RPI of WEEE in Malaysia is developed from a deductive approach, which begins with a theory-driven hypothesis, which guides data collection and analysis. The deductive approach testifies the current theory-based hypothesis (or hypotheses) to specific phenomena, and later, the data collected could be either approve or disapprove the theories applied. If a particular theory or case study implies a causal link or link, this may be true in certain situations. A deductive approach may measure whether this relationship or association has been developed in more general circumstances. And are explained by assumptions that can be extracted from theoretical proposals. To conclude, the ability to explain the causal relationship between concepts and variables, measure concepts quantitatively, and generalize study findings to a certain extent through a deductive approach.

3.1.2.1 The Study Circle

Scientific knowledge of the specific study area depends on a scientific method, representing a virtual diagram of the study process. The study process has four main components: theory, hypothesis, empirical observation, and analysis, as demonstrated in Figure 3.1. A theory defines a set of ideas that help explain a particular social phenomenon. Hypotheses are a testable prediction of the relationship between two or more variables. Empirical observation is what we in the social world want, identify, or label. Virtually, representations (in the context of hypotheses and assumptions) are tested against the real world in scientific observations. These empiric findings lead to other theories being evaluated against the real world. The analysis is a statistic in which numerical data patterns or qualitative data analysis are analyzed to interpret the survey observations' ideas. In this context, the scientific method is recursive. The mode of reasoning in the circle is called deductive and inductive.

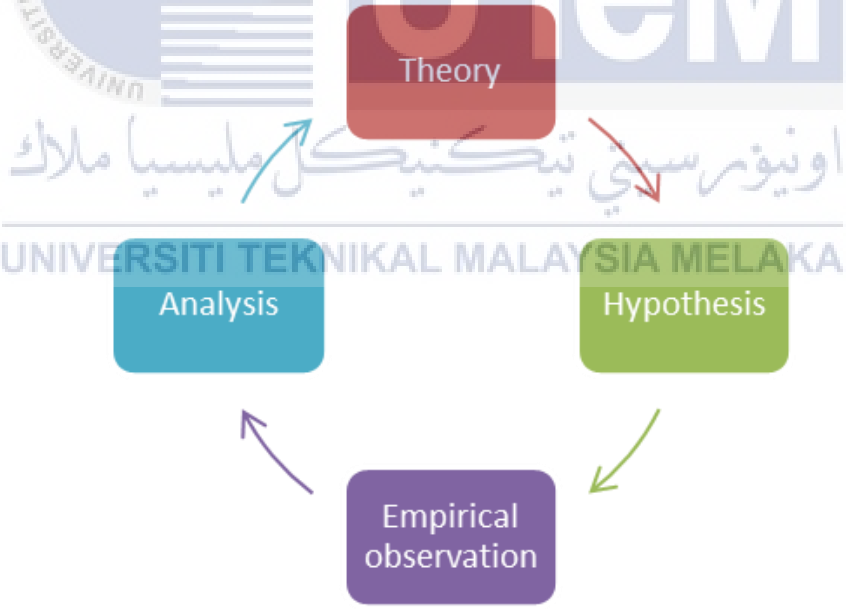

Figure 3. 1 : The study circle

3.2 Study Plan

Gantt chart is a graphical tool that illustrates time-based events or tasks. It is also known as a visual presentation of study planning and scheduling in a chart form that makes it easy to understand and interpret. All study planning is set out and scheduled on an acceptable dateline to prevent duplication and ensure that the study's progress is carried out smoothly. The shaded part on the Gantt chart graph represents the time requires to complete each activity. The activities of the study start from the overview study background until the report submission.

3.3 Study Design Flow

The study design is the framework of the study methods that act as a guideline to carry out the study. It describes a concise and reasonable strategy to answer the defined study question through data collection, interpretation, analysis and discussion. There are three-phase of study design, Phase 1, Phase 2 and Phase 3. Phase 1 and Phase 2 work simultaneously while Phase 3 works consecutively after Phase 1. These three phases are conducted to answered and achieved the study objectives. The framework of this study is constructed and demonstrated in Figure 3.2. below.

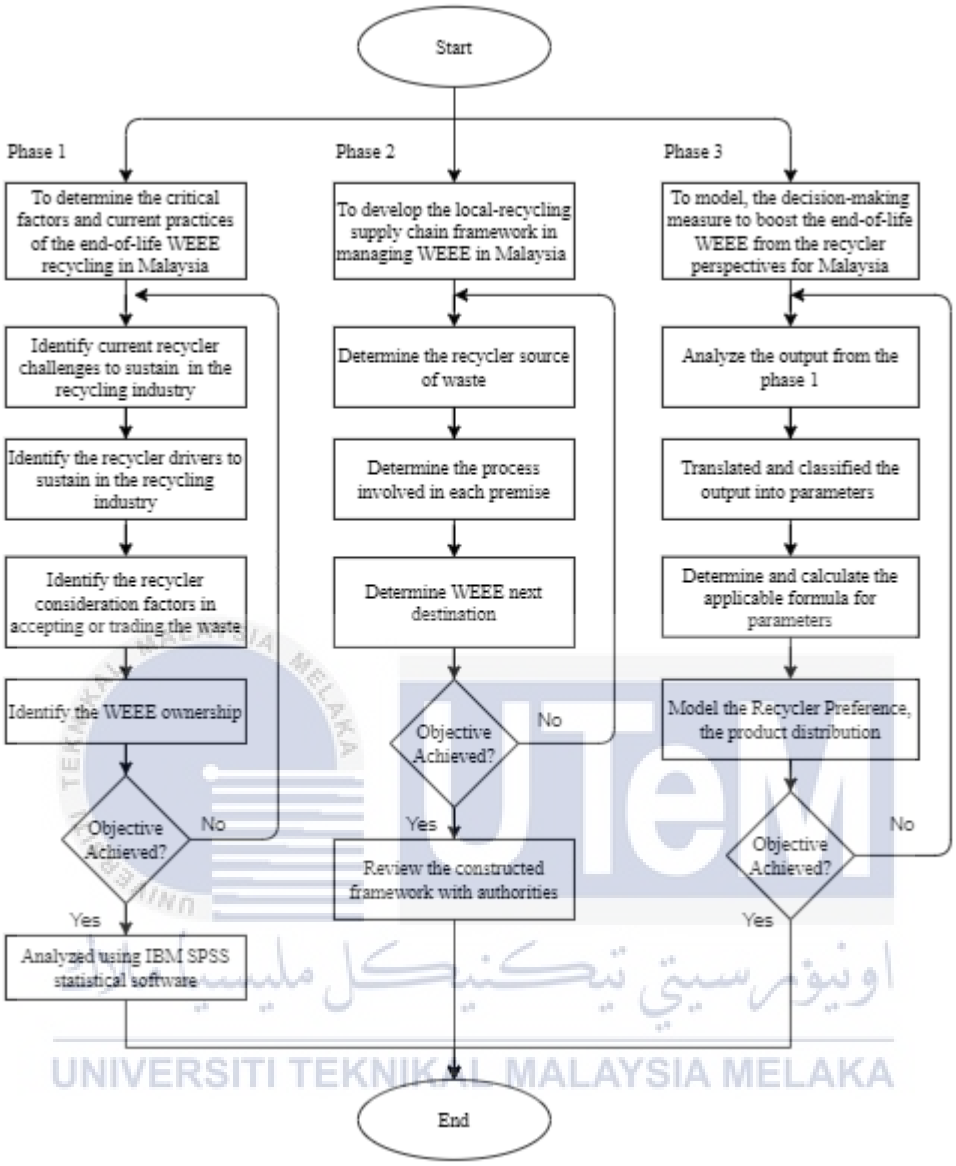

Figure 3. 2 : Study design flowchart

3.3.1 Phase 1, Phase 2 and Phase 3

Phase 1 and phase 2 of the study refer to this study's first objective and second objective. This study's first objective is to determine the critical factors and current practices of the end-of-life WEEE recycling in Malaysia. Determining critical factors that include current driver, barrier and consideration factors for recyclers to sustain in the recycling industry is crucial as their viewpoints will be the government's decision-making tools for improvisation. The lack of sense of ownership of WEEE management in Malaysia has confounded the public. It has become why Malaysia's recycling rate has been rising at a slow pace, which is still far behind from the developed country. Hence, section B of the survey is therefore constructed and narrowed down to answer the first objectives. The survey will carry a guideline that comes with suggestions covering various aspects for plans. Any recommendations from the company will be channelled to the government for a better system, and improvisations. The collected data is analyzed using the IBM SPSS statistical software. This software can understand large and complex data sets with sophisticated statistical procedures that ensure high accuracy and quality decision-making.

Phase 2 of the study is to develop the local-recycling supply chain framework in managing WEEE in Malaysia.Section B of the survey is also well-constructed to obtain the information on the behavior of the local-WEEE recycling supply chain on the premise visited. The developed questions involved the source of waste, the current processes in handling wastes, the identification of materials retrieved from the product, and the next destination for these recyclable and non-recyclable waste. The local-recycling supply chain management of WEEE is well structured based on the data obtained from respondents. Phase 1 and phase 2 of this study is conducted simultaneously.

Phase 3 of the study is to model, the decision-making measure to boost the end-of-life WEEE from the recycler perspectives for Malaysia. The third phase of the study is carried out consecutively after phase 1 where the output from the phase 1 is analyzed and translated for the phase 3 parameters. Each of the parameter obtained are calculated using the appropriate formula

and measure to ensure the validity of the output. The valid output will be the input to model the recycler preference on the WEEE distribution.

3.4. Questionnaire Development

The list of questions developed based on the study objectives is drawn up under the literature review guidelines. As the study focuses on the determination of the recyclers preference index (RPI) for recycling the end-of-life (WEEE) in Malaysia, the survey's constructed questions must aim to analyze the ownership of the circular economy and improve decision-making tools for recycling. This study's questionnaire is divided into several sections; Section A, Section B and Section C.

Section A focuses more on the general company information, nature of the business, number of employees, and space ownership. The purpose of section A is to get respondents demographic data to understand better on the respondent background. Section B focuses on the recycling initiatives; waste supply chain, collection frequency, source of waste, main waste collected, waste consideration factor, barriers and drivers to sustain in the recycling industry, waste ownership and waste framework. The purpose of section B is to achieve objective 1 and objective 2 of the study. The author intended to determine the critical factors and current practices of the end-of-life WEEE recycling in Malaysia and to develop the local-recycling supply chain framework in managing WEEE in Malaysia

Lastly, section C is focusing specifically on WEEE. All the questions asked are related to the WEEE, including numbers of WEEE collected, buy and trade price, recyclable and non-recyclable materials retrieved, and the retrieved materials' next destination. Section C of this survey is prepared for the uses of objective 3 where the author intends to model the recycler preference on WEEE product distribution.

3.4.1 Questionnaire Review

The questionnaire created must first be reviewed by academics before it is distributed to the representatives. The validation questionnaire is essential to keep the author on track and to gather accurate data. The technical expert on manufacturing management is requested to verify the questionnaire issued. In the meantime, the questionnaire is also circulated to potential representatives to ensure that the questions are understandable.

3.4.2 The Questionnaire Reliability

The data obtained from the questionnaire is collected and analyzed using the IBM SPSS software. IBM SPSS software is a powerful statistical software platform capable of understanding broad and complex data sets with sophisticated statistical procedures that ensure high accuracy and quality decision making. The data collected is evaluated using the Cronbach Alpha concept, where the internal accuracy (reliability) of the data is calculated. Cronbach's Alpha is often used when there are many Likert-scale questions.

Cronbach's alpha is a statistic frequently used by studies to prove that the tests and scales that have been developed or adopted for study projects are acceptable. In 2015 alone, approximately 69 separate study papers in four leading science education journals were listed using Cronbach's alpha to assess the study's reliability (Taber, 2018). (Cronbach, 1951) state that Cronbach's alpha specifies the internal consistency or average correlation of items in the survey instrument to gauge its reliability. The Cronbach's alpha is determined from the scale's variance, the number of items on the scale, and the covariance between items. Thus, this method commonly used for Likert-scale questions. In crude criterion, the rule of thumb for interpreting alpha is demonstrated in Table 3.1 below. Nevertheless, a high degree of alpha is the strongest probable source of correlation. Nonetheless, α becomes less sensitive as the number of question in a test increases. A greater volume of items results in a higher reliability, and a lesser amount

of items results in a poorer reliability. If a test involves several questions on a specific problem, it can imply an unnecessary amount of redundancy. A low alpha can suggest that the test does not have enough questions. Adding more content to the test raises the alpha for the test. Weak interrelatedness between test questions or calculating more than one latent variable may trigger low values.

Table 3. 1 : Cronbach's Alpha Rule of Thumb

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

3.5 Data Collection

Data collection is a tool for systematically collecting and analyzing information on variables of interest, allowing the author to address the study questions, test the hypotheses, and evaluate the results. The questions established are focused on the study objectives, particularly on determining the recycling desirability critical factors for WEEE in Malaysia. Surveys were performed and distributed to all recyclers in the Selangor and Johor within four weeks. The questionnaire is distributed via walk-in.

3.6 Data Analysis

Data analysis using descriptive statistical analysis, where the results are illustrated in a form of graph and table.

CHAPTER 4

RESULT AND DISCUSSION

This chapter discusses determining critical recycling factors for waste electrical and electronic equipment (WEEE) in Malaysia. Data were obtained from both qualitative and quantitative methods, which have been concretely presented in Chapter 3. The quantitative approach evaluates the theory with the current situation and measures descriptive statistical analysis method and evaluates by using IBM SPSS statistic software. The constructed questionnaire is divided into two main sections, Section A and Section B. Section A consisted of demographic information of the company, nature of businesses, number of employees, space ownership, and company license status. Section B consisted of recycling initiatives that mainly discussed on the waste supply chain, frequency of collection, source of waste, main product or material collected, consideration factor, challenges and drivers to sustain in the industry, and waste ownership. A pilot study was first performed on a constructed questionnaire to assess the question's accuracy, understanding level and relatability with study purpose. The obtained data were then analyzed using statistical software, and the authorities reviewed the findings.

4.1 Target Population and Data Sampling

The study has been extensively conducted on recyclers, regardless of their scale, the number of employees, and business nature. Target recyclers' goal is that the recycling industry could improve its contribution to Malaysia's economy projected between RM15 billion to RM20 billion annually (Bernama, 2019; MPMA, 2019) if it is professionally handled. Therefore, this study offers an opportunity to determine the crucial factor involving the recyclers' current obstacle. These drivers keep them in the recycling business and ownership of the waste. The recyclers list is obtained from the eSWIS website developed by Department of Environment (DOE), Malaysia. Numbers of recyclers in the Selangor and Johor are calculated using the formula in equation 4.1. Based on the eSWIS website, there is 145 recyclers in Selangor and 138 recyclers in Johor. Out of the 283 recyclers, only 163 recyclers are needed for the data sampling. Previously, the questionnaire has been distributed approximately 163 recyclers around Selangor and Johor. However, this study manages to get 74 respondents due to several limitation. Hence, the response rate is 54.6%.

$$n = \frac{[\,(N)(P)\,(1-P)\,]}{[\,(N-1)\left(\frac{B}{C}\right)^2 + (P)\,(1-P)\,]}$$

Equation 4.1

Where :

N	= population size
P	= proportion population expected to choose, 0.5
B	= acceptable sampling error, 0.05
C	= Z statistic associated with the confidence level which is 1.96 that corresponds to the 95% level

4.2 Questionnaires Finding and Analysis

Cronbach (1951) had suggested that high alpha value is preferable when the instrument was used to assign scores to an individual. Still, he concluded that the main point was that scores obtained when using the instrument had to be interpretable. In this study, Cronbach's alpha is used to measure the internal reliability of the study question. The table 4.1 shows the study questionnaires' reliability, which equates to a figure of 0.790 and is considered acceptable. Thus, it indicates that the constructed questionnaire has high internal reliability that suits for further analysis. Descriptive statistics are brief descriptive coefficients that summaries the data collection and can be either a representation of the population as a whole or a subset of the population. Descriptive statistics are broken down into central tendency measures and variability measures. The central tendency is a central or typical value for a probability distribution. It may also be called a centre or location of the distribution while variability measures represent the dispersion amount in a dataset. The descriptive statistics of this study are shown in the table 4.2 below where mean is a measurement of central tendency, N is a number of respondents, and the rest (minimum, maximum and standard deviation) is a measurement of variability.

Table 4. 1 : The reliability statistics of the study

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.790	0.797	48

Table 4. 2 : The overall reliability statistic of the study

	Descriptive Statistics					
		N	Minimum	Maximum	Mean	Std. Deviation
The Supply Chain of Waste	Nearby, from the same area	74	1	5	4.80	.721
	From same district (within 2km-10km)	74	2	5	4.38	.887
	From same district (within 11km-30km)	74	1	5	2.96	1.418
	Different State	74	1	5	1.86	1.307
	Import	74	1	5	1.08	.517
Source of Waste	Waste bin	74	1	5	3.08	1.431
	Household	74	1	5	4.45	.981
	Small Collector	74	1	5	4.04	1.318
	Office/University	74	1	5	3.19	1.069
	Manufacturer	74	1	5	2.50	1.196
	Waste Company	74	1	5	1.69	1.181
Frequency of waste collection	Waste bin	74	1	5	3.07	1.296
	Household	74	1	5	4.76	.841
	Small Collector	74	1	5	4.32	1.346
	Office/University	74	1	5	2.80	.758
	Manufacturer	74	1	5	2.30	.932
	Waste Company	74	1	5	1.64	1.154
Main product collected	Metal	74	1	5	3.92	1.236
	Plastic	74	1	5	3.93	1.338
	Glass	74	1	5	1.24	.841
	Wood	74	1	5	1.61	.919
	Paper/Cardboard	74	1	5	3.70	1.236
	Electric & Electronic appliances	74	1	5	3.73	1.296
Consideration Factor in collect/trade waste	Large quantities	74	2	5	3.53	1.050
	High demand	74	2	5	4.38	.823
	Profitable	74	2	5	4.73	.626
	Technology readiness	74	1	5	3.28	.958
	Level of cleanliness	74	1	5	3.15	1.002
	Sorted waste	74	2	5	3.16	.876
Current Challenges to sustaining in the recycling industry	Government policy on licensing	74	1	5	4.15	1.056
	Taxes or fees	74	1	5	3.27	1.102
	Complaint from neighbourhood	74	1	5	1.78	1.285
	Insufficient supply	74	1	5	3.73	1.024
	Difficult to identify stolen items	74	1	5	3.31	1.394
	Expensive technology and machinery	74	1	5	3.49	1.101
	Capital, Difficult to get bank loan	74	1	5	3.00	1.216
	Wide collaboration	74	1	5	4.11	.900

Drivers to sustain in the recycling industry	High consumer awareness in recycling	74	2	5	4.62	.753
	Legislation	74	1	5	1.36	.751
	High demand for recycled material	74	3	5	4.54	.623
	Government funding injection	74	1	5	1.34	.848
	Standardized market value of recycled material	74	1	5	3.24	.737
	Guaranteed waste supply	74	2	5	3.41	.859
	Material scarcity	74	1	5	3.22	1.219
Waste Ownership	End-user	74	1	5	4.32	1.048
	Manufacturer	74	1	5	3.59	1.215
	Government	74	3	5	4.65	.560
	Recyclers	74	2	5	4.11	.915
	Valid N (listwise)	74				

4.3 Demographic Analysis

4.3.1 Nature of Business of Respondent

Figure 4.1 demonstrates the survey results in which respondents were asked about the business that took part in their premises. It is useful that the respondents have an environment different enough to determine their activities, whether just collecting and trading or buying and recycling electric and electronic waste. Table 4.3 demonstrate that out of the 74 respondents, 68 respondents carried out activities to collect and sell electrical and electronic waste at their respective premises. On the other hand, the remaining respondent buys and recycles electrical and electronic waste. This can be concluded as most of the respondents collect and trade as their primary activity in managing electric and electronic waste.

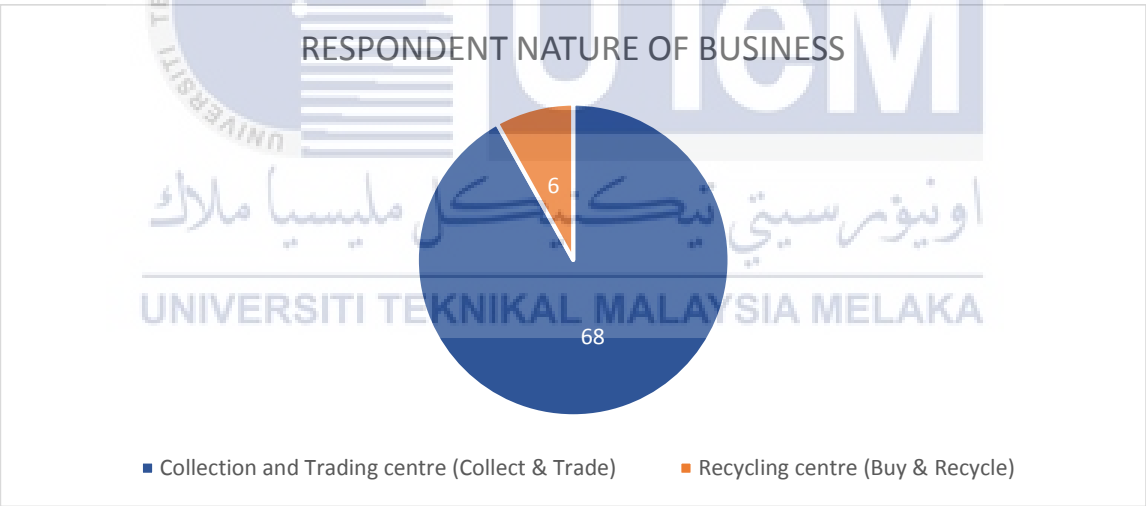

Figure 4. 1 : Nature of business

Table 4. 3 : Nature of business

Nature of business	Number of respondents
Collection and Trading centre (Collect & Trade)	68
Recycling centre (Buy & Recycle)	6

4.3.2 The Number of Employees in the Respondent Premises

The bar chart in figure 4.2 shows the survey results where the respondents reported the number of their employees owned on their premises. Generally, employees are required to facilitate a management matter to carry out a set activity. However, a large number of employees can also determine the category of premises owned by a person whether their premises belong to the category of a small, medium and large business according to the (SME Corp, 2013). Since the recycling activities in the services sector, the definition by the size of operation can be used as stated by the government. It can be illustrated in table 4.4.

Based on the graph above, 61 respondents had employees between 1 to 29, while the remaining 13 respondents had employees between 30 to 75. Out of 74 respondents, none of them has more than 75 employees on their premises. It can be concluded; the majority of respondents have 29 employees and below and can be classified as a small business category in the recycling industry based on the government business category clarification.

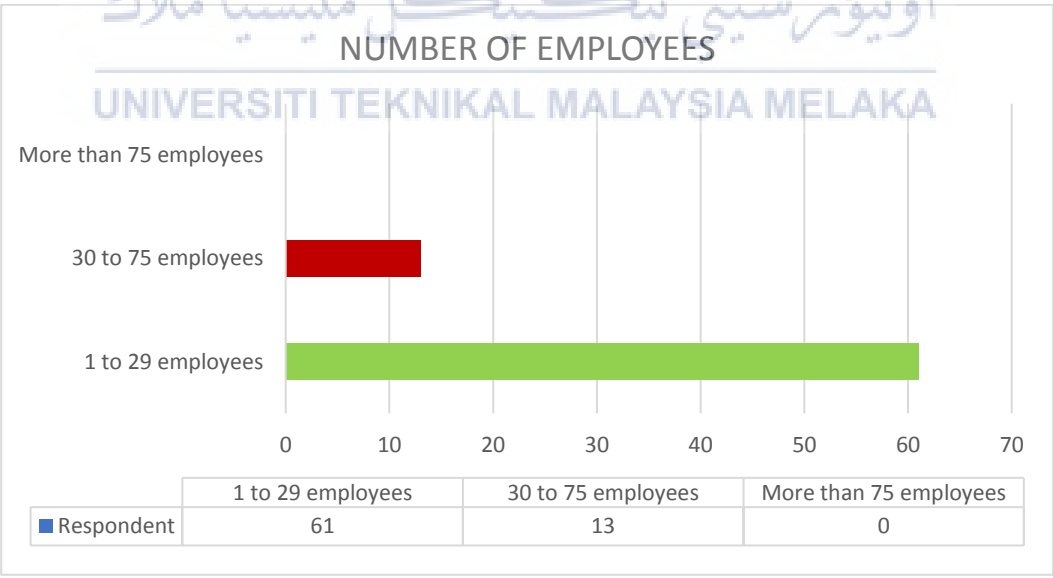

Figure 4. 2 : Number of employees

Table 4. 4 : Definition by Size of Operation (SME Corp, 2013)

Category	Small	Medium
Services and Other Sectors	Sales turnover from RM300,000 to less than RM3 million OR full-time employees from 5 to less than 30	Sales turnover from RM3 million to not exceeding RM20 million OR full-time employees from 30 to not exceeding 75

4.3.3 Space Ownership

The bar chart in figure 4.3 shows the survey results where the respondents reported the premises' land status, which is known as space ownership. The information regarding the status of the premises land is essential to the author to determine whether most of the respondent is a tenant, owner of the land, or still awaiting approval from the government to get permission to carry out collection and recycling centre activities of electric and electronic waste. From the bar chart, 49 respondents are tenants, while 24 respondents are full owners of the land occupied by them and only 1 respondent is waiting for approval from the government to occupy the area they want. From the finding, most of the respondent preferred to rent land or premises rather than buying the land or premises. This situation is parallel to the article made by (Wong, 2019). He stated that more people are renting properties in Malaysia than buying properties such as houses, shops, and land as their price is too high for the average person to buy. The majority of the population cannot afford shops, houses, etc., so they end up renting. Some of them become renters for life, which means they have not saved enough to buy a single property

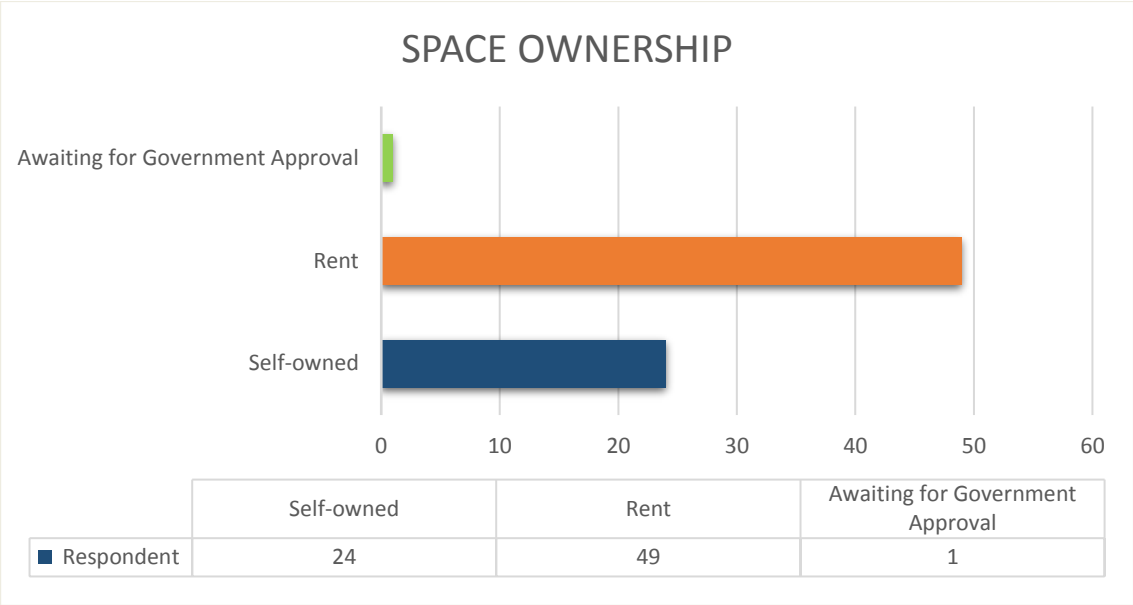

Figure 4. 3 : Space ownership

4.3.4 Premises License Status

In figure 4.4, the pie chart shows the survey results where respondents answered the question about the premises licence's current status. Information on the status of the premises land is essential for the author to determine whether the majority of the respondents hold a temporary or permanent licence granted by the authorities under the terms and conditions for developing and carrying out the electric and electronic waste collection and processing activities. According to our National Land Code 1965, a temporary permit is a permit or authorization to do something temporarily. The document is not a real estate lease and is only valid in the year that it is issued, expiring on 31 December of the following year. It can easily be terminated, but it can be terminated earlier when there is substantial evidence by the State Authority. Permanent occupancy license means that the individual or owner of premises is given full permission to conduct business activities as registered to the authorities. From the pie chart shown in the figure, most of the respondents are temporary licensees granted by the government. In contrast, 35 respondents are given permanent licensees to operate on existing business sites.

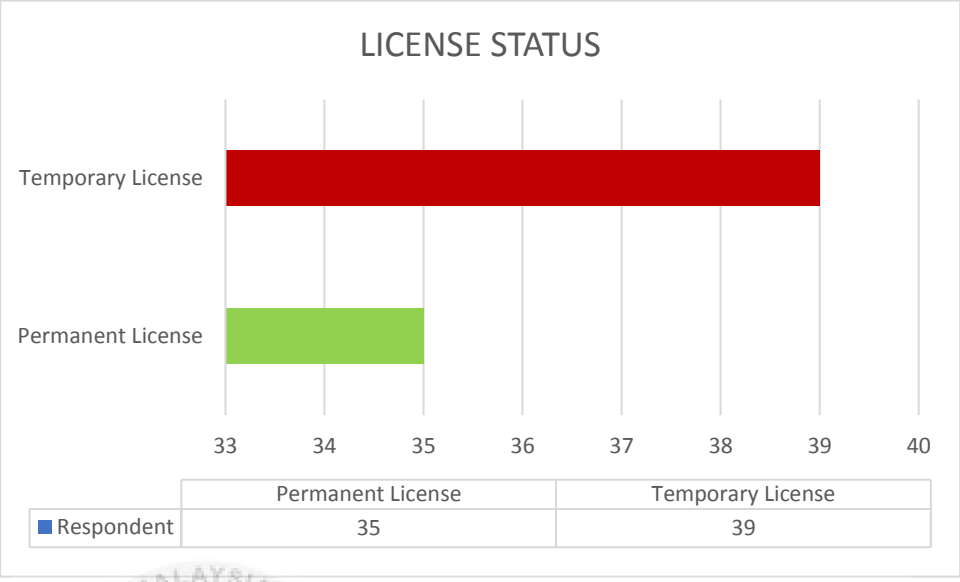

Figure 4. 4 : License status

4.4 Section B: Recycling Initiatives

4.4.1 The Supply Chain of the Waste

Figure 4.5 shows the survey results where the respondents stated the supply chain of electric and electronic waste. Information on the supply chain of electrical and electronic waste is essential for the author to determine where the supplier of e-waste originates from whether the supplier of e-waste is a supplier from the surrounding area, either in the same district or in a different district, different state or a different country.

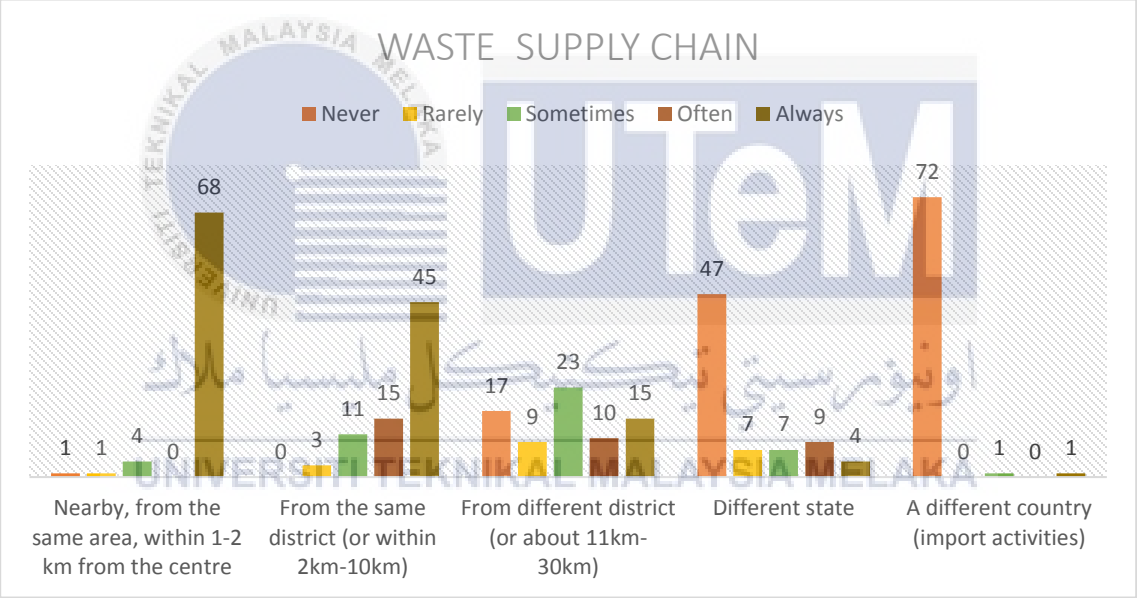

Figure 4. 5 : Supply chain of the waste

The bar chart shown in the figure shows that 68 respondents stated that they always get electric and electronic waste from the nearby supplier around 1 kilometre to 2 kilometres from the premises followed by the supplier from the same district within 10 kilometres from the premises. On the other hand, about 72 respondents stated that they never received electric and electronic waste from a different country imported to Malaysia. According to the Department of Environment of Malaysia, electric and electronic waste are categorized as scheduled wastes

under Solid Waste (SW) 110 code, in Environmental Quality (Scheduled Wastes) Regulation 2005. Due to Malaysia's enactment, e-waste is prohibited imported to Malaysia for material recovery and disposal activities. It consists of heavy metal, a hazardous material that can damage our health and ecosystem, (Suja et al., 2014).

4.4.2 Source of the WEEE

Figure 4.6 shows the survey results where the respondents stated the source of electric and electronic waste. Information on the source of electrical and electronic waste is essential for the author to determine who is the supplier of the e-waste to their premises. The type of supplier/customer is identified from the waste bin owned by the respondent, household, small collector, office or university, manufacturer and waste company such as Alam flora, Majlis Bandaran Johor Bahru (MBJB) and Dewan Bandaraya Kuala Lumpur (DBKL).

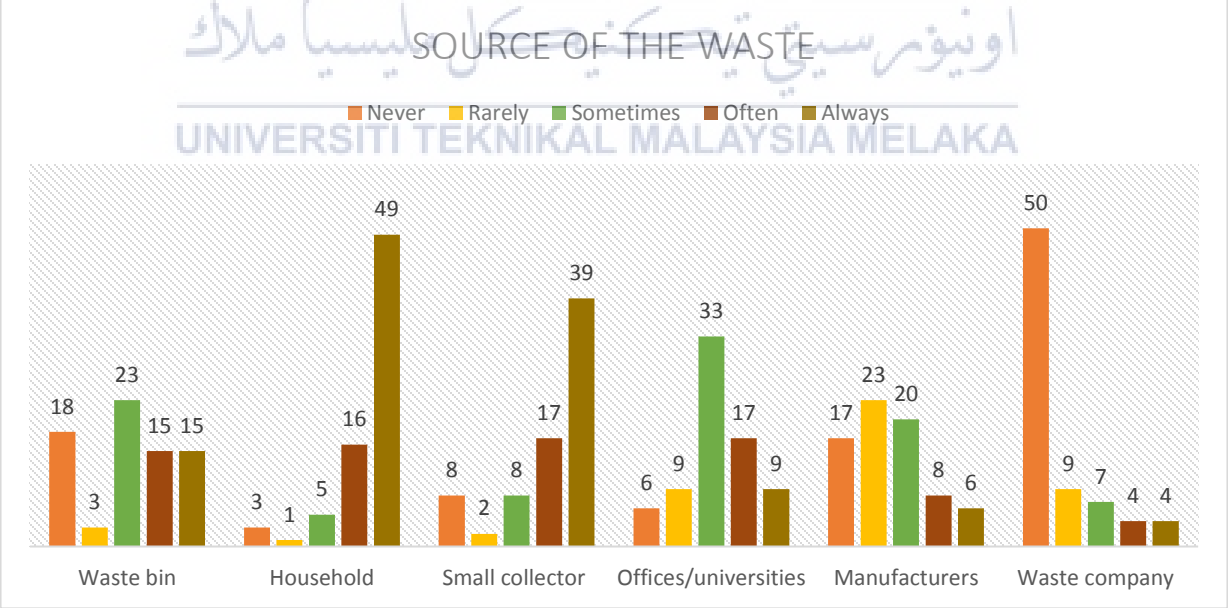

Figure 4. 6 : The source of the waste

From the survey result obtained, 16 respondents stated that they often obtain e-waste from the household, while 49 respondents indicated that they always obtain e-waste from the same supplier. In other words, the household became the majority of the e-waste supplier to the respondent premises, followed by the small collector and the waste bin owned by the respondent. Next, 50 respondents stated that they never received e-waste from the waste company. According to Suja et al. (2014), disposal of e-waste without proper controls can be harmful to human health and the environment because it contains toxic substances and heavy metals. Hence, e-waste which has no monetary value must be discarded of at sites or premises licensed by the Department of Environment (DOE), as it categorized as scheduled wastes under the code Solid Waste (SW) 110, in Environmental Quality (Scheduled Wastes) Regulation 2005. Due to this situation, only the licensed premises by government able to process e-waste.

Many people may not understand recycling beyond what they put in their household garbage. Residential recycling, however, accounts for just about one-quarter of the entire U.S. supply of recycled materials (ISRI, 2020). Most of the scrap comes from industrial and commercial sources. Outdated scrap consists of materials and items of usage and end-of-life. These include cars, appliances, electronics, carton boxes and other paper products, bottles and cans, and clothes. Demolition sites are another common source of outdated scrap. Prompt, prime, or fresh scrap comes out of the production process. These products include metal clippings, stampings and turning, as well as paper overruns and cuttings.

4.4.3 Frequency of WEEE Collection

Figure 4.7 shows the survey results where the respondents stated the frequency of e-waste collection from their customer or waste owned by them. The information regarding the frequency of e-waste collection is essential to the author is to determine how often the respondent obtained the e-waste from their customer.

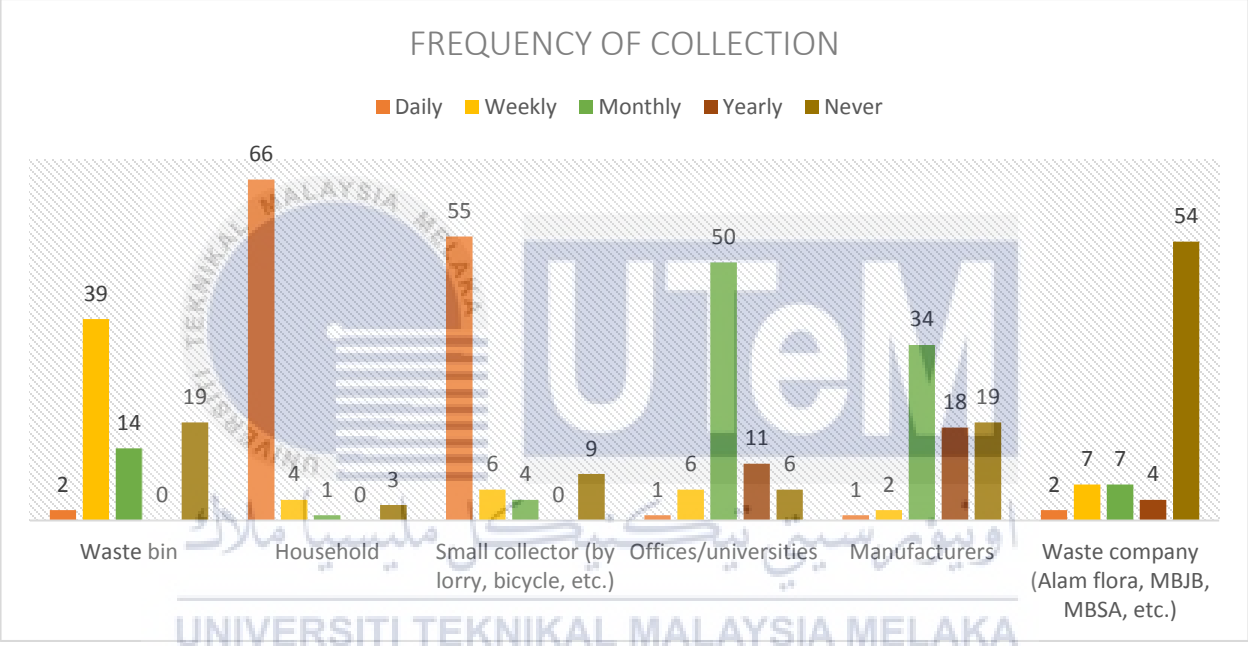

Figure 4. 7 : Frequency of e-waste collection

The survey result obtained 66 respondents stating they received the electric and electronic waste from the household and small collector every day. 39 respondents said they collect the e-waste by waste bin owned by them to a particular place in the industrial area, construction area and residential area every week. Besides, 50 respondents stated that they also obtained electric and electronic waste from the university and office every month followed by the manufacturer. About 54 respondents said that they never collect and received electric and electronic waste from the waste company entrusted by the government to manage solid waste in Malaysia. From this finding, it is clear that most of the respondents collected and received

electric and electronic waste from household every day, followed by the small collectors. In comparison, e-waste from the respondent's waste bin is collected every week while e-waste generated by office or university and manufacturer is collected every month by appointment from the customer.

4.4.4 Main Product Collected and Recycled by the Respondents.

Figure 4.8 shows the survey results where the respondents stated their main product being collected and recycled in their premises. The type of the main product collected and recycled in the respondent premises is required in this study's findings to determine which products are most frequently obtained and desired by respondents to be collected and processed on their premises.

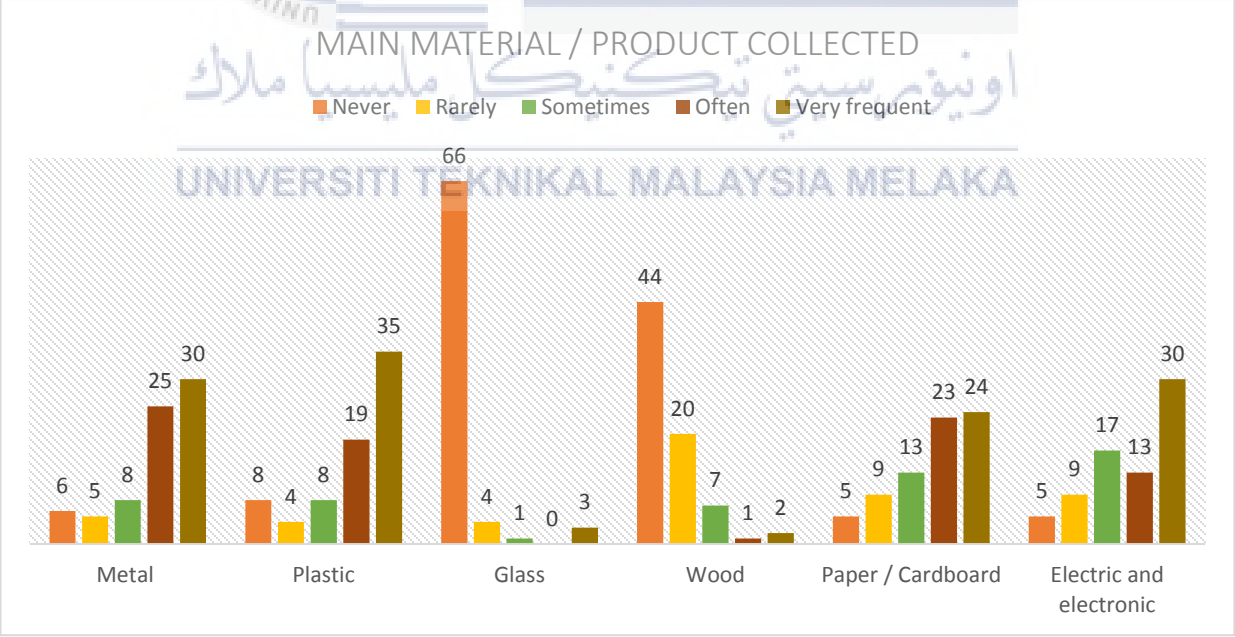

Figure 4. 8 : Main product collected and recycled

From the finding, around 25 respondents stated they often received metal product while 30 respondents state they frequently received the metal product in their premises. For the plastic product, approximately 19 respondents stated they often received plastic product while 35 respondent state they frequently received the plastic product in their premises. Next, for paper or cardboard product, 23 respondent state they often received while 24 respondents frequently received paper or cardboard in their premises. Besides, 13 respondent state they often received electrical and electronic product while 30 respondents frequently received the electrical and electronic product. However, 66 respondents never received the glass product followed by wood on their premises to be collected and recycled. Hence, most of the respondents preferred metal as their primary product to be collected and recycled in their premises, followed by plastic, paper and electric and electronic products. However, most of the respondents did not prefer glass and wood to be collected and recycled in their premises.

4.4.5 Consideration Factor

Objective 1: To determine the critical factors and the current practices of the end-of-life WEEE recycling

As shown in figure 4.9, most of the recyclers voted strongly agree on profitable with 60 respondents vote for Strongly Agree, followed by the high demand (42 respondents), a large quantity (15 respondents), technology readiness (8 respondents), level of cleanliness (6 respondents) and lastly, sorted waste (4 respondents). The numbers of recyclers vote on the Agree is as follow; 25 respondent vote agree for profitability, 20 respondent vote agree for high demand, 9 respondent vote for profitable, 22 respondent vote for technology readiness, 21 respondent vote for the level of cleanliness, 23 respondent vote for sorted waste. The numbers of recyclers vote on Neither Disagree nor Agree is as follow; 18 respondent vote for large quantity, 10 respondent vote for high demand, 4 respondent vote for profitable, 28 respondent vote for technology readiness, 29 respondent vote for the level of cleanliness, and 28 respondent

vote for sorted waste. The numbers of recyclers vote on Disagree is as follow; 16 respondent vote for large quantity, 2 respondent vote for high demand, 1 respondent vote for profitable, 15 respondent vote for technology readiness, 14 respondent vote for the level of cleanliness, 19 respondent vote for sorted waste. Lastly, numbers of recyclers vote on the Strongly Disagree are as follow; none of respondent vote for large quantities, high demand, profitable and sorted waste while the remain vote for technology readiness (1 voter) and level of cleanliness (4 voters).

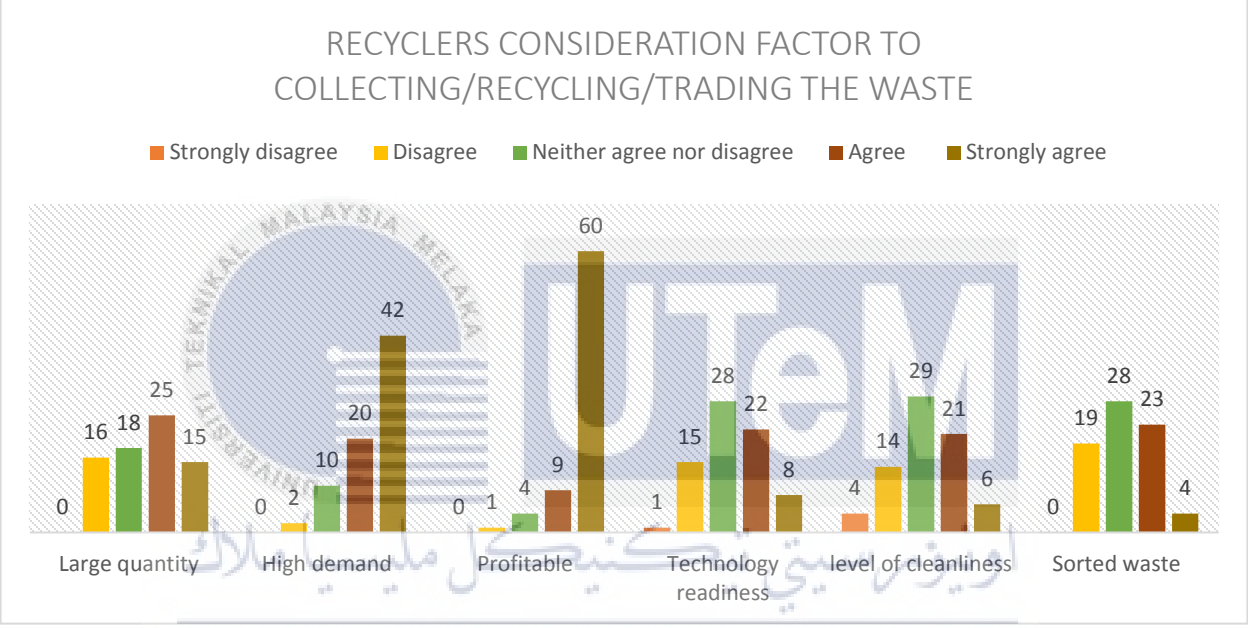

Figure 4. 9 : The recyclers' consideration factor when collecting, recycling or trading the waste.

4.4.5.1 Consideration Factor of Profit

From figure 4.9 demonstrate above, profitable gain highest percentage for strongly agree. The frequency statistics shown in Table 4.5 below illustrate the frequency of each Likert scale. The profitable were vote highest and gain 81.1% makes it the most considered factors. In terms of profitability, waste PCBs are purely valuable to the recyclers as it contains many useful materials that make it trade price higher than any other waste. Most of the first layer traders

would generally collect the waste PCBs in one place until the total weight reached upper trader requirement. However, these waste PCBs also are sold to the computer second hand or repair shop for reuse and refurbished purpose.

Table 4. 5 : Frequencies Statistic of Profitable

Profitable					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.4	1.4	1.4
	Neither Disagree nor Agree	4	5.4	5.4	6.8
	Agree	9	12.2	12.2	18.9
	Strongly Agree	60	81.1	81.1	100.0
	Total	74	100.0	100.0	

Cucchiella et al. (2016) highlighted that Waste Electrical and Electronic Equipment (WEEE) is one of the most important secondary raw materials sources. (Gaines, 2019) highlighted that Low Cobalt Lithium-ion Batteries (LIBs) can obtain profits and reduce transportation cost at their end-of-life process through direct recycling. This is because of the end-of-life LIBs materials could be recovered through the physical processes. The cathode material in the LIBs could be retrieved without breaking down its intricate and significant crystal structure. Thus, the value of these materials can be retained, although cobalt content is low. Not only that, other material such as anode carbon and electrolyte solvents can as well be recovered through direct recycling. These extracted and recovered materials are then remanufactured or reused to avoid high transportation costs of end-of-life WEEE disposal and preserve scarce material for future generations.

4.4.5.2 Consideration Factor of High Demand

From Figure 4.9 demonstrate above, highest demand gains second-highest percentage for strongly agree. The frequency statistics shown in Table 4.6 below illustrate the frequency of each Likert scale. The increased demand was voted second-highest and gain 56.8% makes it the second most considered factors. The electronics industry is the most prominent and rapidly rising sector in the world. The phenomenon of rapid product obsolescence and discarded electronics has become the fastest rising waste stream.

Table 4. 6 : Frequencies Statistic of High Demand

High Demand					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.7	2.7	2.7
	Neither Disagree nor Agree	10	13.5	13.5	16.2
	Agree	20	27.0	27.0	43.2
	Strongly Agree	42	56.8	56.8	100.0
	Total	74	100.0	100.0	

Newswire (2020) highlighted that the WEEE market is projected to reach 65.5 million tonnes by 2025 globally. Factors associated with the recycling industry's growth include the growing numbers of industrial waste, increment disposes of fees, stricter government policies, and declining lifespan of electrical and electronic equipment (Newswire, 2020). The growing awareness of the public on recycling practices reuse extracted materials through recycling process in various industries. Global awareness programs are undertaken by various governments and non-governmental organizations (NGOs). For example, take-back programs have contributed to the increasing demand of WEEE, which makes recycling an attractive and feasible option to meet this industry's resource demands (Gu et al., 2016).

4.4.5.3 Consideration Factor of Large Quantity

From Figure 4.9 demonstrate above, large quantity gains the highest percentage for agree. The frequency statistics shown in Table 4.7 below illustrate the frequency of each Likert scale. The large amount was voted highest for agree and gain 33.8% makes it third considered factors. In terms of quantity, collectors are not restricted to the limit on the number of waste trade. Although they will be delightful to receive large amounts, the recyclers would also consider any amount of waste, even 1 unit.

Table 4. 7 : Frequencies Statistic of Large Quantity

Large Quantity					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	16	21.6	21.6	21.6
	Neither Disagree nor Agree	18	24.3	24.3	45.9
	Agree	25	33.8	33.8	79.7
	Strongly Agree	15	20.3	20.3	100.0
	Total	74	100.0	100.0	

In WEEE cases, the collectors will store WEEE in a certain amount of time until their weight has met the upper trader's requirement. Gu et al. (2016) highlighted that high electrical and electronic equipment (EEE) consumption is followed by high WEEE generation. Even though the various types of WEEE resources will have different properties, their content remains a specific range. Therefore, WEEE recycling is a straightforward option to satisfy the electronics industry's resource requirements. The markets for recyclable products arise as a result of signals from the new resources pricing mechanism. By recycling or reusing these waste, industries benefit directly from the reduced production costs as they reuse used material into new products. The supply of material is collected from the waste products and shipped to the production plant. Similar market forces are set in motion by customer demand for goods made from recovered

materials. By using the preference for recycled products, customers will provide an economic incentive for businesses to pursue supplies of recycled material.

4.4.5.4 Consideration Factor of Technology Readiness, Level of Cleanliness and Sorted Waste

Technology readiness, cleanliness, and sorted waste have the highest voted on neither disagree nor agree as demonstrated in table 4.8, table 4.9, and table 4.10. It shows that these three factors are neutral for the recyclers and not the main priority for considering the waste. The collectors believed that the waste should not have a higher level of cleanliness nor sorted as this behaviour entirely depends on the end-consumer mindset. In Malaysia, the author found out that the technology readiness factor is unnecessary as this WEEE will end up in the full recovery facilities under the Department of Environment supervision. Soo et al. (2013) highlighted that private companies own the recovery facilities, and, presently, there are 20 full recovery facilities and 132 partial recovery facilities in Malaysia. Firms in the formal sector strictly need to properly manage WEEE as they are bounded and supervised under the Department of the Environment (DOE).

Table 4. 8 : Frequencies Statistic of Technology Readiness

Technology Readiness					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.4	1.4	1.4
	Disagree	15	20.3	20.3	21.6
	Neither Disagree nor Agree	28	37.8	37.8	59.5
	Agree	22	29.7	29.7	89.2
	Strongly Agree	8	10.8	10.8	100.0
	Total	74	100.0	100.0	

Table 4. 9 : Frequencies Statistic of Level of Cleanliness

Level of Cleanliness					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	5.4	5.4	5.4
	Disagree	14	18.9	18.9	24.3
	Neither Disagree nor Agree	29	39.2	39.2	63.5
	Agree	21	28.4	28.4	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

Table 4. 10 : Frequencies Statistic of Sorted Waste

Sorted waste					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	19	25.7	25.7	25.7
	Neither Disagree nor Agree	28	37.8	37.8	63.5
	Agree	23	31.1	31.1	94.6
	Strongly Agree	4	5.4	5.4	100.0
	Total	74	100.0	100.0	

In terms of sorted waste, size reduction enables the separation of mixed materials. It also produces lower shipping costs and higher productivity at the scrap processor. Recyclers use large shredders, sizers, grinders, and wire choppers to size-reduce incoming material. Sorting can be achieved by increasingly sophisticated machines that can detect and distinguish materials based on their qualities such as magnetism, density, form, scale, elemental composition, colour, and other characteristics. ISRI (2020) highlighted that United State Material Recovery Facilities (MRF) is now utilized industrial robot to sort and remove contaminants from waste. Meanwhile, in Malaysia, we are still using physical processes; no advanced processes are seen during the study.

4.4.6 Current Challenges for Recyclers to Sustain in the Recycling Industry

Figure 4.10 demonstrates the current challenges in the recycling industry. As shown in the figure above, most of the recyclers voted strongly agree on government policy and licensing with 38 respondents, followed by the insufficient supply (19 respondents), challenging to identify stolen items (17 respondents), taxes or fees (15 respondents), expensive technology and machinery, and capital (14 respondents) and lastly, the complaint from the neighbourhood (5 respondents). The numbers of recyclers vote on the Agree is as follow; 27 respondent vote for insufficient supply, 24 respondent vote for expensive technology and machinery, 22 respondent vote for difficult to identify the stolen item, 16 respondent vote for government policy and licensing, 8 respondent vote for taxes or fees, 5 respondent vote for complaint form neighbourhood and capital. The numbers of recyclers vote on Neither Disagree nor Agree as follow; 37 respondent vote for taxes or fees, 29 respondent vote for capital, 25 respondent vote for expensive technology and machinery, 18 respondent vote for insufficient supply,15 respondent vote both government policy and licensing, and difficult to identify stolen items. The numbers of recyclers vote on Disagree is as follow; 50 respondent vote for complaint from the neighbourhood, 13 respondent vote for difficult to identify stolen items, 7 respondent vote for capital, 5 respondent vote for expensive technology and machinery, 4 respondent vote for taxes or fees, 2 respondent vote for government policy and licensing, and 1 respondent vote for insufficient supply.

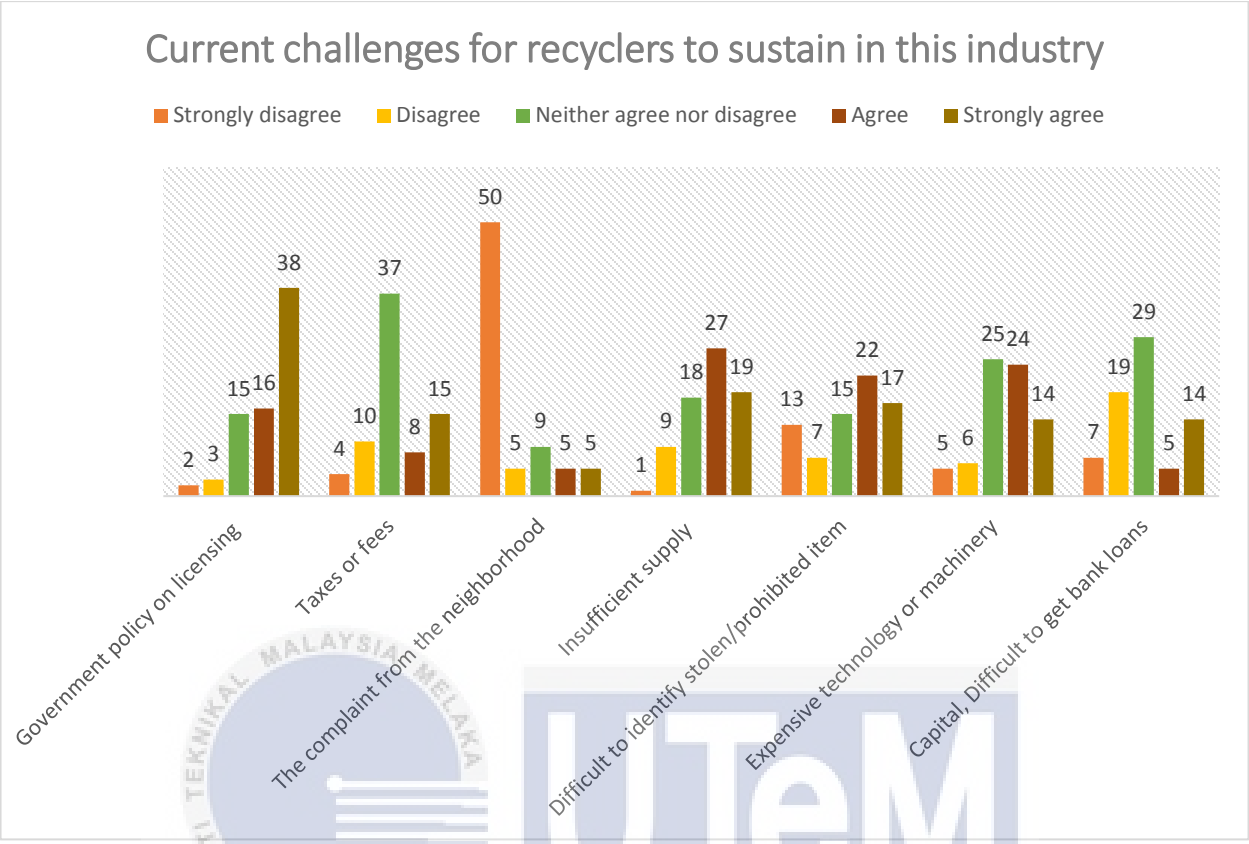

Figure 4. 10 : Current Challenges in the Recycling Industry

4.4.6.1 Current Challenges of Government Policy and Licensing

From Figure 4.10 demonstrate above, government policy and licensing gain the highest percentage for strongly agree. The frequency statistics shown in Table 4.11 below illustrate the frequency of each Likert scale. The government policy and licensing were voted highest and gain 51.4% make it the main current challenges faced by the recyclers in the recycling industry.

Table 4. 11 : Frequencies Statistic of Government Policy and Licensing

Government Policy and Licensing					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	2	2.7	2.7	2.7
	Disagree	3	4.1	4.1	6.8
	Neither Disagree nor Agree	15	20.3	20.3	27.0
	Agree	16	21.6	21.6	48.6
	Strongly Agree	38	51.4	51.4	100.0
	Total	74	100.0	100.0	

Malaysia is now stricter than before in handling the illegal sector. Hence, MalayMail (2019) reported that a total of 139 illegal recycling factories that violated the Environmental Quality Act 1974 had been closed from January 2019 to date. Suja et al. (2014) highlighted that the effective implementation of policies and strategies is required to minimize the environmental and health risks caused by such complex hazardous wastes. WEEE is listed as scheduled waste under the Environmental Quality (Scheduled Wastes) Regulations 2005. These regulations stipulate that no person is allowed to dispose of any WEEE into landfills. WEEE must be recycled and recovered at prescribed or licensed premises, and disposal must only occur and carried out in an environmentally sound manner. The recyclers who accept WEEE need to apply for the additional license from the Department of Environment (DOE) to operate under DOE supervision.

Forti et al. (2020) pointed out, regulatory developments in some regions are sluggish, implementation is weak, and policy, legislation, or regulation has not yet stimulated the collection and proper management of e-waste to lack of investment and political motivation. (TheStar, 2019) points out that adequate policies and legislation must be placed to promote sound waste management practises. This can be concluded as to why government policy and licencing have been the biggest obstacles for recyclers. Many of the protocols and criteria need to be strictly followed to curb the informal sector's development that uses lower efficiency techniques to process and extract valuable components (Herat & Agamuthu, 2012). Most informal recycling operations are carried out at the back of industries that use the most rudimentary technologies that significantly affect the environment (Soo et al., 2013). Hence, stricter regulation on policy and licensing is better to ensure that the WEEE is managed sustainably.

4.4.6.2 Current Challenges of Insufficient Supply

From Figure 4.10 demonstrate above, the insufficient supply gains the highest percentage for agree. The frequency statistics shown in Table 4.12 below illustrate the frequency of each Likert scale. The inadequate supply was voted highest and gain 36.5% makes it the main challenges faced in the recycling industry. Based on the findings, the insufficient supply was caused by the COVID-19 pandemic that appeared in December 2019, causing a temporary closure of many sectors in Malaysia.

Table 4. 12 : Frequencies Statistic of Insufficient Supply

Insufficient Supply					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.4	1.4	1.4
	Disagree	9	12.2	12.2	13.5
	Neither Disagree nor Agree	18	24.3	24.3	37.8
	Agree	27	36.5	36.5	74.3
	Strongly Agree	19	25.7	25.7	100.0
	Total	74	100.0	100.0	

A significant danger to general wellbeing emerged in 2020. The novel acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outbreak appeared in December 2019 from Wuhan City, Hubei Province, China, and spread to the rest of the world. Countries have been responding to the COVID-19 by shutting down their schools, small/local businesses, places of worship, borders to humans and goods from certain parts of the world like China where the COVID-19 originated. L. L. Lim (2020) highlighted that the supply chain disruptions are among the significant impacts of the coronavirus outbreak. Quarantined workers and the shortage of components are affecting manufacturers across the globe. The situation might worsen after the first quarter of this year. Companies having global supply chains could expect a delay in the supply of raw materials and products. Not only that, BeritaHarian (2020b) highlighted that the job losses in Malaysia increased by 42% in the first quarter of the year following the COVID-19 pandemic. Goldman Sachs Group Inc and Morgan Stanley economists shared an opinion with Wall Street to declare COVID-19 has triggered a global recession. That may not be as severe as the 0.8% contraction in 2009, as measured by the International Monetary Fund (IMF), but worse than in 2001 and the early 1990s (BeritaHarian, 2020a). Thus, it can be related to these recyclers' insufficient supply. People losing a job due to the economic recession causes public purchasing power to plummet and lead to less waste produced.

4.4.6.3 Current Challenges of Identification of Stolen Items

Figure 4.10 demonstrates above that the difficult to identify stolen item gain second-highest percentage for agreeing. The frequency statistics shown in Table 4.13 below illustrate the frequency of each Likert scale. The difficulty in identifying stolen items was voted second-highest for agree and gain 29.7%, making it one of the recycling industry's challenges. In Malaysia, the Law strictly prohibited recyclers from accepting any item from suspected traders. The Malaysian Recycling Empowerment Association is actively collaborating with the

Table 4. 13 : Frequencies Statistic of Difficult to identify stolen items.

Difficult to identify stolen items					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	13	17.6	17.6	17.6
	Disagree	7	9.5	9.5	27.0
	Neither Disagree nor Agree	15	20.3	20.3	47.3
	Agree	22	29.7	29.7	77.0
	Strongly Agree	17	23.0	23.0	100.0
	Total	74	100.0	100.0	

Royal Malaysian Police (RMP) to resolve metal theft. In Malaysia, copper products such as bellows, hot water cylinders and cables are the most frequently recorded stolen objects. Other items, such as batteries (for lead), utility hole covers and decorative garden items, have also been targeted (PERKESA, 2020). The recyclers in Malaysia are licensed under the Second-hand Dealer Act 1946, in which if found guilty, the recyclers can be fined and jailed. However, in rural premises, some of the recyclers are not adequately trained in the regulation. Some may secretly accept illegal waste solely for income. Especially during the pandemic, these scenarios could not be avoided as all the business owners struggle to survive. Thus, it explained 17 respondents who vote for strongly agree and 22 respondent vote for agreeing in the challenge of identifying stolen items.

4.4.6.4 Current Challenges of Taxes or Fees

From Figure 4.10 demonstrate above, the taxes or fees gain the highest percentage for neutral. The frequency statistics shown in Table 4.14 below illustrate the frequency of each Likert scale. The taxes or fees were voted highest in neutral and gain 50% makes it the neutral challenges faced in the recycling industry.

Table 4. 14 : Frequencies Statistic of Taxes or Fees

Taxes or Fees					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	5.4	5.4	5.4
	Disagree	10	13.5	13.5	18.9
	Neither Disagree nor Agree	37	50.0	50.0	68.9
	Agree	8	10.8	10.8	79.7
	Strongly Agree	15	20.3	20.3	100.0
	Total	74	100.0	100.0	

Most recyclers have to pay taxes like other business sectors, including income tax, land tax, etc. The implementation of the goods and services tax (GST) in Malaysia on 1 April 2015 was part of the Malaysian government's taxation reforms to improve revenue collection and reduce its budget deficit. Santhariah et al. (2018) highlighted that whilst larger businesses confirmed that they were well prepared for GST, smaller companies experienced tremendous stress in their preparation.

4.4.6.5 Current Challenges of Capital

From Figure 4.10 demonstrate above, capital gain second-highest percentage for neutral. The frequency statistics shown in Table 4.15 below illustrate the frequency of each Likert scale. The capital was voted second-highest in neutral and gain 39.2% makes it the neutral challenges faced in the recycling industry. The findings show that proper documentation is needed to ease the process of loan banks. Hence, having a good system will encounter difficulty getting a loan bank for the recyclers that are illegal or not.

Table 4. 15 : Frequencies Statistic of Capital

Capital					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	9.5	9.5	9.5
	Disagree	19	25.7	25.7	35.1
	Neither Disagree nor Agree	29	39.2	39.2	74.3
	Agree	5	6.8	6.8	81.1
	Strongly Agree	14	18.9	18.9	100.0
	Total	74	100.0	100.0	

4.4.6.6 Current Challenges of Technology and Machinery

From Figure 4.10 demonstrate above, technology and machinery gain third-highest percentage for neutral. The frequency statistics shown in Table 4.16 below illustrate the frequency of each Likert scale. The technology and machinery were voted third highest in neutral and gain 33.8% make it the neutral challenges faced in the recycling industry.

Table 4. 16 : Frequencies Statistic of Technology and Machinery

Technology and Machinery					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	5	6.8	6.8	6.8
	Disagree	6	8.1	8.1	14.9
	Neither Disagree nor Agree	25	33.8	33.8	48.6
	Agree	24	32.4	32.4	81.1
	Strongly Agree	14	18.9	18.9	100.0
	Total	74	100.0	100.0	

Based on the findings, the recyclers were most comfortable with the current process in their premise. Every new process implied in the premises needs to be updated at the local authorities. To obtain a new license, more money needs to be invested, especially in processing fees. Plus, Soo et al. (2013) pointed out that Malaysia's waste treatment plant does not have facilities for treating and recycling hazardous waste such as solidified cyanide, heavy metal sludge, and fibre waste. Instead, the hazardous waste is sent to another private organisation for further treatment to recover precious metals.

4.4.6.7 Current Challenges of Complaint from The Neighbourhood

From Figure 4.10 demonstrate above, the complaint from neighbourhood gain the highest percentage for strongly disagree. The frequency statistics shown in Table 4.17 below illustrate the frequency of each Likert scale. The neighbourhood's complaint was voted highest in strongly disagree and gain 67.6% makes it the least challenges faced in the recycling industry. Most of the premises are found to be in the industrial area or business lot.

Table 4. 17 : Frequencies Statistic of Complaint from Neighbourhood

Complaint from Neighbourhood					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	50	67.6	67.6	67.6
	Disagree	5	6.8	6.8	74.3
	Neither Disagree nor Agree	9	12.2	12.2	86.5
	Agree	5	6.8	6.8	93.2
	Strongly Agree	5	6.8	6.8	100.0
	Total	74	100.0	100.0	

4.4.7 Drivers for Recyclers to Sustain in the Recycling Industry

Figure 4.11 demonstrates the drivers for recyclers to sustain in the recycling industry. As shown in the figure above, most of the recyclers voted strongly agree on high consumer awareness with 60 respondents vote for Strongly Agree, followed by the increased demand for recycled material (45 respondents), a broad collaboration (29 respondents), material scarcity (16 respondents), guaranteed volumes of waste supply (8 respondents) and lastly, standardized market value (4 respondents). The numbers of recyclers vote on the Agree is as follow; 28 respondent vote agree for broad collaboration, 24 respondent vote agree for both high demand recycled material guaranteed volumes of waste supply, 18 respondent vote agree for standardized market value, 9 respondent vote agree for material scarcity, 7 respondent vote agree for high consumer awareness. The numbers of recyclers vote on Neither Disagree nor Agree is as follow; 45 respondent vote neutral for standardized market value, 32 respondent vote neutral for guaranteed volumes of waste supply, 31 respondent vote neutral for material scarcity,14 respondent vote neutral for broad collaboration, 9 respondent vote neutral for high consumer awareness, and 5 respondent vote neutral for the high demand for recycled material.

The numbers of recyclers vote on Disagree is as follow; 11 respondents vote to disagree for both legislation and material scarcity, 10 respondent vote disagree for guaranteed volumes of waste supply, 6 respondent vote disagree for both government funding injection and standardized market value, 2 respondent vote disagree for broad collaboration, and 1 respondent vote disagree for high consumer awareness. Lastly, the number of recyclers voting on the Strongly Disagree is as follow; non of respondents vote for high consumer awareness, high demand for recycled material and guaranteed volumes of waste supply. 56 respondent vote strongly disagree for legislation, 61 respondent vote strongly disagree for government funding injection, 7 respondent vote strongly disagree for material scarcity, 1 respondent vote strongly disagree for both standardize market value and broad collaboration.

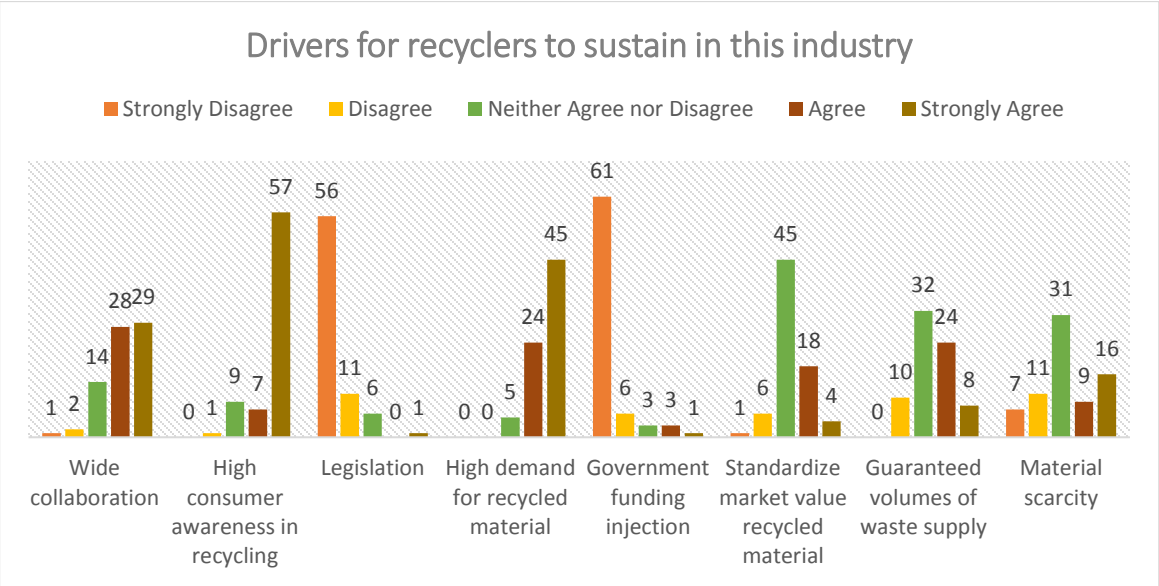

Figure 4. 11 : Drivers for recyclers to sustain in the recycling industry

4.4.7.1 Drivers of High Consumer Awareness

From Figure 4.11 demonstrate above, high consumer awareness gains the highest percentage for strongly agree. The frequency statistics shown in Table 4.18 below demonstrate the frequency of each Likert scale. The high consumer awareness was voted highest in strongly agree and gain 77% makes it the main drivers for the recycler to keep striving in the industry.

Table 4. 18 : Frequencies Statistic of High Consumer Awareness

High Consumer Awareness					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.4	1.4	1.4
	Neither Disagree nor Agree	9	12.2	12.2	13.5
	Agree	7	9.5	9.5	23.0
	Strongly Agree	57	77.0	77.0	100.0
	Total	74	100.0	100.0	

TheStar (2020) highlighted that Malaysia had reached the target of a 30% recycling rate this year. This recycling rate was drastically increased during the implementation of movement control order (MCO) starts last March, contributing to better awareness of recycling among the public, reducing the amount of solid waste sent to landfills. NST (2020b) reported that 307.52 tonnes of recycled items are collected in March compared to 163.04 tonnes during the previous months. This has demonstrated the positive trend of recycling which can significantly be a resource for circular economy practices. According to Juana & Vivian Tunn (2019) highlighted that consumption and consumers are the primary consideration to organisations and economies that aim to enhance their circular economy involvement. Thus it left with the government strategy to keep the positive trend continue. The feedback obtained from the data collection can be concluded that Malaysia is ready to transition practices. It is crucial to understand that CE is not a new thing and has been physically applied, but it has only recently begun to be recognised in the literature.

4.4.7.2 Drivers of High Demand for Recycled Materials

Figure 4.11 demonstrates that high demand for recycled material gains the second-highest percentage for strongly agree. The frequency statistics shown in Table 4.19 below illustrate the frequency of each Likert scale. The high consumer awareness was voted second-highest in strongly agree and gain 60.8% makes it second drivers for the recycler to keep striving in the industry.

Table 4. 19 : Frequencies statistic of high demand for recycled materials

High Demand for Recycled materials					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither Disagree nor Agree	5	6.8	6.8	6.8
	Agree	24	32.4	32.4	39.2
	Strongly Agree	45	60.8	60.8	100.0
	Total	74	100.0	100.0	

ISRI (2020) highlighted that recycled commodities are a key global manufacturing feedstock that meets about 40% of the world's industrial raw material needs. Worldwide, manufacturers consume about 900 million mt of scrap each year. About 20% of that volume, or nearly 180 million mt, results from global scrap trade. The high demand for recycled material obtains higher voter due to transition towards the circular economy. The circular economy encourages the transformation of the linear consumption model into a closed production model. The production and consumption waste is reused and integrated into the economy to generate more value while promoting economic practises that reduce, reuse and recycle resources in production, distribution and consumption processes (Calvo-Porral & Lévy-Mangin, 2020).

The economic model, also known as the Circular Economic, is a pragmatic response to the emerging global resource crisis. This model has been an incentive to overcome the constraint of a linear economy. Santibanez Gonzalez et al. (2019) highlighted an immediate need to detach the speed of world economic growth and demand to the rate of consumption of our natural resources. With rising global publicity and increasing customer awareness of the number of natural resources needed for the production of products, the depletion of natural resources by waste and its scarcity, businesses and companies around the globe have been encouraged to develop sustainable practises and make their activities more sustainable, i.e. to find the right balance between profitability and impacts. The CE approaches are considering the life cycle of the goods. These approaches would result in a reduced amount of waste produced and improved resource utilisation and the generation of environmental benefits. Amui et al. (2017) stressed that the material should be kept available rather than disposed of in such a way as to create a

closed-loop for the material to circulate within the product lifecycle to reduce the use of resources and energy demand.

4.4.7.3 Drivers of wide collaboration

From Figure 4.11 demonstrate above, wide collaboration gains third-highest percentage for strongly agree. The frequency statistics shown in Table 4.20 below illustrate the frequency of each Likert scale. The wide collaboration was voted third highest in strongly agree and gain 39.2% makes it third drivers for the recycler to keep striving in the industry.

Table 4. 20 : Frequencies statistic of wide collaboration

Wide Collaboration					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.4	1.4	1.4
	Disagree	2	2.7	2.7	4.1
	Neither Disagree nor Agree	14	18.9	18.9	23.0
	Agree	28	37.8	37.8	60.8
	Strongly Agree	29	39.2	39.2	100.0
	Total	74	100.0	100.0	

According to De Angelis et al. (2018), collaboration plays a crucial role in the supply chain from buyer-supplier relationships, SMEs integration and consumers. The closed-loop supply chain conquering possibilities in parts recycling, remanufacturing and repairs, and thus, reducing overall material consumption (Mishra et al., 2019). CE's collaboration has become a necessity in modern supply chains and plays a crucial role in eliminating wasted material and increasing products' value (V. Kumar et al., 2019). The collaboration of all stakeholders into the company's strategy is an essential part of strategy design. Companies with alternative ways of

doing business could profit from partnering with other companies heading towards circularity. Mishra et al. (2019) highlighted that local suppliers could be educated on the value of recycling and reuse, thus avoiding waste.

4.4.7.4 Drivers of the standardized market value of recycled material

From Figure 4.11 demonstrate above, standardized market value gains the highest percentage for neutral. The frequency statistics shown in Table 4.21 below illustrate the frequency of each Likert scale. The wide collaboration was voted highest in neutral and gain 41.9% makes it neutral drivers for the recycler to keep striving in the industry. There is an absence of standardized market value of waste in Malaysia as the price is determined based on their upper traders. Although the price is based on the upper trader, the price must be in the range of plus-minus 10-20 cent. Mollona et al. (2019) highlighted that governments are increasingly pushing for a larger proportion of products and services to be recycled, but the marketplace largely dictates the cost of achieving these goals.

Table 4. 21 : Frequencies statistic of the standardized market value of recycled material

Standardized Market Value					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	9.5	9.5	9.5
	Disagree	11	14.9	14.9	24.3
	Neither Disagree nor Agree	31	41.9	41.9	66.2
	Agree	9	12.2	12.2	78.4
	Strongly Agree	16	21.6	21.6	100.0
	Total	74	100.0	100.0	

4.4.7.5 Drivers of guaranteed volume of waste supply

From Figure 4.11 demonstrate above, the guaranteed volume of waste supply gain second-highest percentage for neutral. The frequency statistics shown in Table 4.22 below illustrate the frequency of each Likert scale. The guaranteed volumes of waste supply were voted second-highest in neutral and gain 43.2% makes it neutral drivers for the recycler to keep striving in the industry. Most recyclers did not have the guaranteed volumes of waste supply during the data collection unless they contract with the manufacturers. Most of the manufacturers will produce numbers of output. Hence they will be a rejected product and waste. These will be sent to the recyclers for the subsequent processing. Unlike any other waste generator, it is hard to predict numbers of waste supply received.

Table 4. 22 : Frequencies statistic of guaranteed volume of waste supply

The guaranteed volume of waste supply					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	10	13.5	13.5	13.5
	Neither Disagree nor Agree	32	43.2	43.2	56.8
	Agree	24	32.4	32.4	89.2
	Strongly Agree	8	10.8	10.8	100.0
	Total	74	100.0	100.0	

Nevertheless, Forti et al. (2020) highlighted that the global generation of e-waste has grown by 9.2 Mt since 2014 and is expected to rise to 74.7 Mt. Asia generated the highest quantity of e-waste at 24.9 Mt in 2019, followed by the Americas (13.1 Mt) and Europe (12 Mt), while Africa and Oceania generated 2.9 Mt and 0.7 Mt respectively. Forti et al. (2020) reported that WEEE managed to be collected and recycled amounted to 9.3 Mt, which has grown from 1.8 Mt since 2014. Although good initiatives have been taken to curb the growth of WEEE, the global development of WEEE is still increasing due to consumer demands. Recycling activities are not keeping pace with the global development of e-waste.

4.4.7.6 Drivers of material scarcity

From Figure 4.11 demonstrate above, material scarcity gain third-highest percentage for neutral. The frequency statistics shown in Table 4.23 below illustrate the frequency of each Likert scale. The material scarcity was voted third highest in neutral and gain 41.9% makes it neutral drivers for the recycler to keep striving in the industry. In terms of material scarcity, the recyclers are less concern on the environment, unlike end-consumer. The recyclers are more focusing on profitability; after all, it is all about business.

Table 4. 23 : Frequencies statistic of material scarcity

Material Scarcity					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	9.5	9.5	9.5
	Disagree	11	14.9	14.9	24.3
	Neither Disagree nor Agree	31	41.9	41.9	66.2
	Agree	9	12.2	12.2	78.4
	Strongly Agree	16	21.6	21.6	100.0
	Total	74	100.0	100.0	

Reduction in the life cycle of electronic devices and lack of precious metals drives the global e-waste management industry's development. Nevertheless, APNews (2020) pointed out that high recycling costs due to a lack of infrastructure and e-waste initiatives by electronic manufacturers worldwide are expected to negatively impact business growth. Developing countries are leading the recycling of e-waste, while the bulk of e-waste is shipped to developing countries. The global e-waste management market is expected to register the highest Compound Annual Growth Rate of 16.3%, owing to the rapid rise in the adoption of electronic equipment that creates a favourable environment for e-waste processing companies.

4.4.7.7 Drivers of Legislation and Government Funding Injection

From Figure 4.11 demonstrate above, legislation and government funding injection gain the highest percentage for strongly disagree. The frequency statistics are shown in Table 4.25 and Table 4.4.7.8 above illustrate the frequency of each Likert scale. The Legislation and government funding injection were voted highest in strongly disagree with 75.7%, and 82.4% makes it the least drivers that keep recyclers in the industry.

Table 4. 24 : Frequencies Statistic of legislation

Legislation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	56	75.7	75.7	75.7
	Disagree	11	14.9	14.9	90.5
	Neither Disagree nor Agree	6	8.1	8.1	98.6
	Strongly Agree	1	1.4	1.4	100.0
	Total	74	100.0	100.0	

Table 4. 25 : Frequencies statistic of Government Funding Injection

Government Funding Injection					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	61	82.4	82.4	82.4
	Disagree	6	8.1	8.1	90.5
	Neither Disagree nor Agree	3	4.1	4.1	94.6
	Agree	3	4.1	4.1	98.6
	Strongly Agree	1	1.4	1.4	100.0
	Total	74	100.0	100.0	

The absence of legislation and government funding injection on supporting recycling industry has led to the same process done in the premises from one recycler to another. Most of the recycler in Malaysia is found to be only collect and sort the waste. The waste's supply chain can be concluded that the waste goes through many sorting levels until it reaches the last stage, recycling. The author found out that recyclers stuck on the same process during the data collection due to financial. More process in the premises means more fees, hence more investment. Every process and machine used in the premises needs to be declared and have a regular inspection. Therefore, the recyclers tend to have a more straightforward process; collect, sort and trade.

4.4.8 WEEE Ownership

Figure 4.12 demonstrates the result of the preferred WEEE ownership. As shown in the figure above, most recyclers vote Strongly Agree on the government with 51 respondents, followed by end-users with 45 respondents, recycler 33 respondents and manufacturers with 21 respondents. The numbers of recyclers vote on the Agree is as follow; 21 respondents vote for the manufacturer, 20 respondents vote for the government, 18 respondents vote for recycler and 16 respondents vote for end-user. The numbers of recyclers vote on the Neither Agree nor Disagree are as follows; 21 respondents vote for recyclers, 18 respondents vote for manufacturers, 8 respondents vote for end-users, and 3 respondents vote for the government. The numbers of recyclers vote on the Disagree is as follow; 9 respondents vote for the manufacturer, 2 respondents vote for recyclers and 2 respondent vote for end-user. The numbers of recyclers vote on the Strongly Disagree as follow; 5 respondents vote for manufacturers, and 3 respondents vote for end-user.

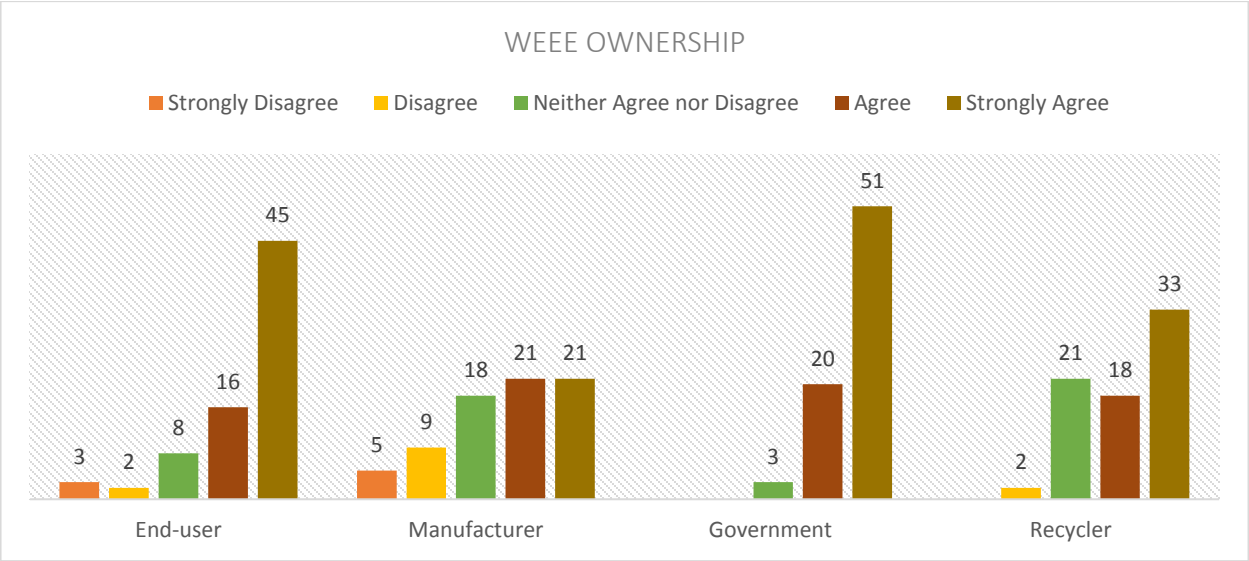

Figure 4. 12 : WEEE Ownership

4.4.8.1 Responsible Identity on WEEE Ownership: Government

From Figure 4.12 demonstrate above, Government gains the highest percentage for strongly agree for WEEE ownership. The frequency statistics shown in Table 4.26 above illustrate the frequency of each Likert scale in which 51 respondents vote strongly agree, 20 respondents vote for agreeing, and 3 respondents vote for neither disagree nor agree. The author believed the government plays the most prominent role in ensuring the recycling industry keep striving forward so that the circular economy could be fully implemented in Malaysia.

Table 4. 26 : Frequencies Statistic of WEEE ownership: Government

WEEE Ownership: Government					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither Disagree nor Agree	3	4.1	4.1	4.1
	Agree	20	27.0	27.0	31.1
	Strongly Agree	51	68.9	68.9	100.0
	Total	74	100.0	100.0	

According to ISRI (2020) highlighted that the electronic recycling industry's total economic impact in the United States is nearly $5.45 billion. The recycling industry generated $109.78 billion in 2018, which was 0.54% of total U.S. economic activity that year. Based on the findings, the author believed if the WEEE recycling industry is adequately managed and got incentives from the government, we could boost our economy in this era. The global demand for WEEE management is projected to rise from $9.15 in 2011 to $20.25 billion in 2016 at a CAGR of 17.22% (PRNewswire, 2014). We believe it is in everyone's best interests that growth occurs primarily through formal WEEE recycling, through an infrastructure responsibly ensuring its operation. Legal WEEE recycling offers the highest economic return while also serving as the most important way to prevent environmental degradation as the Department of Environment supervises it.

Previously FMT (2019) reported that tens of thousands of e-waste containers were imported through the ports in Pasir Gudang, Johor and Port Klang, and Selangor, resulting in the China ban on hazardous materials 2018. Importers use standard techniques to conceal their actions as legal, using such names as scrap metal or other products permitted by customs. This is then smuggled to several illegal e-waste sites in the peninsula. In the initiative towards a sustainable country, stricter policy needs to be enforced. Based on the findings, the government shall put special attention to the recycling industry. The author believed that if it is well managed and stricter policy enforces, these illegal activities can be prevented.

4.4.8.2 Responsible Identity on WEEE Ownership: End-User

From Figure 4.12 demonstrate above, End-user gains second-highest percentage for strongly agree for WEEE ownership. The frequency statistics shown in Table 4.27 above illustrate each Likert scale's frequency in which 45 respondents vote strongly agree, 16 respondents vote for agreeing, 8 respondents vote for neither disagree nor agree, 2 respondent vote agree, and 3 respondent vote strongly disagree. The author believed the end-user also have roles in ensuring the recycling industry keep striving forward so that the circular economy could be fully implemented in Malaysia.

Table 4. 27 : Frequencies statistic of WEEE ownership: End-User

End-User					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	3	4.1	4.1	4.1
	Disagree	2	2.7	2.7	6.8
	Neither Disagree nor Agree	8	10.8	10.8	17.6
	Agree	16	21.6	21.6	39.2
	Strongly Agree	45	60.8	60.8	100.0
	Total	74	100.0	100.0	

People play two roles in the e-waste cycle: one as a purchaser and the other as an e-waste handler. The WEEE management system cannot be effective if there is low public awareness of the dangerous of WEEE can poses. WEEE recognition as resources has contributed to a paradigm change in e-waste management. Concern has risen over sustainability for the adverse environmental effects and the lack of rare earth elements used in electronics manufacturing. Both issues have contributed to a global effort to practice sustainable management of WEEE. A successful approach to WEEE management aims to achieve economic productivity while minimizing impacts on the environment.

4.4.8.3 Responsible Identity on WEEE Ownership: Recyclers

From Figure 4.12 demonstrate above, Recyclers gain third-highest percentage for strongly agree for WEEE ownership. The frequency statistics shown in Table 4.28 above illustrate the frequency of each Likert scale in which 33 respondents vote strongly agree, 18 respondents vote for agree, 21 respondents vote for neither disagree nor agree, and 2 respondent vote disagree. The author believed the end-user also have roles in ensuring the recycling industry keep striving forward so that the circular economy could be fully implemented in Malaysia.

Table 4. 28 : Frequencies statistic of WEEE ownership: Recyclers

Recyclers					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.7	2.7	2.7
	Neither Disagree nor Agree	21	28.4	28.4	31.1
	Agree	18	24.3	24.3	55.4
	Strongly Agree	33	44.6	44.6	100.0
	Total	74	100.0	100.0	

The recycling industry is a key player in protecting the environment, conserving resources and ensure sustainability. According to ISRI (2020), recycled materials are a significant global manufacturing feedstock that supports about 40% of material demand. Manufacturers worldwide annually use around 900 million metric tonnes of scrap. Almost 20% of that amount, or approximately 180 million mt, results from global scrap trade. Global trade in recyclable materials exists because no community has the infrastructure and technology needed to collect and adequately process recyclable materials into specification-grade commodities.

Based on the findings, this recycling industry can have a bright future with the government's full support. The recycling industry in Malaysia is still not on par with others in developed countries due to the technology's availability here to advanced process the WEEE. Thus, in ensuring the smooth transition towards the circular economy, these challenges must be the government's main priority.

4.4.8.4 Responsible Identity on WEEE Ownership: Manufacturers

From Figure 4.12 demonstrate above, manufacturers gain the least percentage for strongly agree for WEEE ownership. The frequency statistics shown in Table 4.29 above illustrate each Likert scale's frequency in which 21 respondents vote strongly agree, 21 respondents vote for agreeing, 18 respondents vote for neither disagree nor agree, 9 respondent vote disagree and 5 respondent vote for strongly disagree. The author believed the manufacturer also plays a part in ensuring the recycling industry keeps striving forward so that the circular economy could be fully implemented in Malaysia. In perspectives of recyclers, the manufacturer was the least preferred party to handle the WEEE. Based on the findings, the manufacturers' involvement in WEEE handling will disrupt the recycling business.

Table 4. 29 : Frequencies Statistic of WEEE ownership: Manufacturers

Manufacturers					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	5	6.8	6.8	6.8
	Disagree	9	12.2	12.2	18.9
	Neither Disagree nor Agree	18	24.3	24.3	43.2
	Agree	21	28.4	28.4	71.6
	Strongly Agree	21	28.4	28.4	100.0
	Total	74	100.0	100.0	

Nevertheless, NST (2020a) highlighted that the recyclers lacked budget in promoting the recycling culture compared to commercial electronics firms with the budget in promoting new devices. Even so, Agamuthu & Victor (2011) highlighted that Extended Producer Responsibility (EPR) is already being applied in the industry, especially for WEEE. Major multinational corporations such as Motorola, Nokia, Dell, and HP have implemented EPR related initiatives such as Take-Back-Program (TBP) to promote recycling culture. These initiatives were a part of their global corporate environmental policies.

ECOMOTO is Motorola Malaysia TBP program is to initiate the recycling culture for their workers and the public in Malaysia. The ECOMOTO bins were presently located in Penang, which accepts any electrical and electronic appliance. These discarded products would be sorted out and either reused, recycled, or disposed of sustainably. However, Nokia has different ways of attracting the public to participate in its programs. The Nokia launched its Nokia INK somewhere around Klang Valley and promoted environmental preservation by giving away tree with their name to be planted in every WEEE received. Since then, Agamuthu & Victor (2011) stated that Nokia managed to recycled estimated 1400 phones in 2008.

Dell Malaysia has established 15 recycling centres in Penang and 10 recycling centres in Petaling Jaya. Dell Malaysia's initiative was an enticing way every user can obtain a new DELL computer for every old DELL computer they deliver. HP Malaysia offers the take back on end-of-life HP and non-HP computing equipment through its HP Planet Partners Hardware Return and Recyclability Program. Besides the manufacturers, Ch'ng (2020) highlighted that the retailers also ensure the WEEE is managed in sustainable manners.

4.5 Objective 2: To develop Local-Recycling Supply Chain Framework of Managing WEEE in Malaysia

Figure 4.13 show the Local-Recycling Supply Chain Framework that has been developed in this study. The framework will guide handling and managing electric and electronic waste with an environment responsive approach in Malaysia.

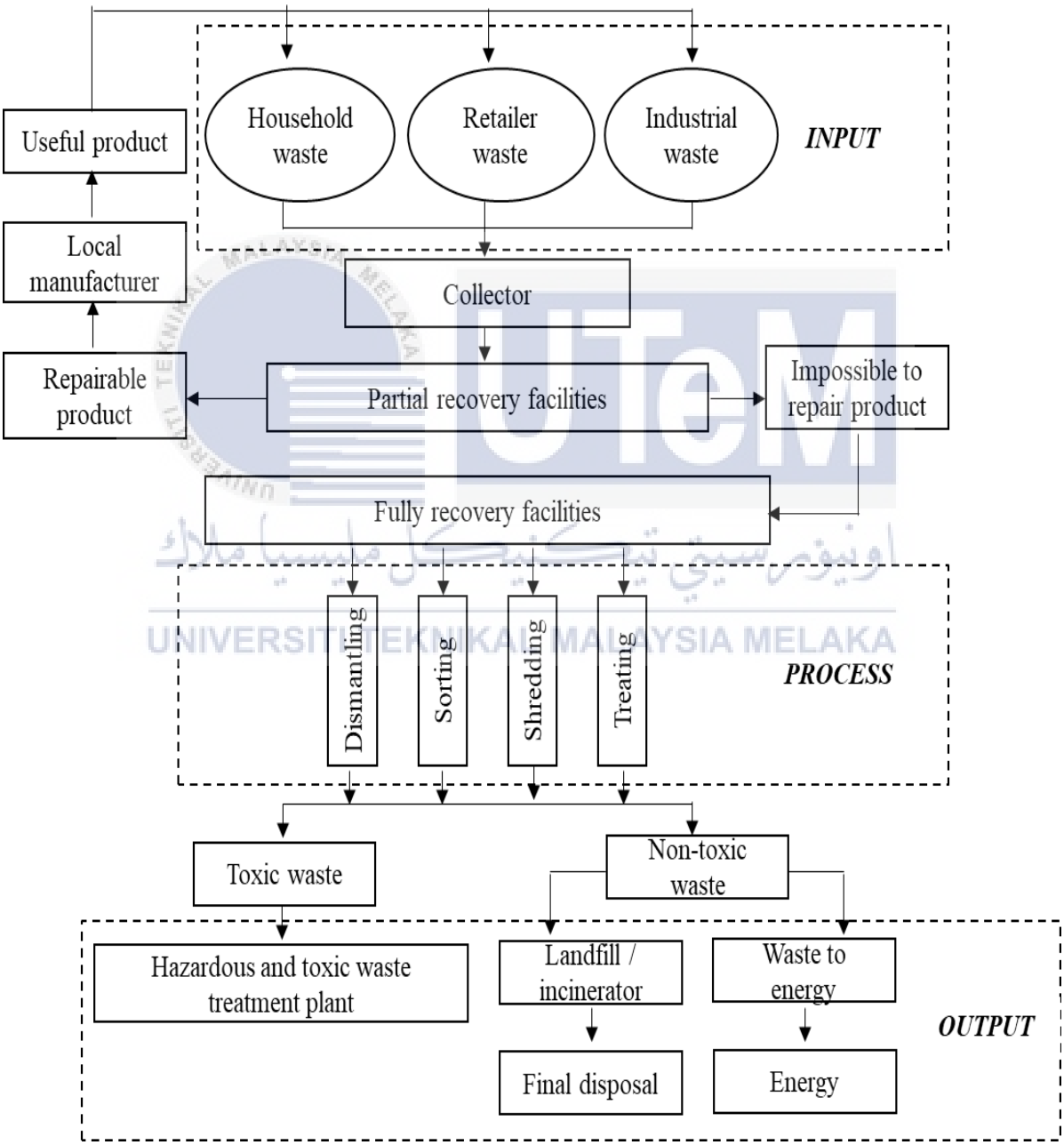

Figure 4. 13 : Local recycling supply chain of WEEE

The WEEE source is identified from different sources such as household, industrial waste and retailer waste. The collectors will collect electric and electronic waste generated from them through lorry entrusted by waste collection companies on a door-to-door basis. In general, collectors are divided into two types which are a formal and informal collector. Legal collectors are collectors entrusted by the government to manage the country's solid waste such as Solid waste management Malaysia, Majlis Bandaran, Alam Flora, etc. In contrast, the informal collector is the business owned by the individual to collect various type of waste and trade them to the market for profitability.

The next destination of the WEEE is delivered to the partial recovery facilities. In these facilities, WEEE undergoes the primary process in which sorting and segregation of electronic waste occur. The primary purpose is to identify the electrical and electronic waste product and component that can be repair and impossible to be repaired by the facilities. Repairable of electric and electronic waste will be resold to local manufacturers to make useful products to the consumer. In contrast, non-repairable WEEE will be sent to the full recovery facilities for the disposal process as a secondary operation. The second operation's first step is to dismantle and sort the waste categories before cut into smaller pieces. A fully automated system ensures employees' safety to handle hazardous materials such as batteries containing lead or mercury. The toxic waste's final destination is sent to the hazardous and toxic waste plant to be treated. At the same time, the other goes to landfill as final disposal or turned into energy.

4.5.1 Framework Review

The framework has been reviewed with the Department Of Environment of Malaysia's officer known as Puan Hasnita Binti Mansor, environmental control officer (C44) to ensure the finding's framework is parallel to the current framework managing WEEE in Malaysia. As indicated by Puan Hasnita, WEEE is listed as scheduled waste under the Environmental Quality Regulations 2005. These Regulations instruct that no person is permitted to dispose of any WEEE in landfills,

and WEEE must be recycled and recovered in prescribed or licenced premises. That disposal must take place only in prescribed premises must be carried out in an environmentally sound manner. Therefore, the constructed framework is intended to demonstrate the current local-recycling supply chain framework in managing WEEE in Malaysia.

4.6 Objective 3: To model, the decision-making measure to boost the end-of-life WEEE from the recycler perspectives for Malaysia

The recycling desirability model was a new approach that evaluates recycling desirability in many items (Mohamed Sultan et al., 2017). Three critical end-of-life product parameters have been measured based on their findings in the United Kingdom (UK); material separation, material criticality and technology readiness. Despite this, the study results were varied as the author obtained three criteria: high recycled demand, profitable, and government policy and licensing. Thus, these 3 criteria are more suitable for developing the recyclers preference index (RPI) than the recycling desirability index (RDI). The RPI is, as shown in figure 4.6 below. All the data provided were obtained during the survey.

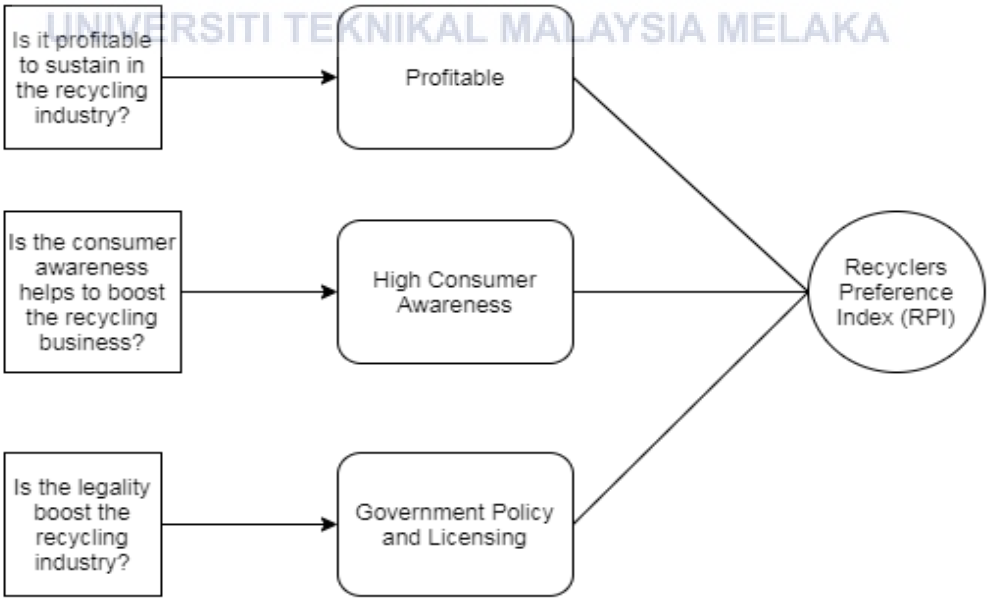

Figure 4. 14 : The Recyclers Preference Index

4.6.1 Parameter 1: Profit in the Recycling Industry

Table 4.3 to 4.34 demonstrate parameter 1 of RPI, which measure the profit for the recyclers in the recycling business. Refrigerators, air-conditioner, television, laptop and mobile phone were the typical product that existed everywhere including in the industrial, school, universities, offices, and even home. These products are mostly accepted in any recycling business; hence it is chosen to measure the recycling industry's profit. Table 4.3 represents the refrigerator's profitability calculation with a weight of 40kg and capacity of 280L. Table 4.31 represents the Air Conditioner (AC)'s profitability calculation with a weight of 28kg. Table 4.32 represents the mobile phone's profitability calculation with a weight of 200g. Table 4.33 represents the laptop's profitability calculation with a weight of 2.5kg. Table 4.34 represents 42-inch television's profitability calculation with a weight of 14kg.

The table is equipped with the recyclers to buy price based solely on the Zain Paper Enterprise and Nadim Metal pricing, the number of materials in the product, its weight composition, and the retrieved materials sell price to other upper traders. As demonstrated in table 4.3, the recyclers' buy price indicates the end-users price in every product received. However, the price of the products is vary depending on the recyclers. The data provided were solely based on the study output. Every material has its type and grade. Hence, the price of the table supplied was the price of mix-grade of materials. The findings show that total revenue for these products after dismantling is higher than the buy cost. The product that is not dismantled obtains less money is due to the higher price, effort, and energy of the dismantling process. Also, sorted waste is more preferred in the upper traders. The net profit margin of the product is calculated based on the formula (8) below. The calculated net profit margin is demonstrated in table 4.30 below.

Table 4. 30 : Parameter 1 (Profit in recycling industry) - Refrigerator

Name of the Product	Recyclers Buy Price per unit	Materials Contained in Refrigerator	Sell price of each material/kg	Weight Composition	Weight of the material in a product	Total Profit
Refrigerator Weight: 40kg Capacity: 280L	Zain Paper Enterprise					
	RM10	Steel	RM2.80	60%	24 kg	RM67
		Printed Circuit Board	RM15 per unit	5%	1 unit	RM15
		Plastic	RM 0.50	13%	5.2 kg	RM2.6
		Aluminium	RM2.50	3%	1.2 kg	RM4.2
		Copper	RM3.50	13%	5.2 kg	RM18.2
		Rubber	-	3%	-	-
		Glass	-	3%	-	-
	Total					RM107
	Nadim Metal					
	RM15	Steel	RM1.80	60%	24 kg	RM43.2
		Printed Circuit Board	RM20 per unit	5%	1 unit	RM20
		Plastic	RM0.70	13%	5.2kg	RM3.64
		Aluminium	RM1.80	3%	1.2kg	RM2.16
		Copper	RM3.50	13%	5.2kg	RM18.2
		Rubber	-	3%	-	-
		Glass	-	3%	-	-
Total						RM87.2

Table 4. 31 : Parameter 1 (Profit in recycling industry) – Air Conditioner

Name of the Product	Recyclers Buy Price per unit	Materials Contained in Refrigerator	Sell price of each material/kg	Weight Composition	Weight of the material in a product	Total Profit
Air Conditioner (Outdoor) – 28kg	Zain Paper Enterprise					
	RM30	Steel	RM2.80	46%	12.88kg	RM36
		Copper	RM3.50	17%	4.76kg	RM16.6
		Aluminium	RM2.50	13%	3.64kg	RM9.10
		Plastic	RM 0.50	15%	4.2kg	RM2.10
		Printed Circuit Board	RM8 per unit	3%	1 unit	RM8
		Others	-	6%	1.68kg	-
	Total					RM71.8
	Nadim Metal					
	RM25	Steel	RM1.80	46%	12.88kg	RM23
		Copper	RM3.50	17%	4.76kg	RM16.6
		Aluminium	RM1.80	13%	3.64kg	RM6.5
		Plastic	RM0.70	15%	4.2kg	RM2.9
		Printed Circuit Board	RM9 per unit	3%	1 unit	RM9
		Others	-	6%	0.84kg	-
Total						RM58

Table 4. 32 : Parameter 1 (Profit in recycling industry) – Mobile Phone

Name of the Product	Recyclers Buy Price per unit	Materials Contained in Refrigerator	Sell price of each material/kg	Weight Composition	Weight of the material in a product	Total Profit
Mobile Phone (200g)	Zain Paper Enterprise					
	RM1.00	Steel	RM2.80	5%	0.01kg	RM0.03
		Copper	RM3.50	13%	0.03kg	RM0.11
		Aluminium	RM2.50	1%	0.002kg	RM0.01
		Plastic	RM0.50	57%	0.11kg	RM0.06
		Glass Fibre	-	2%	0.004kg	-
		Others	-	22%	0.044kg	-
		PCB	RM2	Unit	1Unit	RM2
	Total					RM2.21
	Nadim Metal					
	RM1.50	Steel	RM1.80	5%	0.01kg	RM0.02
		Copper	RM3.50	13%	0.03kg	RM0.12
		Aluminium	RM1.80	1%	0.002kg	RM0.03
		Plastic	RM0.70	57%	0.11kg	RM0.08
		Glass Fibre	-	2%	0.004kg	-
		Others		22%	0.044kg	-
		PCB	RM2.50	Unit	1Unit	RM2.50
Total						RM2.75

Table 4. 33 : Parameter 1 (Profit in recycling industry) – Laptop

Name of the Product	Recyclers Buy Price per unit	Materials Contained in Refrigerator	Sell price of each material/kg	Weight Composition	Weight of the material in a product	Total Profit
Zain Paper Enterprise						
Laptop (2.5kg)	RM5.00	Steel	RM2.80	7%	0.18kg	RM0.50
		Copper	RM3.50	20%	0.50kg	RM1.75
		Aluminium	RM2.50	5%	0.13kg	RM0.33
		Glass	-	23%	0.58kg	-
		Plastic	RM0.50	18%	0.09kg	RM0.05
		Others	-	27%	0.68kg	-
		PCB	3.50	Unit	1Unit	RM3.50
	Total					RM6.13
	Nadim Metal					
	RM4.50	Steel	RM1.80	7%	0.18kg	RM0.32
		Copper	RM3.50	20%	0.50kg	RM1.75
		Aluminium	RM1.80	5%	0.13kg	RM0.23
		Glass	-	23%	0.58kg	-
		Plastic	RM0.70	18%	0.09kg	RM0.06
		Others	-	27%	0.68kg	-
		PCB	RM3.50	Unit	1Unit	RM3.50
	Total					RM5.86

Table 4. 34 : Parameter 1 (Profit in recycling industry) – 42inch -Television

Name of the Product	Recyclers Buy Price per unit	Materials Contained in Refrigerator	Sell price of each material/kg	Weight Composition	Weight of the material in a product	Total Profit
42-inch Television (14kg)	Zain Paper Enterprise					
	RM6.00	Steel	RM2.80	26%	0.26kg	RM0.73
		Copper	RM3.50	9%	1.26kg	RM4.41
		Aluminium	RM2.50	9%	1.26kg	RM3.15
		Plastic	RM0.50	25%	3.50kg	RM1.75
		Glass	-	20%	2.80kg	-
		Others	-	11%	1.54kg	-
		PCB	RM4	Unit	1Unit	RM4
	Total					RM14
	Nadim Metal					
	RM5.00	Steel	RM1.80	26%	0.26kg	RM0.50
		Copper	RM3.50	9%	1.26kg	RM4.41
		Aluminium	RM1.80	9%	1.26kg	RM2.30
		Plastic	RM0.70	25%	3.50kg	RM2.45
		Glass	-	20%	2.80kg	-
		Others	-	11%	1.54kg	-
		PCB	RM3.50	Unit	1Unit	RM3.50
	Total					RM13.16

Net Profit Margin formula:

$$Net\ profit\ margin = \frac{(Revenue - Cost)}{Revenue}\ x\ 100\% \qquad \text{Equation 4.6.1.4}$$

The calculated net profit margin of each product in each premise is demonstrated in the Table above. Zain Paper Enterprise received 90.65% of profit in every dismantled refrigerator sold while Nadim Metal received 82.8%. Rubber and glass are less preferred due to many factors; low market demand, lack of tools and machinery, in need of specific licensed to dismantled or processed, etc. The average net profit margin of a refrigerator from both companies is 86.73%. In the air conditioner case, Zain Paper Enterprise received 58.2% of profit in every dismantled air conditioner sold while Nadim Metal received 56.9%. The average net profit margin of an air conditioner from both companies is 57.55%.

Zain Paper Enterprise received 54.8% of profit in every dismantled mobile phone sold in a mobile phone while Nadim Metal received 45.45%. The average net profit margin of mobile phone from both companies is 50.13%. In a laptop, Zain Paper Enterprise received 18.43% of profit in every dismantled laptop sold while Nadim Metal received 23.21%. The average net profit margin of a laptop from both companies is 20.82%. In the case of television, Zain Paper Enterprise received 57.14% of profit in every dismantled television sold while Nadim Metal received 62%. The average net profit margin of television from both companies is 59.57%. In conclusion, end-of-life refrigerator is the most profitable for the recyclers where it obtained the first rank, followed by the television, air conditioner, mobile phone and laptop.

Table 4. 35 : Net Profit Margin of the Product

Product	Zain Paper Enterprise		Nadim Metal		Average Net Profit Margin	Rank
Refrigerator	Net Profit Margin	90.65%	Net Profit Margin	82.8%	86.73%	1
Air Conditioner	Net Profit Margin	58.2%	Net Profit Margin	56.9%	57.55%	3
Mobile Phone	Net Profit Margin	54.8%	Net Profit Margin	45.45%	50.13%	4
Laptop	Net Profit Margin	18.43%	Net Profit Margin	23.21%	20.82%	5
Television	Net Profit Margin	57.14%	Net Profit Margin	62%	59.57%	2

4.6.2 Parameter 2: High Consumer Awareness

Table 4.6.2 demonstrate parameter 2 of recyclers preferred index, which measures the level of community awareness in the state. The output from this parameter is the number of waste collected per household. Zain Paper Enterprise located near Ampang, Selangor with a population of 800 000 while Nadim Metal Enterprise is located at Pontian, Johor with a population of 155 541. The data from Zain Paper Enterprise demonstrate that in 2019 alone, the recyclers managed to obtain 600 unit of end-of-life refrigerator and 1000 unit of end-of-life air-conditioner. This two-product contributed 1600 units to the overall WEEE collected in Zain Paper Enterprise. Nadim Metal's data demonstrate that in 2019, the recyclers managed to collect 400 unit of end-of-life refrigerator and 590 unit of end-of-life air-conditioner. This two-product contributed to 990 units to the overall WEEE collected in Nadim Metal. The consumer awareness percentage is calculated as in the formula (4.6.2).

$$Consumer\ awareness = \frac{Total\ of\ WEEE\ collected}{No.of\ population}\ x\ 100\% \qquad \text{Equation 4.6.2}$$

Zain Paper Enterprise is located near Ampang, Selangor. Therefore, the total number of WEEE collected in the premise is 8600 unit. The Zain Paper enterprise obtained 0.0110 of WEEE collected per household in Ampang Selangor. Nadim Metal is located at Pontian, Johor. The total WEEE collected in the premise is 3490 units. Nadim Metal obtained 0.0224 of waste collected per household in Pontian, Johor as demonstrated in Table 4.6.2.

Table 4. 36 : Parameter 2 (High Consumer Awareness)

Product	Numbers of material collected (2019) at Zain Paper Enterprise	Population In Ampang, Selangor	Awareness Percentage (Tons of waste collected per household)	Numbers of material collected (2019) at	Population in Pontian, Johor	Awareness Percentage (Tons of waste collected per household)
Refrigerator	600 Unit	800 000	0.0110	400 Unit	155 541	0.0224
Air conditioner	1000 Unit			590 Unit		
Mobile Phone	5000 Unit			1000 Unit		
Laptop	1000 Unit			600 Unit		
Television	1000 Unit			900 Unit		
Total	8600 unit			3490unit		

4.6.3 Parameter 3: Government Policy and Licensing

Table 4.37 demonstrate parameter 3 of recyclers preferred index, which measures the country's level of regulation. The federal legislation passed by the Federal Assembly or better known as the Parliament of Malaysia applies throughout the nation. Malaysia is a constitutional monarchy of the federal state. It has a parliamentary form of government led by a prime minister appointed by annual, multi-party elections. Thus, the government policy and licensing ranking is constant for score 2 and applies to all waste types.

Table 4. 37 : Parameter 3 (Government Policy and Licensing)

Score	Explanation
Score 1	The regulation is according to the state level
Score 2	The regulation is according to the federal level
Score 3	The regulation is according to the international level

To seek the further declaration, the finding for current recycler challenges mainly on the government policy and licensing are reviewed with the authorities representatives from Department of Environment, police and Majlis BandaranTo start up the recycling business, the recyclers need to seek approval from these authorities. The recyclers are bound under Undang-Undang Pelesenan Tred, Perniagaan dan Perindustrian 1986 where no person shall carry on any trading, business and industrial activities or use any place premises within the council area without a license issued by the authority. The recyclers shall pay process fees to the Majlis Bandaran, and these fees are not refundable regardless of the status of an application. The license shall be renewed every 31st December and fail to do so; Majlis Bandaran has the right to enforce the recyclers to stop the business immediately unless they have documentation on license renew (in progress). To apply for the license from Majlis Bandaran, the recyclers need to seek approval from a local authority such as police, BOMBA, JKR, Kesihatan, etc.

From the police perspectives, the recyclers need to apply for the license under Act 189 – Secondhand dealers Act 1946. In this act, the recyclers shall only trade secondhand goods except in accordance with the terms of the license issued under this act in the interests in the first schedule, and at the place specified in the license. Each licensee shall bring his license with him and submit the license for inspection at any time upon request by any police officer. The act has also highlighted that the recycling premise shall only accept or trade any waste within 7 in the morning until 7 in the evening, or else, they will be penalties. There are three categories of licenses that traders need to apply for based on the type of business, License A, License B and License C. License A can only be applied for by traders who have premises, License B can be applied for by mobile hawkers and can only buy permitted items while License C is in addition to the License A where it will be allowed to buy and sell tin and copper.

From the Department of Environment perspective, only recyclers who processed or collected scheduled waste shall apply. As the WEEE is categorized as a scheduled waste, the recyclers shall apply for the Department of Environment license although they are only collecting. Firstly, the recyclers need to get approval from the local authorities. When the

recyclers are getting support from a local authority, only then the recyclers could apply. The license from the Department of Environment is divided into two; premises license and a transport license. The recyclers need to apply both of the licenses for them to collect and process the WEEE.

Nevertheless, before getting the Department of Environment's license, the recyclers need to apply for written permission under section 19 (KB 19). The KB 19 is an approval for the recyclers to set up off-site recovery facilities. Many government agencies' involvement and stricter regulation in getting a license are among the causes of the rising numbers of illegal recyclers due to many procedures and fees. Despite so, this has seen as a good initiative from the government to ensure the WEEE is managed sustainably.

The DOE has partnered with 15 companies or retailers that act as collection centres for household e-waste. Some of these collection centres are familiar, such as Senheng and SenQ, generally found in residential areas. These collection centres focus on six categories: refrigerators, washing machines, television, air-conditioners, computer laptops, and mobile phones. DOE will monitor these collected WEEE flows until the transportation to licensed recycling centre through an online tracking system called Scheduled Waste Information System (Eswis). The system is capable of tracks the number of items collected and recycled at the respective premises. This way, the department could keep track of the e-waste and ensure that these recycling centres operated to observe rules and regulations.

4.6.4 Recyclers Preference Model: The Products Distribution

Figure 4.6. demonstrate the output graph of the index. The graph illustrates the percentage of WEEE profitability against the level of regulation. As calculated on table 4.6.2, the WEEE profitability is placed in the graph according to the rank. The WEEE are placed in between 2.0 and 3.0 because the Malaysia regulation is on the federal level in which all the enacted or proposed regulation must undergo the parliament, only then it will be either approved or disapproved.

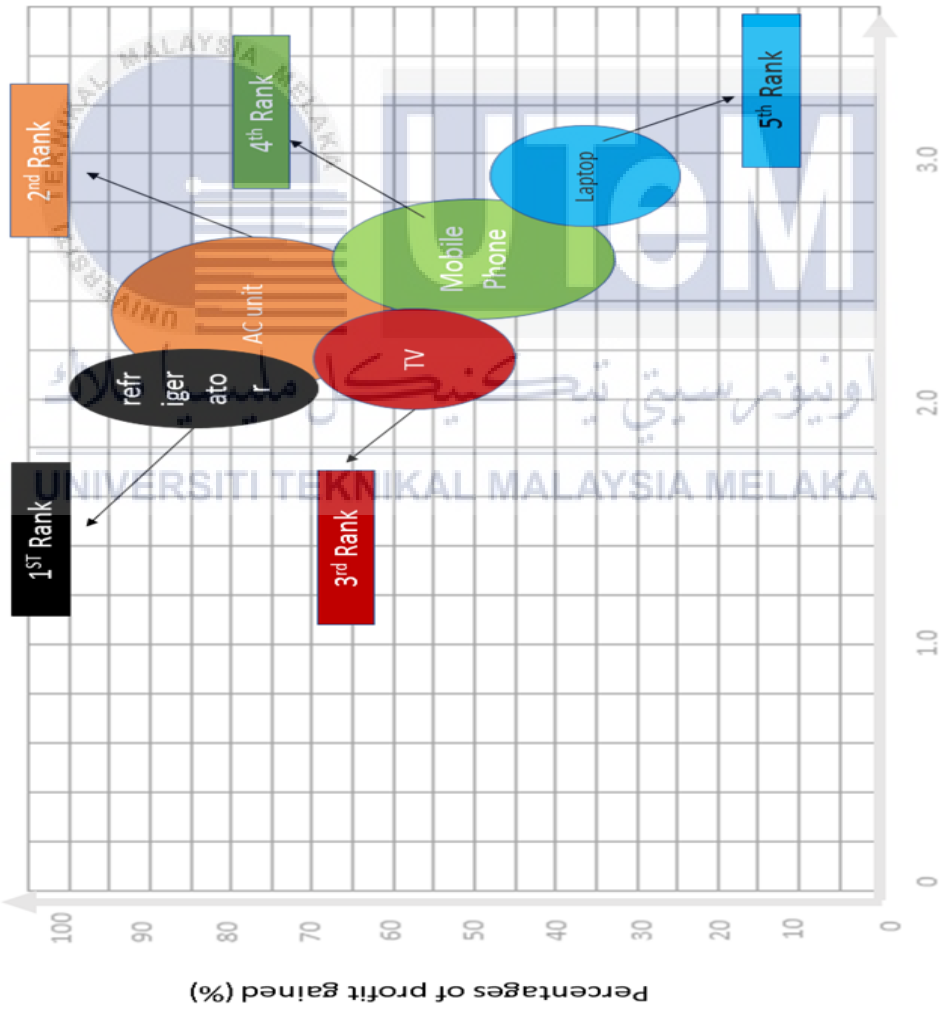

Figure 4. 15 : Output graph of the index

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter is discussed about the conclusion from the research findings and analysis. The finding and analysis come from the quantitative study that is a survey questionnaire. Future research is discussed in this chapter for future improvement.

5.1 Conclusion

As the world's population continues to grow, electrical and electronic equipment production has been maximized to meet current demand. These demands also increase the amount of WEEE. Of the total WEEE generated in 2020, only 25% of WEEE is discarded sustainably, while the rest is burned or mixed with residual waste for disposal in landfills. Because WEEE contains many valuable materials that can be processed into other product resources, many WEEE that is ultimately wasted in landfills is wasted. This situation led to discussions with experts on resource sustainability issues because we did not fully implement circular economy practices in Malaysia to ensure continuous product life cycles.

Making the best choice to tackle end-of-life waste was one of the most difficult challenges. The possibility of a hazardous and toxic material being contaminated inside the products has become a threat to life, particularly in the event of improper waste management. In Malaysia, electronic waste is known as e-waste and has been listed as one of the scheduled wastes under code SW 110 in the Environmental Quality Regulations 2005. Electronic waste is categorized as a scheduled waste because it has characteristics such as flammability, corrosion, reaction, and even toxic material. Therefore, the disposal of electric and electronic waste must follow the government's procedure by sending the waste to the premises licensed by the government to dispose of electronic waste properly and safely. Electronic waste has been included in the international context as codes A1180 and A2010 following the Basel Agreement. It seeks to mobilize the international community to safeguard the environment and human health from the effects of dangerous waste and reduce production and control hazardous waste movement across continents.

Malaysia is one of 116 countries which in 1989 signed the Basel Agreement. The responsible identities in Malaysia must adequately handle the WEEE. However, the consumer and collector side's lack of responsibilities has encouraged the informal sector's growth. The primitive method used by the informal sector releases volumes of toxic fumes, hazardous acids and organic pollutants. These informal recycling practices WEEE have not only polluted the environment but to us as well. The informal sector and weak law enforcement have become a drawback for Malaysia to develop a circular economy fully.

The research work in this study was designed to identify the current critical factor from the recyclers' point of view, identify the responsible identities for WEEE management, and build an index on current recyclers' preferences specifically for WEEE issues. A systematic analysis was carried out in this report to provide a reliable and scientifically supported preference model that could be incorporated into the improvement of the recycling industry's current practice. The WEEE recycling industry is one of the most important sources of secondary raw materials. The electronics industry is the most prominent and rapidly rising sector in the world. The phenomenon of rapid product obsolescence and discarded electronics has become the fastest rising waste stream. Despite so, the WEEE recycling industry opportunities are big where this industry is projected to reach 65.5 million tonnes by 2025 globally. Factors associated with the recycling industry's growth include the growing numbers of industrial waste, increment disposes of fees, stricter government policies, and declining lifespan of electrical and electronic equipment. Besides, it could obtain profits and reduce transportation cost; the WEEE materials could be recovered through direct recycling. These extracted and recovered materials could be remanufactured or reused to avoid high transportation costs of end-of-life WEEE disposal, preserve scarce material for future generations and boost Malaysia’s economy.

In this study, the current critical factor faced by the recyclers in the recycling industry was measured by 3 factors, including the consideration factors, drivers and challenges. The output from the result was profitable, high consumer awareness and government policy and licensing. The objective 1 output was then analyzed using a theoretical approach, and IBM SPSS software to measure the data's reliability. Objective 1 in this study are well correlated with objective 3 where the output from objective 1 is then translated into objective 3 parameters. These parameters are calculated using the formula for the net profit margin, level of awareness and Malaysia level of regulation to validate the output. The develop Recyclers Preference Index (RPI) in a model form is prepared for future work analysis and government guidelines to improve Malaysia's recycling industry.

5.2 Recommendation

This study aims to identify the challenges and drivers faced by the recycling sector in Malaysia. The study results show that Malaysia needs to take specific steps and strategies to ensure that electronic waste is managed and disposed of safely and adequately. Among the steps and strategies that may be taken by Malaysia are:

- Slightly loosen and expedite issuing licenses in managing and disposing of electronic waste in Malaysia to the informal sector of recycling facilities to enhance our recycling rate. Through this method, the government can produce more recycling centre than waste collection centre in Malaysia.
- Further encourage the recycling sector by providing adequate funding, methods, and education to purchase appropriate equipment and machinery to manage toxic electronic waste in their premises. With the government's help, more stakeholders will be interested in venturing into Malaysia's recycling industry.
- Extended producer responsibility (EPR) makes electric and electronic manufacturers cover the collection, recycling and disposal costs. Responsibility will include the use of eco-friendly designs, the selection of non-hazardous material and components, recyclable materials and the provision of information to assist with recycling.
- The government should introduce formal and informal recycling industries with advanced recycling facilities in developing countries to manage and dispose of electric and electronic waste. This system will obtain more information and ways to improve waste management and disposal on their premises.
- The government should continue to promote an e-waste recycling campaign for Malaysians to increase their awareness of e-waste handling at home. This campaign aims to educate people on how to dispose or manage electronic waste by sending or trading it to licenced electronic waste management and disposal facilities to ensure no leakage of hazardous materials to the environment at the end of the life of electronic waste. In this current situation, the government shall raise the WEEE recycling price to attract the public interest.

5.3 Sustainable Design and Development

The study is concerned with sustainable growth, where, within a certain timeframe, these services that we are granting today will be the one that we are looking forward to in the future if we are not using them carefully. Through the findings, the author has learned the value of recycling where the wastes are a threat to the environment and human as well. The piles of waste in the landfill can be one source of revenue for Malaysian, as this waste can be recycled into new product resources. The continuous supply chain is needed to ensure Malaysia's recycling industry can be on par with other developed countries. From the engineering profession's perspective, a potential product shall be designed for recycling designed for disassembly. It explicitly discusses the collection of materials and sets their recycling rate. Engineers must ensure that the design product is intended for recovery, conservation of value and meaningful subsequent usage. Only then will Malaysia be ready for a fully integrated circular economy and work towards a sustainable country.

5.4 Complexity of the research

The study requires the knowledge from the literature review as an early picture to achieve the specific objective in this study. There is level of interaction involve in this study were the author need to be creative to tackle the respondent's interest. This is due to most of the recyclers is family-business and have no proper management such no Human Resources (HR) department like other sectors. Therefore, to obtain the feedback from the recyclers are challenging due to its highly depends on the recyclers behavior. Even so, the findings from the study are crucial to carry a guideline that comes with suggestions covering various aspects for future plans. Any recommendations from the company will be channelled to the government for a better system, and improvisations.

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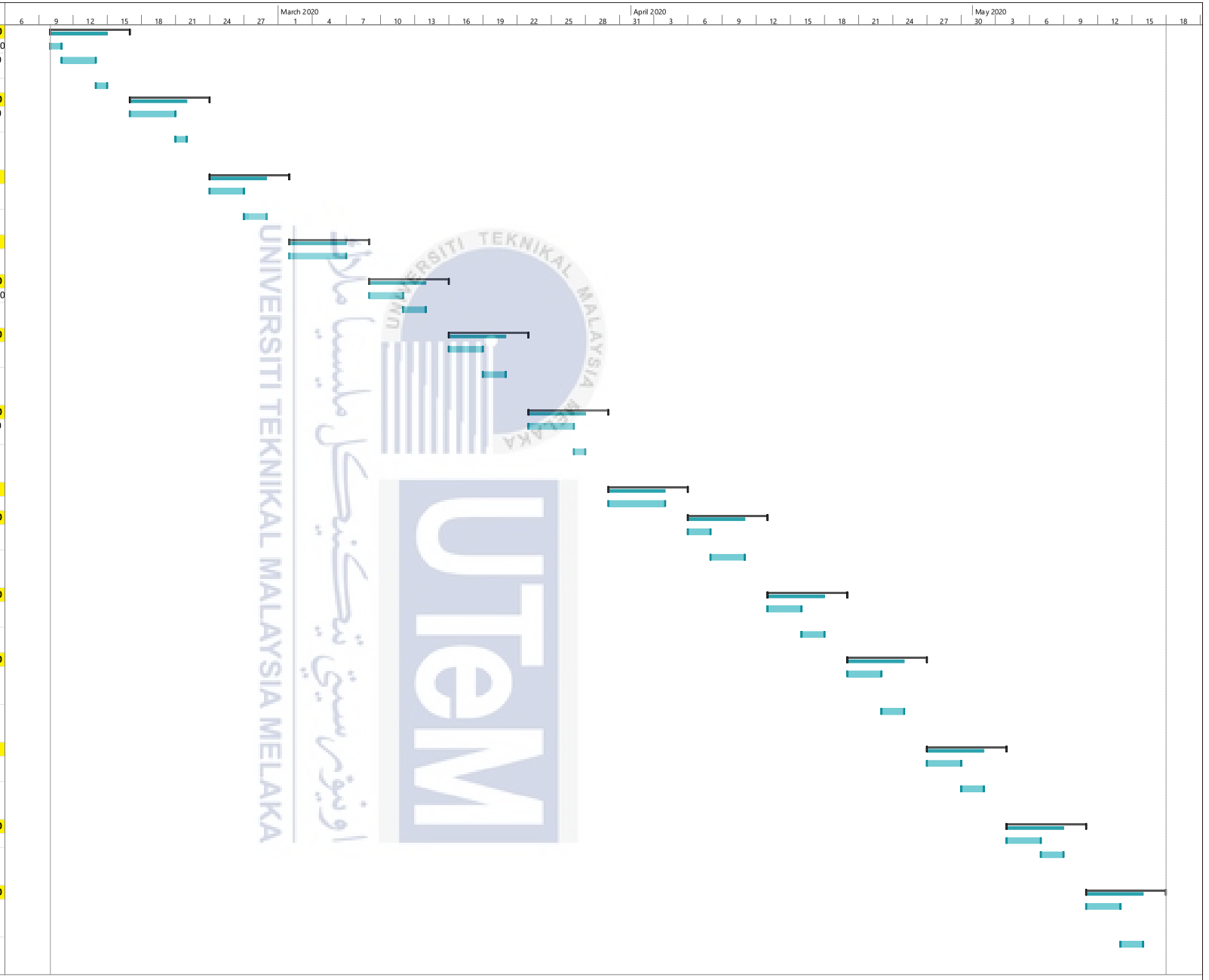
APPENDIX

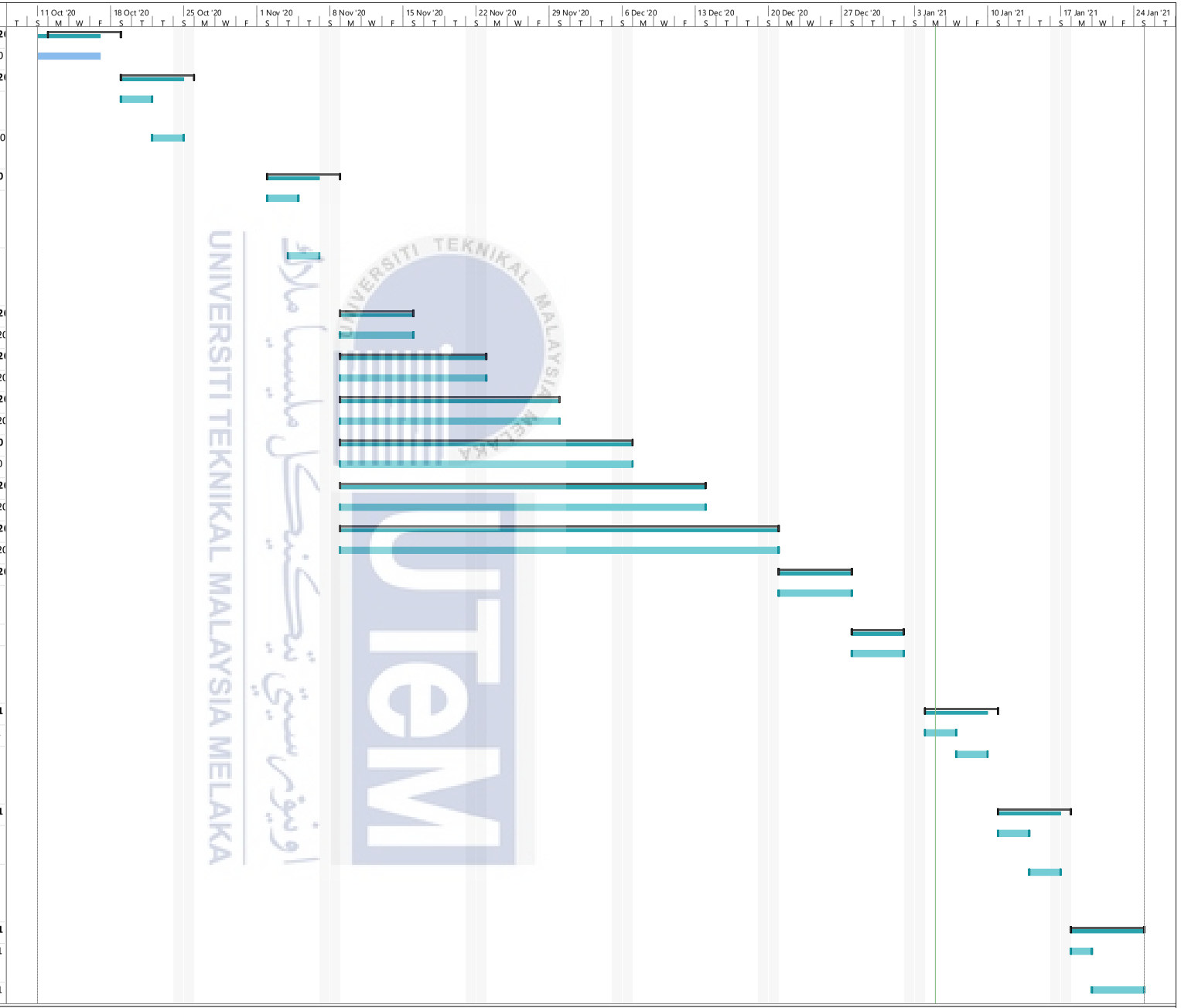
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Week 1**	**6 days**	**Mon 10/2/20**	**Sun 16/2/20**
2		PSM briefing	1 day	Mon 10/2/20	Mon 10/2/20
3		Selection of supervisor	3 days	Tue 11/2/20	Thu 13/2/20
4		Selection of title	1 day	Fri 14/2/20	Fri 14/2/20
5		**Week 2**	**6 days?**	**Mon 17/2/20**	**Sun 23/2/20**
6		Research journal related to recycling	4 days	Mon 17/2/20	Thu 20/2/20
7		Selection of recycling material/product	1 day	Fri 21/2/20	Fri 21/2/20
8		**Week 3**	**6 days**	**Mon 24/2/20**	**Sun 1/3/20**
9		Determining objective	3 days	Mon 24/2/20	Wed 26/2/20
10		Determining problem statement	2 days	Thu 27/2/20	Fri 28/2/20
11		**Week 4**	**6 days**	**Mon 2/3/20**	**Sun 8/3/20**
12		Completing chapter 1	5 days	Mon 2/3/20	Fri 6/3/20
13		**Week 5**	**6 days**	**Mon 9/3/20**	**Sun 15/3/20**
14		Repairing chapter 1	3 days	Mon 9/3/20	Wed 11/3/20
15		Constructing literature review	2 days	Thu 12/3/20	Fri 13/3/20
16		**Week 6**	**6 days**	**Mon 16/3/20**	**Sun 22/3/20**
17		Completing chapter 2	3 days	Mon 16/3/20	Wed 18/3/20
18		Supervisor checking and repairing chapter 1 and 2	2 days	Thu 19/3/20	Fri 20/3/20
19		**Week 7**	**6 days**	**Mon 23/3/20**	**Sun 29/3/20**
20		Researching on the methodology	4 days	Mon 23/3/20	Thu 26/3/20
21		Presenting the methodology to Supervisor	1 day	Fri 27/3/20	Fri 27/3/20
22		**Week 8**	**6 days**	**Mon 30/3/20**	**Sun 5/4/20**
23		Midsem break	5 days	Mon 30/3/20	Fri 3/4/20
24		**Week 9**	**6 days**	**Mon 6/4/20**	**Sun 12/4/20**
25		Drafting survey questionaire	2 days	Mon 6/4/20	Tue 7/4/20
26		Supervisor review on the survey questionaire	3 days	Wed 8/4/20	Fri 10/4/20
27		**Week 10**	**6 days**	**Mon 13/4/20**	**Sun 19/4/20**
28		Improving survey questionaire	3 days	Mon 13/4/20	Wed 15/4/20
29		Completing survey questionaire	2 days	Thu 16/4/20	Fri 17/4/20
30		**Week 11**	**6 days**	**Mon 20/4/20**	**Sun 26/4/20**
31		Sending survey questionaire to the expert to be review	3 days	Mon 20/4/20	Wed 22/4/20
32		Improving the questionaire survey based on comment	2 days	Thu 23/4/20	Fri 24/4/20
33		**Week 12**	**6 days**	**Mon 27/4/20**	**Sun 3/5/20**
34		Preparing for PSM 1 presentation	3 days	Mon 27/4/20	Wed 29/4/20
35		Developing slide presentation and video	2 days	Thu 30/4/20	Fri 1/5/20
36		**Week 13**	**6 days**	**Mon 4/5/20**	**Sun 10/5/20**
37		PSM 1 Presentation	3 days	Mon 4/5/20	Wed 6/5/20
38		Subbmission of report from chapter 1 to 3	2 days	Thu 7/5/20	Fri 8/5/20
39		**Week 14**	**6 days**	**Mon 11/5/20**	**Sun 17/5/20**
40		Waiting the feedback of report from supervisor	3 days	Mon 11/5/20	Wed 13/5/20
41		Repairing and completing the report	2 days	Thu 14/5/20	Fri 15/5/20



Project: Simple Project Plan
Date: Tue 5/1/21

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Week 1**	**6 days**	**Mon 12/10/2**	**Sun 18/10/2**
2		PSM 2 briefing	6 days	Sun 11/10/2	Fri 16/10/20
3		**Week 2**	**6 days?**	**Mon 19/10/2**	**Sun 25/10/2**
4		Identifying target population	3 days	Mon 19/10/20	Wed 21/10/20
5		Calculating sample size of respondent	3 days	Thu 22/10/20	Sat 24/10/20
6		**Week 3**	**6 days**	**Mon 2/11/2**	**Sun 8/11/20**
7		Rechecking and presenting sample size to surpervisor	3 days	Mon 2/11/20	Wed 4/11/20
8		Waiting for supervisor comment	3 days	Wed 4/11/20	Fri 6/11/20
9		**Week 4**	**6 days**	**Mon 9/11/2**	**Sun 15/11/2**
10		Collecting data	6 days	Mon 9/11/20	Sun 15/11/2
11		**Week 5**	**11 days**	**Mon 9/11/2**	**Sun 22/11/2**
12		Collecting data	11 days	Mon 9/11/20	Sun 22/11/2
13		**Week 6**	**16 days**	**Mon 9/11/2**	**Sun 29/11/2**
14		Collecting data	16 days	Mon 9/11/20	Sun 29/11/2
15		**Week 7**	**21 days**	**Mon 9/11/2**	**Sun 6/12/20**
16		Collecting data	21 days	Mon 9/11/20	Sun 6/12/20
17		**Week 8**	**26 days**	**Mon 9/11/2**	**Sun 13/12/2**
18		Collecting data	26 days	Mon 9/11/20	Sun 13/12/2
19		**Week 9**	**31 days**	**Mon 9/11/2**	**Sun 20/12/2**
20		Collecting data	31 days	Mon 9/11/20	Sun 20/12/2
21		**Week 10**	**6 days**	**Mon 21/12/2**	**Sun 27/12/2**
22		Extracting data collection	6 days	Mon 21/12/20	Sun 27/12/20
23		**Week 11**	**5 days**	**Mon 28/12/2**	**Fri 1/1/21**
24		Reviewing framework with DOE officer	5 days	Mon 28/12/20	Fri 1/1/21
25		**Week 12**	**6 days?**	**Mon 4/1/21**	**Sun 10/1/21**
26		Writing the report	3 days	Mon 4/1/21	Wed 6/1/21
27		Discussing the finding with supervisor	3 days	Thu 7/1/21	Sat 9/1/21
28		**Week 13**	**6 days**	**Mon 11/1/21**	**Sun 17/1/21**
29		Preparing slide for presentation	3 days	Mon 11/1/21	Wed 13/1/21
30		Checking the slide presentation with supervisor	3 days	Thu 14/1/21	Sat 16/1/21
31		**Week 14**	**6 days**	**Mon 18/1/21**	**Sun 24/1/21**
32		Report presentation	2 days	Mon 18/1/21	Tue 19/1/21
33		Report submission	4 days	Wed 20/1/21	Sun 24/1/21



Project: Simple Project Plan
Date: Tue 5/1/21

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

SURVEY EXPERT REVIEW FORM

This is a form for the expert to review the developed questionnaire survey. The review on overall questionnaire including the suitability of the questions, structure and language.

Title of the research: The Determination Of The Recyclers Preference Index (RPI) For Recycling The End-Of-Life Waste Electrical And Electronic Equipments In Malaysia

	Items and Agreement Statements'	Level of agreement on the quality of the developed items in the questionnaire (1 is the lowest score – 5 is the highest score) Please circle one				
1	The questions are few, short, clearly worded, simple and easy to reply.	**1**	**2**	**3**	**4**	**5**
2	The questions are within the information scope of the respondents.	**1**	**2**	**3**	**4**	**5**
3	The questions have direct relation to subject of the investigation.	**1**	**2**	**3**	**4**	**5**
4	The opening questions are not be such as to abuse human interest.	**1**	**2**	**3**	**4**	**5**
5	Units and technical terms are correctly used in question as far as possible.	**1**	**2**	**3**	**4**	**5**
6	The questions are be inter-related with each other.	**1**	**2**	**3**	**4**	**5**
7	The questions are proceed in logical sequence moving from basic to more intense questions.	**1**	**2**	**3**	**4**	**5**
8	Personal and intimate questions are not included unnecessary	**1**	**2**	**3**	**4**	**5**
9	Emotional questions are avoided.	**1**	**2**	**3**	**4**	**5**
10	The questions are framed that there is a minimum of writing works. Questions may be dichotomous or multiple choice. Open-ended questions are limited to important questions.	**1**	**2**	**3**	**4**	**5**
11	The questions are free from ambiguity. Vague expressions capable of different interpretations are avoided in a questionnaire.	**1**	**2**	**3**	**4**	**5**
12	Answer to a question are be objective and have a capacity of easily classified, tabulated and analyzed.	**1**	**2**	**3**	**4**	**5**

SURVEY EXPERT REVIEW FORM

13	There are be some control questions in the questionnaire which indicate the reliability of the respondent.	**1**	**2**	**3**	**4**	**5**
14	Adequate space for answers are be provided in the questionnaire.	**1**	**2**	**3**	**4**	**5**
15	There are always be provision for indications of uncertainty, e.g. "low score indication"	**1**	**2**	**3**	**4**	**5**
16	Questions are be so worded that ego of the respondents is not injured in any way.	**1**	**2**	**3**	**4**	**5**
17	If there is more than one page of questionnaires, each page of questionnaires are be numbered serially.	**1**	**2**	**3**	**4**	**5**
18	A place in the questionnaire are be provided for the signature of the respondent.	**1**	**2**	**3**	**4**	**5**
19	Brief directions with regard to filling up the questionnaire are be given.	**1**	**2**	**3**	**4**	**5**
20	The physical appearance of the questionnaire are be good. The quality of the paper, along with its colour must be good.	**1**	**2**	**3**	**4**	**5**

REVIEWER OVERALL COMMENTS	

REVIEWER NAME, POSITION SIGNATURE AND STAMP	Mohd Shamsuri Md Saad Coordinator Centre for Technopreneurship Development
DATE	25/11/2020

SURVEY EXPERT REVIEW FORM

This is a form for the expert to review the developed questionnaire survey. The review on overall questionnaire including the suitability of the questions, structure and language.

Title of the research: The Determination Of The Recyclers Preference Index (RPI) For Recycling The End-Of-Life Waste Electrical And Electronic Equipments In Malaysia

	Items and Agreement Statements'	Level of agreement on the quality of the developed items in the questionnaire (1 is the lowest score – 5 is the highest score) Please circle one				
1	The questions are few, short, clearly worded, simple and easy to reply.	**1**	**2**	**3**	**4**	**5**
2	The questions are within the information scope of the respondents.	**1**	**2**	**3**	**4**	**5**
3	The questions have direct relation to subject of the investigation.	**1**	**2**	**3**	**4**	**5**
4	The opening questions are not be such as to abuse human interest.	**1**	**2**	**3**	**4**	**5**
5	Units and technical terms are correctly used in question as far as possible.	**1**	**2**	**3**	**4**	**5**
6	The questions are be inter-related with each other.	**1**	**2**	**3**	**4**	**5**
7	The questions are proceed in logical sequence moving from basic to more intense questions.	**1**	**2**	**3**	**4**	**5**
8	Personal and intimate questions are not included unnecessary	**1**	**2**	**3**	**4**	**5**
9	Emotional questions are avoided.	**1**	**2**	**3**	**4**	**5**
10	The questions are framed that there is a minimum of writing works. Questions may be dichotomous or multiple choice. Open-ended questions are limited to important questions.	**1**	**2**	**3**	**4**	**5**
11	The questions are free from ambiguity. Vague expressions capable of different interpretations are avoided in a questionnaire.	**1**	**2**	**3**	**4**	**5**
12	Answer to a question are be objective and have a capacity of easily classified, tabulated and analyzed.	**1**	**2**	**3**	**4**	**5**

SURVEY EXPERT REVIEW FORM

13	There are be some control questions in the questionnaire which indicate the reliability of the respondent.	**1**	**2**	**3**	**4**	**5**
14	Adequate space for answers are be provided in the questionnaire.	**1**	**2**	**3**	**4**	**5**
15	There are always be provision for indications of uncertainty, e.g. "low score indication"	**1**	**2**	**3**	**4**	**5**
16	Questions are be so worded that ego of the respondents is not injured in any way.	**1**	**2**	**3**	**4**	**5**
17	If there is more than one page of questionnaires, each page of questionnaires are be numbered serially.	**1**	**2**	**3**	**4**	**5**
18	A place in the questionnaire are be provided for the signature of the respondent.	**1**	**2**	**3**	**4**	**5**
19	Brief directions with regard to filling up the questionnaire are be given.	**1**	**2**	**3**	**4**	**5**
20	The physical appearance of the questionnaire are be good. The quality of the paper, along with its colour must be good.	**1**	**2**	**3**	**4**	**5**

REVIEWER OVERALL COMMENTS	Overall, all questions are easily to understand and most of them are related to the current study. However, in pdf format, some of wording arrangement especially for table header are not properly arranged. On the other hand, I would suggest to add a glossary to ensure that the respondent has same understanding for each of question or terminologies in the survey.

REVIEWER NAME, POSITION SIGNATURE AND STAMP	ASSOC PROF TS DR WAN HASRULNIZZAM BIN WAN MAH MOOD Faculty of Mechnical and Manufacturing Engineering Technology Universiti Teknikal Malaysia Melaka
DATE	12 Nov 2020

SURVEY EXPERT REVIEW FORM

This is a form for the expert to review the developed questionnaire survey. The review on overall questionnaire including the suitability of the questions, structure and language.

Title of the research: The Determination Of The Recyclers Preference Index (Rpi) For Recycling The End-Of-Life Waste Electrical And Electronic Equipments In Malaysia

	Items and Agreement Statements'	Level of agreement on the quality of the developed items in the questionnaire (1 is the lowest score – 5 is the highest score) Please circle one				
1	The questions are few, short, clearly worded, simple and easy to reply.	**1**	**2**	●	**4**	**5**
2	The questions are within the information scope of the respondents.	**1**	**2**	**3**	●	**5**
3	The questions have direct relation to subject of the investigation.	**1**	**2**	**3**	●	**5**
4	The opening questions are not be such as to abuse human interest.	**1**	**2**	●	**4**	**5**
5	Units and technical terms are correctly used in question as far as possible.	**1**	**2**	**3**	●	**5**
6	The questions are be inter-related with each other.	**1**	**2**	**3**	●	**5**
7	The questions are proceed in logical sequence moving from basic to more intense questions.	**1**	**2**	**3**	**4**	●
8	Personal and intimate questions are not included unnecessary	**1**	**2**	**3**	**4**	●
9	Emotional questions are avoided.	**1**	**2**	**3**	**4**	●
10	The questions are framed that there is a minimum of writing works. Questions may be dichotomous or multiple choice. Open-ended questions are limited to important questions.	**1**	**2**	**3**	**4**	●
11	The questions are free from ambiguity. Vague expressions capable of different interpretations are avoided in a questionnaire.	**1**	**2**	●	**4**	**5**
12	Answer to a question are be objective and have a capacity of easily classified, tabulated and analyzed.	**1**	**2**	**3**	●	**5**

SURVEY EXPERT REVIEW FORM

13	There are be some control questions in the questionnaire which indicate the reliability of the respondent.	**1**	**2**	**3**	●	**5**
14	Adequate space for answers are be provided in the questionnaire.	**1**	**2**	**3**	**4**	**5**
15	There are always be provision for indications of uncertainty, e.g. "low score indication"	**1**	**2**	**3**	**4**	**5**
16	Questions are be so worded that ego of the respondents is not injured in any way.	**1**	**2**	**3**	**4**	**5**
17	If there is more than one page of questionnaires, each page of questionnaires are be numbered serially.	**1**	**2**	**3**	**4**	●
18	A place in the questionnaire are be provided for the signature of the respondent.	**1**	**2**	**3**	**4**	**5**
19	Brief directions with regard to filling up the questionnaire are be given.	**1**	**2**	**3**	●	**5**
20	The physical appearance of the questionnaire are be good. The quality of the paper, along with its colour must be good.	**1**	**2**	**3**	●	**5**

REVIEWER OVERALL COMMENTS	1. Overall is good. 2. For Question A2, if you want to calculate mean in your analysis, you need to ma ke the class size equals. 3. For Questions C1 and D1, the questions are fine. However, respondents need to fill up in details. Could be challenging to get responses from them.

REVIEWER NAME, POSITION SIGNATURE AND STAMP	SAYED KUSHAIRI BIN SAYED NORDIN
DATE	13/11/2020

SURVEY ON THE RECYCLING DESIRABILITY CRITICAL FACTORS FOR E-WASTE

Title of the research: The determination of the recyclers preference index (RPI) for recycling the end-of-life waste electrical and electronic equipments in malaysia

This survey aims to analyze the ownership of the circular economy and improve decision-making tools for recycling. The following objectives should discuss the goal:

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.

Conducted by:

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Notes: Your response will be treated as highly confidential and will only be used for academic and research purposes. Thank you in advance for your willingness to participate in the survey.

UTeM UNIVERSITI TEKNIKAL MALAYSIA MELAKA	**SURVEY ON THE RECYCLING DESIRABILITY CRITICAL FACTORS FOR E-WASTE**

Section A: General information on your company

Name of company	
Address	
Company stamp	
Number of working days per week	
Operational hours	
Phone no. and Email	

1. What is your nature of business?

Collection and trading centre (collect and trade) ☐

Recycling centre (buy and recycle) ☐

2. How many employees are there in your company?

1 to 29 employees ☐

30 to 75 employees ☐

More than 75 employees ☐

3.Space ownership (Please (/) where applicable)

Self-owned ☐

Rent ☐

Waiting for government approval ☐

4. What is your premise's status?

Status	Description	Tick (/) where Applicable
Temporary license	license or permission to occupy the land for a temporary period. It is not a property or lease. It is limited in terms of time, which is only valid in the year it is issued and will expire on 31 December every year, unless it is terminated earlier by the State Authority	
Permanent license	License or permission to occupy the land permanently. The tenant does not require the conversion of land status and premises relocation.	

Section B: Recycling initiatives

1. The supply chain of the waste

Where is your customer coming from?	Never	Rarely	Sometimes	Often	Always
Nearby, from the same area, within 1-2 km from the centre					
From the same district (or within 2km-10km)					
From different district (or about 11km-30km)					
Different state					
A different country (import activities)					

2. Source of the waste

Type of customer	Never	Rarely	Sometimes	Often	Always	% of the waste
Waste bin						
Household						
Small collector (by lorry, bicycle, etc.)						
Offices/universities						
Manufacturers						
Waste company (Alam flora, MBJB, MBSA, etc.)						
Other (please specify) 1.						

2.						

3. Frequency of waste collection and the collection method

Method	Frequency of collection					Collection method (DTD/WI)
	Daily	Weekly	Monthly	Yearly	Never	
Waste bin						
Household						
Small collector (by lorry, bicycle, etc.)						
Offices/universities						
Manufacturers						
Waste company (Alam flora, MBJB, MBSA, etc.)						
Other (please specify) 1. 2.						

* Door-To-Door (DTD) // Walk In (WI)

4. What is the main product do you collect/recycle/trade?

Product	Never	Rarely	Sometimes	Often	Very frequent	Rank the material you preferred 1-5 (5 is most preferred)	Price sold per kg (RM)
Metal							
Plastic							
Glass							
Wood							
Paper / Cardboard							
Electric and electronic							
Other							

(please specify) 1. 2.							

5. The consideration factors that encourage for collecting/recycling/trading the waste?

Reason	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Large quantity					
High demand					
Profitable					
Technology readiness					
level of cleanliness					
Sorted waste					
Other (please specify) 1. 2.					

6. What are the current challenges for your premise to survive in this industry?

Business challenges	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Explanation
Government policy on licensing						
Taxes or fees						
The complaint from the neighborhood						
Insufficient supply						
Difficult to identify stolen/prohibited item						
Expensive technology or machinery						

Capital, Difficult to get bank loans						
Other (please specify) 1. 2.						

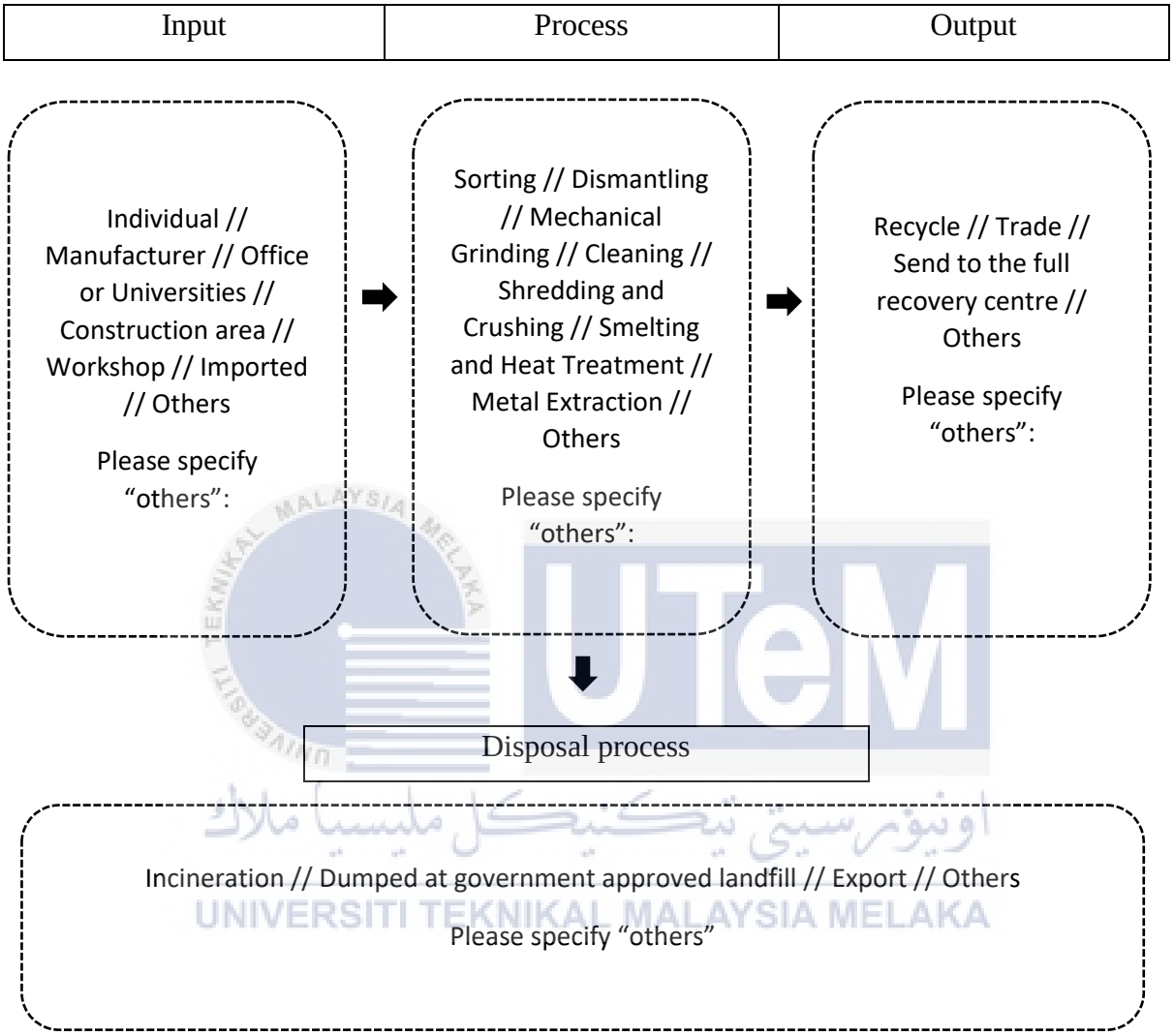
7. What are the drivers for your premises to sustain in this business?

Example	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Wide collaboration					
High consumer awareness in recycling					
Legislation					
High demand for recycled material					
Government funding injection					
Standardize market value recycled material					
Guaranteed volumes of waste supply					
Material scarcity					
Other (please specify) 1. 2.					

8. Who should be responsible for the end-of-life product waste?

Parties	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
End-user					
Manufacturer					
Government / recycler					
Other (please specify) 1. 2.					

9. The direction of the collected waste. (You can circle more than one)



10. Do you receive imported waste?

Yes ☐

No ☐

11. If yes, what kind of imported waste did you received?

Recyclable ☐

Non-recyclable ☐

Mixed ☐

12. Where did you get imported waste from?

SURVEY ON THE RECYCLING DESIRABILITY CRITICAL FACTORS FOR E-WASTE

Section C: E-waste

1. What would be the amount of e-waste collected on your premises?

Examples	Numbers of unit collected 2019	Recyclers accepted price per unit (RM)	Total Product parts	Numbers of recyclable part per unit	Numbers of non-recyclable part per unit	Where do you send the recyclable part?	Where do you send the non-recyclable part?
Refrigerators							
Washing machines							
Air conditioner							
Microwaves							
Printer							
Electric kettles							
Mobile phone							
Laptop							
Photocopy machine							
Computers							
Central processing unit (CPU)							

2. What is the preferable e-waste you would like to recycle?

E-waste category	Example	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Large household appliances	Refrigerators					
	Freezers					
	Washing machines					
	Dryers					
	Electric cooking stoves					
	Air conditioner					
Small household appliances	vacuum cleaners					
	Water heater					
	microwaves					
	Printer					
	electric kettles					
Information technology (IT) and telecommunications equipment	Routers					
	Laptop					
	Printer & scanner					
	Printed Circuit Board (PCB)					
	Computers					
	Central Processing Unit (CPU)					
	Mouse					

Other	Please specify 1 2. 3. 4.					

3. Tick the process available in your premise and tick the process you need according to your premise priority

Process	Tick where applicable	Which is the process that you prefer to do/have?				
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Incineration						
Sorting						
Dismantling						
Mechanical grinding						
Shredding and crushing						
Smelting or heat treatment						
Metal extraction						
Other;(please specify) 1. 2.						

4. If the university research team wants to send the 'Recycling Business Needs in Malaysia,' what would you like to convey to the government to empower your recycling business activities?

1.

2.

3.

4.

5.

6.

5. Would you like to receive a summary of the result of the survey?

Yes ☐

No ☐

Thank you very much for your time and kind co-operation

FRAMEWORK EXPERT REVIEW FORM

Title of the research: Determination of the recycling desirability critical factors for e-waste in Malaysia

This is a form for the expert to review the constructed framework based on the student scope of research. The objective of the research to develop local-recycling supply chain for e-waste management.

	Items and Agreement Statement	Level of agreement on the quality of the developed items in the questionnaire (1 is the lowest score – 5 is the highest score) Please circle one				
1	The process flow is inter-related from one source to another.	1	2	3	(4)	5
2	The constructed framework is within the current framework	1	2	3	(4)	5
3	The technical terms are correctly used in a framework as far as possible.	1	2	3	(4)	5
4	The constructed framework flow in logical sequence moving from basic to the manufacturer	1	2	3	(4)	5

REVIEWER OVERALL COMMENTS	The diagram must be given a spesific title. All the residue of processes that still e-waste need to send to full recovery facilities.
REVIEWER NAME, POSITION, SIGNATURE AND STAMP	HASNITA BINTI MANSOR Pegawai Kawalan Alam Sekitar C44 Jabatan Alam Sekitar W.P Kuala Lumpur
DATE	23/12/2020

Recycling Centre Premises

Local Authorities

Police	Majlis bandaran	DOE