Remanufacturing in Malaysia - An Assessment of the Current and Future Remanufacturing Industry

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Remanufacturing in Malaysia

An assessment of the current and future remanufacturing industry

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Remanufacturing in Malaysia

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# Contents

**Executive summary**  
1

**Introduction**  
1
  1.1 Motivation for study  
  1.2 Remanufacturing – a background  
2

**2 Scope of the remanufacturing market in Malaysia**  
5
  2.1 Methodology  
  2.2 Market assessment  
  2.3 Summary and national estimate  
33

**3 Barriers to remanufacturing**  
33
  3.1 Common barriers  
  3.2 Vehicle component remanufacture  
  3.3 Printer cartridges  
  3.4 ICT  
  3.5 Aerospace  
34

**4 Recommendations and opportunities for expanding remanufacturing**  
36

**5 Summary and implications for the remanufacturing Pathfinder**  
38

**6 Appendix A**  
41
  6.1 List of on-site interviews  
7

**7 Appendix D**  
42
  7.1 Criteria for the determination of e-waste (Imports)  
8

**8 Glossary**  
45
Illustrations

Figures
Figure 1: Spectrum of end-of-life options 3
Figure 2: Annual vehicle production in Malaysia 6
Figure 3: Re-use activities within the automotive sector 8
Figure 4: Remanufacturing channels for automotive components 11
Figure 5: Case study - Motor Teknologi & Industri 14
Figure 9: Inkjet and toner cartridge technologies 15
Figure 10: Case study - Cartridge World 19
Figure 11: Case study - Prota Remanufacturing Sdn Bhd 20
Figure 12: Refurbishers listed in Microsoft directory 22
Figure 13: Case study - SOLS Tech 26
Figure 14: Rentwise case study 27
Figure 15: GE case study 31
Figure 16: Current and potential size of the market for remanufactured goods in Malaysia 32

Tables
Table 1: Terminology related to remanufacturing 4
Table 2: Information sources and methods 5
Table 3: Characteristics of the Malaysian automotive aftermarket in 2008 7
Table 4: Automotive component remanufacturers in Malaysia 10
Table 5: Energy savings and pollution prevented from engine remanufacture 12
Table 8: Warranties and guarantees offered for remanufactured printer cartridges 16
Table 9: Remanufactured printer cartridges in 2012 17
Table 10: Environmental benefit of remanufacturing printer cartridges in 2012 18
Table 11: ICT market segmentation 21
Table 12: Percentage of electrical and electronic equipment purchased new or second-hand 23
Table 13: Environmental impact of ICT equipment 24
Table 14: MRO organizations in Malaysia 28
Table 16: Organizations visited during the study 41
Table 18: Criteria for the determination of e-waste 43
Executive summary

This report has been commissioned by the U.S. Government via the United States Agency for International Development (USAID) to investigate remanufacturing activities within Malaysia. Remanufacturing activities in four product areas were investigated and found to contribute RM3.8-4.0 billion a year to the Malaysian economy, with the potential for this contribution to more than double if the market matured in proportion to the U.S.’s remanufacturing market. The environmental benefits of Malaysia’s remanufacturing activities are significant, diverting approximately 37k tonnes from disposal and avoiding approximately 62k tonnes of CO2e from being emitted each year. We found no direct evidence specifically preventing the trade, shipment or sale of remanufactured goods in the sectors investigated. The nascent benefits of remanufacturing could significantly boost the Malaysian economy; joining the APEC Pathfinder on remanufacturing could help precipitate the national actions needed to promote this emerging industry and open up new international markets.

Remanufacturing is the industrial process of restoring an end-of-life product back to an as-new condition with a warranty to match. It has both economic and environmental benefits over the manufacture of new products. The activity occurs in many different industry sectors and it is usually hidden or poorly understood within the wider economy. Even so, the benefits of remanufacturing are slowly being realized. One area where this is evident is in the Asia-Pacific Economic Cooperation (APEC) free trade zone where, in 2011, a Pathfinder on facilitating the trade of remanufactured goods was agreed upon by 11 APEC economies. The Pathfinder set out a series of commitments that promote free trade of remanufactured products between the Asia-Pacific economies. As the Pathfinder gains momentum, more economies are becoming interested in remanufacturing and wish to investigate its benefits to their economy.

Four product areas were targeted through a series of industry interviews, literature reviews and site visits. The key findings are:

- **Vehicle components.** There is a domestic remanufacturing industry which feeds into the domestic aftermarket for vehicle components. Most of the parts are sourced and imported from Japan and Europe. There are some restrictions on the import of used ‘safety-critical’ components such as brakes. The market for remanufactured components is estimated to be RM207-345 million, but has the potential to grow to RM670 million.
• **Printer cartridges.** There is an active domestic remanufacturing industry for printer cartridges. Many of the operators are relatively small, employing fewer than 25 people. Remanufactured cartridges do not appear to be imported into Malaysia, but empty cartridges are imported for remanufacturing and used domestically. The main threat to this industry is illegal activities by which remanufactured cartridges are sold as new cartridges. The value of this industry is estimated at RM73 million.

• **Information and communication technology (ICT).** ICT ‘refurbishment’ is conducted by both Original Equipment Manufacturers (OEMs) and third-party independent companies. Computers are sourced both domestically and internationally. Problems around illegal activities persist, particularly with pirated software. The market for this industry is estimated at RM109 million.

• **Aerospace.** Maintenance Repair and Overhaul (MRO) of aero-engines, airframes and other aerospace components is an important sector in Malaysia. There are strategies in place to increase this activity, and ambitions to turn Malaysia into a hub for South East Asia. There are no institutional barriers preventing this activity. Most of the problems with this industry center on a lack of skills in the workforce and the need for more investment in test equipment. The market for these services is valued at RM3.4 billion.

In total, these sectors represent a RM 3.8 – 4.0 billion-a-year industry to the Malaysian economy. If the market were to grow to a similar proportion of the overall economy to that in the United States, we predict that the market for these remanufactured goods would be worth RM 14.3 – 14.5 billion. In addition to the sectors examined in this report, other sectors may have the potential to contribute to remanufacturing activity; for example, mechanical power machinery, machine tools, rubber products, and rail.

We identified a series of common barriers preventing the expansion of remanufacturing within Malaysia. These barriers included: Lack of skills in the workforce; access to ‘core’; no standardized methods; and lack of industry representation. There were several specific policies that impacted on remanufacturing activities, in particular in relation to importing used components for remanufacturing within Malaysia.

Recommendations for increasing remanufacturing in Malaysia focus on developing a common definition for the term ‘remanufacturing,’ promoting consistently high quality products through developing operating standards and product specifications, and encouraging the formation or development of trade associations to help represent and self-regulate the industry.

A key aim of this work was to help Malaysia develop a national position on joining the Pathfinder. This research shows that the nascent benefits of remanufacturing could significantly

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1 The term ‘core’ is used throughout this document to mean feedstock for remanufacturing and related activities.
boost the Malaysian economy. However, to realize those benefits, additional national measures would need to be enacted in addition to joining the Pathfinder. In particular, a common definition of ‘remanufacturing’ is needed, as is education of both policymakers and customs officials on the subject of remanufactured goods. Robust industry representation will also be important to help legitimize the domestic market. Joining the Pathfinder would be a positive move to help shape internal policy around addressing key issues that face the industry and ultimately lead to the potential benefits identified in the report.
Introduction

1.1 MOTIVATION FOR STUDY
While the industrial practice of remanufacturing has occurred around the world for decades, the term ‘remanufacturing’ is not widely recognized and its definition has been the subject of much debate. Many definitions of remanufacturing exist, from both academic and industrial sources. Most contain common threads relating to ‘like-new performance’ and an ‘as-new warranty.’ For the purposes of this report, remanufacturing is defined as:

“A series of manufacturing steps acting on an end-of-life part or product in order to return it to like-new or better performance, with warranty to match.”

Remanufacturing has potential economic benefits, from consumers gaining access to products at a reduced price, to environmental benefits arising from savings in material and energy. An additional benefit is the creation of skilled jobs in an industry requiring high levels of manual technical skills.

The “all-round sustainability benefits” of remanufacturing have led to increased interest in this industry. However, mature remanufacturing economies such as the USA have identified the existence of barriers to the trade of remanufactured goods to some economies, restricting the growth of the industry. In 2011, a Pathfinder on facilitating the trade of remanufactured goods was agreed upon by 11 APEC economies. The participating economies agreed to adhere to the following four Pathfinder elements when implementing current, or developing new, tariff and non-tariff measures:

1. “Apply import-related measures specifically concerning used goods only to used goods and refrain from applying them to remanufactured goods. Remanufactured goods are not used goods. Therefore economies should not be prohibiting or limiting their importation based on reasoning that they use to restrict trade of used goods.

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2 Centre for Remanufacturing and Reuse (2009) An Introduction to Remanufacturing
4 Australia, Canada, Chile, Chinese Taipei, Japan, Mexico, New Zealand, Papua New Guinea, the Republic of Korea, Singapore, and the United States of America
2. **Refrain from applying import prohibitions against all remanufactured goods or against remanufactured goods in specific sectors.** If economies do not prohibit the importation of new goods, they should not be prohibiting the importation of remanufactured goods.

3. **Treat remanufactured goods like corresponding new goods when applying tariffs or other border charges.** Treatment of remanufactured goods as new goods for customs purposes can further facilitate trade in these products by avoiding the application of higher duties or other charges to remanufactured goods that economies sometimes apply to imports of used goods. For example, an economy would no longer apply the same tariffs to a remanufactured engine or printer cartridge that they might apply to a used engine or printer cartridge. Instead, they would apply the same tariffs to remanufactured printer cartridges that they normally apply to new ones. Economies usually apply lower duties or other charges to new goods than they apply to used goods.

4. **Generally apply technical regulations, conformity assessment procedures, and documentation and import licensing requirements concerning new goods to remanufactured goods.** If a remanufactured good meets the technical specifications of the importing economy and can be easily distinguished from used goods by labelling or invoicing, then the importing economy should not require importers to provide additional information. Remanufactured goods should only be subject to import licensing requirements that an economy applies to the importation of new goods."

This report will examine the market size and scope of selected sectors of the Malaysian remanufacturing industry and identify any current tariff and non-tariff measures that impede the trade of remanufactured goods both in and out of Malaysia. For the sectors examined in this report, we will illustrate whether and where conflicts with the APEC Pathfinder elements have been observed.

The scope of this project has been limited to examining the remanufacturing activities in four product category groups: automotive products; printer cartridges; information and communications technology (ICT); and aerospace.

**1.2 REMANUFACTURING – A BACKGROUND**

Remanufacturing is one strategy for the practical implementation of the circular economy. This is illustrated in Figure 1, which also describes other product and material re-use activities. The diagram is not a hierarchy of the environmental impact of end-of-life decisions; for some products, the environmental impact of remanufacturing may be greater than recycling or disposal.

Remanufacturing typically occurs when the following conditions apply:

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- the product is complex
- the product contains significant embedded energy and material
- the product was labor-intensive to manufacture originally
- techniques exist for disassembling and recovering the value of components within the product.

**Figure 1: Spectrum of end-of-life options**
Source: Oakdene Hollins, 2013

The lack of a universally recognized definition for remanufacturing has resulted in a wide variety of terminology being used to describe remanufacturing and other related activities. Table 1 provides a list of other terminology used to describe industrial practices that are similar or related to remanufacturing. These definitions will be used throughout the rest of the report and instances where local Malaysian industries describe their activities using conflicting terminology will be identified.
Table 1: Terminology related to remanufacturing
Source: Modified from Motor Teknologi & Industri, 2013

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Purpose</th>
<th>Description</th>
<th>Relation to remanufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair</td>
<td>Extend useful life</td>
<td>Replacement of defective components</td>
<td>Repair activities are normally limited to specific defective components. In remanufacturing, individual components may undergo repair.</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>Extend useful life</td>
<td>Extensive product recovery process</td>
<td>N/A</td>
</tr>
<tr>
<td>Refurbishment/rebuilding</td>
<td>Extend useful life</td>
<td>Complete revamp of systems (internals and externals)</td>
<td>Individual components may have undergone remanufacturing. Overall warranty and performance may not be equivalent to remanufactured products.</td>
</tr>
<tr>
<td>Overhaul</td>
<td>Part of maintenance cycle</td>
<td>Process specified by service manuals</td>
<td>Overhaul activities may be akin to remanufacturing if restoring as-new functionality is specified.</td>
</tr>
<tr>
<td>Reconditioning</td>
<td>Enhance resale value</td>
<td>Returns product appearance to as-new</td>
<td>This is not true remanufacturing as it focuses on restoring the form, and not the function, of the product.</td>
</tr>
</tbody>
</table>

In our experience, these definitions vary between industries and, under certain circumstances, remanufacturing can be occurring even though it is not termed as such. As a consequence, this report will document where activities in each of these categories occur and discuss their relationship to remanufacturing.

The term ‘core’ is used throughout this document to mean feedstock for remanufacturing and related activities.

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2 Scope of the remanufacturing market in Malaysia

2.1 METHODOLOGY
An overview of current remanufacturing activities in Malaysia was compiled from a range of data sources and methods shown in Table 2. Our methodology focused heavily on stakeholder engagement due to a lack of nationally-collated trade information on remanufactured products. The interviews were also important in understanding the practicalities of remanufacturing in Malaysia. Interviews were conducted with government departments, trade associations, remanufacturing companies and academics. A full list of on-site interviews conducted during the study is given in Appendix A.

Table 2: Information sources and methods
*Source: Oakdene Hollins, 2013*

<table>
<thead>
<tr>
<th></th>
<th>Government agencies</th>
<th>Trade associations</th>
<th>Companies</th>
<th>Academics</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical analysis</td>
<td>Trade databases</td>
<td>Member statistics</td>
<td>Company statistics</td>
<td>-</td>
<td>Market reports</td>
</tr>
<tr>
<td>Literature review</td>
<td>Official publications</td>
<td>Association websites and publications</td>
<td>Company websites</td>
<td>Research papers</td>
<td>Secondary literature e.g. articles and commentaries</td>
</tr>
<tr>
<td>Interviews</td>
<td>Face-to-face and telephone interviews</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Questionnaires</td>
<td>-</td>
<td>Sector information</td>
<td>Company information</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The total market size of the remanufacturing industry has been estimated by scaling up confirmed remanufacturers’ activities with estimates of the number of companies involved in remanufacturing, or by scaling up remanufacturing volumes by an approximate unit price. Estimates on the potential size of the remanufacturing industry in Malaysia were made by scaling
up the current contribution towards the economy to that of the contribution of a more mature remanufacturing economy, such as the USA or the UK.

2.2 MARKET ASSESSMENT

2.2.1 Vehicles: Overview
The automotive sector is an important market for Malaysia: it was the world’s 23rd largest automotive producer in 2012, producing over 570,000 vehicles, and was the third largest ASEAN automotive producer, behind Thailand and Indonesia.7 Within the automotive sector, production can be divided between activities in the commercial vehicles sector, in which vehicles are used for transporting goods (trucks and lorries) or fee-paying passengers (buses and coaches), and the passenger vehicles sector, in which vehicles are primarily used for private passenger transport (cars).

The historical production and assembly of commercial and passenger vehicles in Malaysia is shown in Figure 2 using data from the Malaysian Automotive Association (MAA). Production has shown a large increase from the 1980s, predominantly in passenger vehicle production. The change from five-yearly to annual data from 2005 allows us to see volatility in recent production due to factors such as: the 2008 financial crisis; supply chain disruption, from natural disasters, including the 2011 earthquake and tsunami in Japan; and amendments to the 1967 Hire Purchase Act, which caused delays to new vehicle registrations.8

Figure 2: Annual vehicle production in Malaysia9

7 http://oica.net/category/production-statistics/
Malaysia also has a thriving automotive aftermarket, which includes used vehicle sales, repair and maintenance activities, and the sale of spare parts and accessories. Table 3 shows the characteristics of the automotive aftermarket in 2008, which is the latest year for which data are available.\footnote{From “Developing the Malaysia automotive aftermarket through sustainable developments”, a presentation by the Automotive Aftersales Development Division, MAI, presented at the Automotive Aftermarket Conference “Automotive Aftermarket: Towards sustainability developments”, March, 2013}

**Table 3: Characteristics of the Malaysian automotive aftermarket in 2008**

*Source: Census of Distributive Trade, 2009*\footnote{From “Developing the Malaysia automotive aftermarket through sustainable developments”, a presentation by the Automotive Aftersales Development Division, MAI, presented at the Automotive Aftermarket Conference “Automotive Aftermarket: Towards sustainability developments”, March, 2013}

<table>
<thead>
<tr>
<th>2008 reference</th>
<th>Number of establishments</th>
<th>Employment</th>
<th>Output (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales of used motor vehicles</td>
<td>3,515</td>
<td>42,994</td>
<td>13.3 billion</td>
</tr>
<tr>
<td>Repair and maintenance</td>
<td>18,834</td>
<td>81,726</td>
<td>5.2 billion</td>
</tr>
<tr>
<td>Sales of parts and accessories</td>
<td>10,589</td>
<td>68,971</td>
<td>6.9 billion</td>
</tr>
<tr>
<td>Total</td>
<td>32,938</td>
<td>193,691</td>
<td>25.4 billion</td>
</tr>
</tbody>
</table>

Through literature surveys and stakeholder engagement, for each of the commercial and passenger vehicle sub-sectors, we observed re-use activities for both components and whole vehicles (Figure 3). Each of these sub-sectors displays distinct market features and incorporates varying levels of remanufacturing. For example, the commercial vehicle whole vehicle rebuilding sector currently undertakes refurbishing or rebuilding activities (according to the definitions in Table 1). While the industry has aspirations to transform to a full remanufacturing industry in the future, its current activities are outside the scope of this study. Similarly, passenger vehicle whole vehicle rebuilding does not constitute remanufacturing according to the definition in section 1.1. The only instance of true remanufacturing was observed in vehicle component remanufacturing and this sub sector is explored in the following section.
2.2.2 Vehicle component remanufacturing

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RM207 million</td>
<td>RM670 million</td>
<td>RM325 million</td>
</tr>
<tr>
<td>– RM345 million</td>
<td></td>
<td>– RM463 million</td>
</tr>
</tbody>
</table>

2.2.2.1 Introduction and background

The remanufacturing of automotive parts and components is perhaps the oldest and most mature remanufacturing market in the world, with the size of the global industry estimated to be approximately $85-100 billion\(^{11}\) (approximately RM283-333 billion). In Malaysia, the component remanufacturing industry for both commercial and passenger vehicles sells product into the aftermarket (servicing and repairing used vehicles).

Component remanufacturing is performed almost exclusively by independent third parties. Only Caterpillar (through Tractor Malaysia, its local partner dealer), Hitachi and Volvo have been identified as OEMs active in component remanufacturing within Malaysia. Automotive components that are commonly remanufactured are typically high value and require technical expertise and knowledge to remanufacture.\(^{12}\) Examples of commonly remanufactured automotive components include:

- engines and their sub-components (e.g. crankshaft, camshafts)
- drivetrain components (e.g. clutches, gear boxes, axels)
- rotating electric and ignition parts (e.g. alternators, starter motors, dynamos)
- turbochargers and superchargers

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\(^{12}\) Centre for Remanufacturing and Reuse (2009) Remanufacturing in the UK: A snapshot of the UK remanufacturing industry
• air conditioning elements (e.g. compressors)
• electronics.

Table 4 is a non-exhaustive list of companies that have been identified as being involved in automotive component remanufacturing and examples of the components that they remanufacture. Academics at Universiti Teknologi Malaysia (UTM) observed that most component remanufacturers currently in operation are small companies dispersed around Malaysia.\textsuperscript{13}

\textsuperscript{13} Universiti Teknologi Malaysia (2013) Interview, 23\textsuperscript{rd} August 2013
Table 4: Automotive component remanufacturers in Malaysia

Source: Oakdene Hollins, 2013

<table>
<thead>
<tr>
<th>Company</th>
<th>Motor Teknologi &amp; Industri Sdn Bhd</th>
<th>Motorcar Parts of America</th>
<th>Everspark Industries Sdn Bhd</th>
<th>Wah Seng Industry Sdn Bhd</th>
<th>Volvo Malaysia Sdn Bhd</th>
<th>Precision Automotive Industries</th>
<th>Soon Lian Trading Sdn Bhd</th>
<th>EH Auto Link Asia Sdn Bhd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternator</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/C compressor</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clutch pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distributor</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive shaft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gear box</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starter</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbo</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are four channels for automotive component core for remanufacturing activities in Malaysia (Figure 4). Examples of all of these channels have been observed in the companies listed in Table 4. However, the president of the Federation of Engineering and Motor Parts Trader’s Association Malaysia (FEMPTAM) states that most used components are imported from Japan and Europe, with limited components sourced from the local market. Remanufactured components are exported for sale in economies around the world including Europe, North America and, in particular, South East Asia.

14 http://www.miti.gov.my/cms/content.jsp?id=com.tms.cms.article.Article_e61b6279-c0a8156f-6f346f34-d0228b1d
The Review of the National Automotive Policy (NAP) in 2009 had important implications for the first two remanufacturing channels. The review advocated the gradual phase-out of imported used parts and components due to safety and environmental concerns. The first stage of this ban came into effect in June 2011 and prohibited the import of used brake linings, brake pads, batteries and tyres.14 This subject is further discussed in section 3.1.

### 2.2.2 Domestic market

The current size of the components remanufacturing industry is difficult to estimate due to the wide range of organizations involved in the spectrum of re-use and remanufacturing activities. Used automotive components may undergo any or all of the activities involved in remanufacturing (disassembly, cleaning, repair, worn part replacement, manufacturing processes, assembly and testing); however, the terminology used to describe whether a part has been remanufactured is inconsistent between companies. Remanufacturing activities could fall under the category of both ‘Repair and maintenance’ and ‘Sales of parts and accessories’, the automotive aftermarket activities distinguished in Table 3, which has a total value of RM12.1 billion ($3.6 billion) in 2008, including exports.

The proposed ban on importing used automotive components was estimated to affect over 34,500 companies, with an average workforce of 25 people,15 some of whom will have been involved in remanufacturing. However, there is little information on the size of the current domestic market for remanufactured automotive components. An estimate of the size of the automotive components remanufacturing market from the United States International Trade Commission of

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$7 million, or approximately RM23 million per year is thought to be low. Using conservative industry estimates, if component remanufacturing contributed between 3% and 5% of the sales of aftermarket parts and accessories (Table 3), the industry would be between RM207 million and RM345 million ($62-104 million) in 2008.

### 2.2.2.3 Import market

MAI confirms that there is no specific tariff heading for remanufactured automotive components and there are no data available on the market for importing remanufactured components. Remanufactured components would be classified as used components, and subject to the same import restrictions. For example, Malaysia prohibits imports of used brake pads, brake lining, batteries and tyres; these are considered to be safety-critical components. Clarification on the definition of remanufactured automotive components will be necessary to ensure that they are not considered used. This will be particularly important if Malaysia joins the Pathfinder. Imports of automotive parts and components were reported to amount to RM7.55 billion in 2012 ($2.3 billion). Research by the University Utara Malaysia, commissioned by MAARA, found that - of the second-hand automotive components used in Malaysia - over 90% are imported. There are no data available to tell us whether any of these imported components had been remanufactured; some of these imported components may be a source of core for local remanufacturers. Imported used components are approximately 50% of the price of new OEM parts. However, not all imported used parts are used for the local market: 35% are re-exported to economies in the Middle East and Africa. Again, there are no data which show whether the parts are remanufactured before being re-exported.

### 2.2.2.4 Environmental benefits

The environmental benefit of remanufacturing vehicle components will vary depending on the composition of the components. Previous work has sought to evaluate the environmental benefit of remanufacturing some components. For example, Table 5 presents the energy saved and pollution prevented from remanufacturing an engine compared to new production:

**Table 5: Energy savings and pollution prevented from engine remanufacture**  
*Source: Smith and Keoleian, 2008 and Jaafar et al., 2009*

<table>
<thead>
<tr>
<th>Saving (%)</th>
</tr>
</thead>
</table>

---

16 MAI Interview, 29th August, 2013
For nearly all of the environmental categories in Table 5, remanufacturing saves 50-90% of the impact when comparing a remanufactured engine with a new engine. Assuming that remanufacturing other automotive components may achieve comparable savings to the engine example, we estimate that remanufacturing automotive components reduces the environmental impact for all environmental categories by approximately 75%. Without a bottom-up estimate of the quantity of automotive components that are remanufactured per year, we cannot accurately evaluate the absolute environmental impact of remanufacturing activities in the automotive components industry. However, as an initial estimate, if we assume an average remanufactured component price of RM250, this corresponds to sales of between 828,000 and 1,380,000 units in 2008. If an average remanufactured component has a mass of 20kg and is predominantly made of steel, remanufacturing displaced approximately 16,600 to 27,600 tonnes of material from disposal and saved 18,100 to 30,200 tonnes CO₂e in 2008.¹⁹

### 2.2.2.5 Growth potential

The potential market growth for remanufactured automotive components can be estimated by comparison with the more mature USA market. In 2010, remanufacturing of automotive components had a market size of nearly 10% of the aftermarket parts industry.³¹¹ If the Malaysian automotive components remanufacturing industry had achieved a similar level of market penetration in 2008 (the latest year for which Malaysian market data were available) remanufacturing activities could have contributed RM670 million ($201 million) in total. This is a one to two-fold increase on the current level. This could increase further: the recent Malaysian National Automotive Policy (NAP) expects the gross domestic product (GDP) contribution from the automotive sector to increase from just over 3.2% in 2012, to over 10% by 2020.²⁰

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¹⁹ *Calculated assuming remanufacturing saves 75% of the component mass multiplied by the emissions factor for pig iron (1.46 kg CO₂e/kg iron)³³*

2.2.2.6 Case study

Figure 5: Case study - Motor Teknologi & Industri

Motor Teknologi & Industri Sdn Bhd

Company background – established in 2005,
• Remanufactured approx. 1800 cylinder heads and 24 engines in 2012
• 63 employees
• Turnover RM16 million in 2012

Remanufacturing markets
• All cylinder heads are imported from and exported to the customer’s central collection point in Singapore
• All remanufactured engines are for the local market

Remanufactured products – remanufactures equipment, diesel engines and their components, including:
• Cylinder heads
• Turbo charger
• Pumps
• Alternators
• Crank cases
• Crank shafts
• Camshafts

Products are remanufactured to the OEM’s original specifications. When the specifications are insufficient to inform the remanufacturing process or parts are obsolete, the engineering team must specify their own remanufacturing process or replacement parts.

Certification – ISO 9001:2000 and by Mercedes Benz Malaysia, Tognum Asia Pte Ltd (formerly MTU Asia Pte Ltd) and MTU GmbH Germany as "their preferred business partner for remanufacturing and precision machining activities". Key processes have been audited and approved by customers.


Images credit: MTI
2.2.3 Printer cartridges

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RM73 million</td>
<td>RM127 million</td>
<td>RM54 million</td>
</tr>
</tbody>
</table>

2.2.3.1 Introduction and background

There are two technologies that dominate the printer cartridge market: inkjet cartridges and toner (or laser) cartridges. Inkjet cartridges contain liquid ink, which is sprayed onto the paper surface; toner cartridges contain toner power, which is drawn on to the paper surface using electrostatic attraction, before being fused to the surface with heat. Inkjet cartridges are generally smaller and less technically complex than toner cartridges, which consist of over one hundred moving parts. These two technologies are described in more detail in Figure 6.

Figure 6: Inkjet and toner cartridge technologies

Specific terminology is used to describe different cartridges, which has important implications for identifying true remanufacturing activities:

**Refilled cartridge:** Refilled cartridges are cartridges in which the ink or toner has been replaced, but no other manufacturing operations have been performed.

**Remanufactured cartridge:** Remanufactured cartridges are cartridges which have undergone a full disassembly and cleaning procedure, worn parts are replaced, and the cartridge is refilled and reassembled before testing and packaging.

**Compatible cartridge:** Compatible cartridges are new cartridges that have been manufactured by a third party company (i.e. not an OEM) and which are compatible with OEM printers. In certain instances, compatible cartridges have infringed on the intellectual property of the OEM.
**Counterfeit cartridge:** Counterfeit cartridges are refilled, remanufactured or compatible cartridges that are branded illegally using OEM packaging and are sold ‘as new’ to consumers.

The cartridge remanufacturing industry in Malaysia is predominantly made up of small companies. There are an estimated 100-200 remanufacturers currently operating, many of which have fewer than 25 employees. Most of these remanufacturers are based in the Klang Valley area. The cartridge remanufacturing industry is estimated to supply approximately 1.2 million cartridges per year, which is approximately 10% of the total market for printer consumables. There is both an active local and export market for remanufactured cartridges.

The availability and quality of core is crucial to cartridge remanufacturing, and core is both collected locally and imported from abroad to meet the demand. Some remanufacturers will purchase used printer cartridges for a small fee to secure supply. There is also a distinction made on the source of the cartridges. For example, Prota Remanufacturing Sdn Bhd distinguishes between two different remanufacturing routes: one for cartridges that have not previously been remanufactured (virgin cartridges) and cartridges that have undergone previous remanufacturing operations (non-virgin cartridges). The variation in quality of spent non-virgin cartridges is greater than that of virgin ones. As a result, the remanufacturing process takes 20-40% longer for non-virgin cartridges.

The Malaysian Cartridge Remanufacturers Association was founded in 2006 to represent the interests of cartridge remanufacturers in Malaysia. However, the association was only active for a few months before being disbanded. Survey respondents have suggested that this is due to the high number of cartridge remanufacturers involved in illegal activities, such as the production of counterfeit cartridges. This may have an impact on the availability of core for legitimate remanufacturers: firstly, fewer cores are available for genuine remanufacturing activities; secondly, these companies can pay a higher price for core as they can sell the counterfeit cartridges at a higher price to customers.

Many cartridge remanufacturers provide warranties or guarantees to assure customers of the quality of their products. We observed a wide variety of warranty options offered by Malaysian cartridge remanufacturers. Examples of these options are shown in Table 6.

**Table 6: Warranties and guarantees offered for remanufactured printer cartridges**

*Source: Oakdene Hollins, 2013*

<table>
<thead>
<tr>
<th>Cartridge Remanufacturer</th>
<th>Warranty or guarantee offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartridge World</td>
<td>100% guarantee that a remanufactured cartridge will perform as well as the original.</td>
</tr>
<tr>
<td>Hileytech Sdn Bhd</td>
<td>Defective cartridges replaced free of charge.</td>
</tr>
<tr>
<td>Laser Re Nu</td>
<td>Guarantees the same density and coverage as the original cartridge. Will replace defective cartridge and will repair or clean printer if damage is caused by the remanufactured cartridge.</td>
</tr>
</tbody>
</table>
Table 7 shows the number of inkjet and toner cartridges remanufactured in 2012 in Malaysia.

**Table 7: Remanufactured printer cartridges in 2012**

<table>
<thead>
<tr>
<th>Number of remanufactured cartridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inkjet cartridges</td>
</tr>
<tr>
<td>Toner cartridges</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

**2.2.3.2 Domestic market**

Table 7 shows the number of inkjet and toner cartridges remanufactured in 2012 in Malaysia.

**2.2.3.3 Import market**

No evidence was found of an active market for importing remanufactured cartridges into Malaysia. This was reinforced by anecdotal evidence from cartridge remanufacturers. Conversely, there is an active market for importing empty cartridges for remanufacture locally. There appears to be little barrier to this activity, with remanufacturers reporting that they do not encounter any issues when importing core into the economy. Currently, the duty rate for importing ink-filled printer cartridges is set at 0% and no separate tariff heading exists for used cartridges. Based on this information, it is unlikely that there would be any trade or institutional barriers to importing remanufactured printer cartridges.

---

**Notes:**

21 IDC (2012) A snapshot of the consumables market in Q4 2012 in Malaysia

2.2.3.4 Environmental benefits

The environmental benefit of remanufacturing printer cartridges varies greatly between inkjet and laser cartridges. A study comparing the carbon footprint of new and remanufactured inkjet cartridges\(^\text{23}\) estimated that the carbon saving was approximately 0.38 kg CO\(_2\)e per cartridge. A similar study for a mono-toner printer cartridge estimated that the remanufacturing process saves approximately 2.5 kg CO\(_2\) per cartridge.\(^\text{24}\)

Remanufacturing also displaces material from the waste stream. Assuming that remanufacturing an inkjet cartridge preserves all non-ink and packaging components of a cartridge, remanufacturing displaces around 35g of material from the waste stream per cartridge.\(^\text{23}\) Remanufacturing a laser cartridge allows much of the material in the casing (predominantly high impact polystyrene (HIPS) and steel) to be re-used.\(^\text{24}\) In total, remanufacturing displaces nearly 700g of material from the waste stream per cartridge.

The environmental benefit of remanufacturing printer cartridges in Malaysia 2012 measured as avoided CO\(_2\) and avoided waste is shown in Table 8.

<table>
<thead>
<tr>
<th></th>
<th>Number of remanufactured cartridges</th>
<th>Avoided CO(_2) (t CO(_2))</th>
<th>Avoided waste (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inkjet cartridges</td>
<td>773,000</td>
<td>294</td>
<td>27</td>
</tr>
<tr>
<td>Toner cartridges</td>
<td>435,000</td>
<td>1,088</td>
<td>303</td>
</tr>
<tr>
<td>Total</td>
<td>1,208,000</td>
<td>1,382</td>
<td>330</td>
</tr>
</tbody>
</table>

2.2.3.5 Growth potential

Perhaps the biggest opportunity for the remanufactured cartridge industry to grow in Malaysia is through the elimination of illegal competitors, including counterfeit cartridges and compatible cartridges in breach of patents or copyright. While it difficult to obtain an accurate estimate of the size of illegal activities in the industry, market research\(^\text{21}\) does provide some estimate of the size of the counterfeit and ‘grey’ market. If counterfeit and grey products were displaced by legitimate remanufactured inkjet and toner cartridges, sales could increase by up to 70% for toner cartridges and 112% for inkjet cartridges. Assuming an average unit price of RM10 for a remanufactured inkjet cartridge and RM150 for a remanufactured toner cartridge, the potential size of the industry in 2012 is RM127 million ($38 million).


2.2.3.6 Case studies

Figure 7: Case study - Cartridge World

Cartridge World

Company background – has been remanufacturing cartridges for 7 years
- Remanufactures approx. 30,000 units/year
- Less than 1% market share
- 99% of company business is in remanufacturing
- 10 employees and 3 franchisees

Remanufacturing markets
- Used cartridges are predominantly imported from the U.S. and Germany
- Replacement components are manufactured by international suppliers managed by the international Cartridge World® organisation
- 100% of remanufactured cartridges are sold into the local market

Remanufactured products
- Faulty products are either repaired, replaced or refunded
- Remanufactured inkjet cartridges are 10-20% of the price of new
- Remanufactured toner cartridges are 60-75% of the price of new

25 Information from interview with Mr Daniel Wong, Master Franchisee (2013)
Figure 8: Case study - Prota Remanufacturing Sdn Bhd

Prota Remanufacturing Sdn Bhd

Company background – has been remanufacturing cartridges for 8 years
- Remanufactures approx. 16,000 toner cartridges/year
- Estimated 15% market share in remanufactured toner cartridges
- 100% of company business is in remanufacturing
- 26 employees

Remeanufacturing markets
- Used cartridges are sourced via agents. Empty cartridges are purchased in the local market for RM1 to 30, or if there is an insufficient supply, core may be imported from Thailand and Singapore
- Replacement components are imported from China, Japan and Thailand
- 75% of remanufactured cartridges are sold into the local market and 25% are exported

Remanufactured products
- Cartridges provided to the local market are guaranteed to provide up to 80% of the original toner coverage
- Export cartridges are not guaranteed but instead an additional 3% of units are shipped to replace any defective cartridges
- Remanufactured cartridges are 30-70% of the price of new

26 Information from interview with Mr Chris Kay, General Manager (2013)
2.2.4 Information and communication technology (ICT)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RM109 million</td>
<td>RM139 million</td>
<td>RM30 million</td>
</tr>
</tbody>
</table>

2.2.4.1 Introduction and background

In the ICT industry, remanufacturing activities are commonly described as ‘refurbishment’. This distinction is justified when the refurbishment process involves only the replacement of broken or obsolete components and/or the upgrade of software. However, in some cases, the refurbishment process - in particular that carried out by OEMs Dell, HP and Apple - represents formal remanufacturing, with an as-new warranty provided for each product. For the rest of this section, we will distinguish between remanufacturing (whereby products are supplied with an ‘as-new’ warranty) and refurbishing (whereby products are supplied with a lower, or no, warranty).

Remanufacturing appears to be limited to OEM activities, while refurbishment is practised by third-party organizations. OEM activities exist for both the business and personal computer markets: the HP Renew programme offers remanufactured servers, blades, storage and networking systems for the business market, while Dell Outlet serves individuals.

Larger third-party refurbishment organizations work with local businesses to collect end-of-life ICT stock and supply them with refurbished systems. Organizations may offer both rental and ownership business models to make their products more accessible to their customers, and trade-in incentives can help secure a ready supply of core. At the lowest end of the scale, small-scale refurbishers operate all over the economy, often concentrated in shopping malls, refurbishing and reselling ICT equipment to individual consumers.

Table 9: ICT market segmentation

Source: Oakdene Hollins, 2013

<table>
<thead>
<tr>
<th>Consumer</th>
<th>Consumer characteristics</th>
</tr>
</thead>
</table>
| Large corporations/organizations| **Requirements**: Large volumes, high performance, comprehensive technical support, short lead times  
|                                 | **Likely purchasing decisions**: Purchase new OEM equipment with support package          |
| SMEs                            | **Requirements**: Small to medium volumes, moderate performance, basic technical support  
|                                 | **Likely purchasing decisions**: Purchase or lease new or refurbished                      |

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Microsoft distinguishes between Authorized Refurbishers and Registered Refurbishers, as shown in Figure 9, which lists the one authorized refurbisher and six registered refurbishers located in Malaysia.

**Figure 9: Refurbishers listed in Microsoft directory**

![Refurbishers listed in Microsoft directory](http://www.microsoft.com/RefurbishedPCs/Directory.aspx)

The practice of ICT refurbishment is not constrained to the commercial market. ICT refurbishment programmes run by non-governmental organizations (NGOs) are able to donate valuable equipment to charities and other organizations that would otherwise not have access to computers.

### Domestic market

The size of the domestic market for consumer electronics was approximately RM27.7 billion ($8.3 billion) in 2012. This consisted of computer hardware sales of RM9.0 billion ($2.7 billion), audio visual sales (e.g. televisions and digital cameras) of approximately RM13.3 billion ($4.0 billion) and mobile telephone handset sales of RM5.3 billion ($1.6 billion).

An e-waste inventory project conducted in 2009 found no data were available on the volume of electrical and electronic equipment that is repaired and reassembled in Malaysia: therefore the size of the market for refurbished electronics is difficult to estimate. There is also no information on the export of used electrical and electronic equipment.

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30 Perunding Good Earth Sdn Bhd (2009) The E-waste inventory project in Malaysia
An approximation of the size of the domestic market for refurbished electronics can be made using the responses to the e-waste inventory questionnaire. Individual and business respondents were asked about the proportion of their electrical and electronic equipment that had been purchased new or second-hand. Their responses are summarized in Table 10.

Table 10: Percentage of electrical and electronic equipment purchased new or second-hand

<table>
<thead>
<tr>
<th>Product</th>
<th>Individuals</th>
<th></th>
<th>Businesses</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New</td>
<td>Second-hand</td>
<td>New</td>
<td>Second-hand</td>
</tr>
<tr>
<td>Personal computer</td>
<td>98.5%</td>
<td>1.5%</td>
<td>96.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Television set</td>
<td>95.2%</td>
<td>4.8%</td>
<td>91.1%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Mobile telephone</td>
<td>99.6%</td>
<td>0.4%</td>
<td>91.2%</td>
<td>8.8%</td>
</tr>
</tbody>
</table>

Using certain approximations\(^{31}\), the size of the refurbished ICT industry in 2012 is estimated to be RM109 million ($32.8 million).

2.2.4.3 Import market

Importing refurbished ICT products is not prohibited; however, refurbished products must fulfill several criteria to prevent electronic waste from being imported. The Department of Environment has issued a guide for the classification of used electrical and electronic equipment in Malaysia. The criteria for determining whether used electrical and electronic equipment can be imported are shown in Appendix D. Based on these criteria, refurbished ICT products less than three years old and destined for re-use (and not recycling or disposal) can be imported, subject to approval from the Department of Environment.

The Microsoft refurbisher directory lists 27 registered refurbishers from outside Malaysia that supply products to Malaysia, confirming that refurbished ICT products are currently being imported into the economy; however, a condition of the refurbisher license is that these imports are for donation purposes only.

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\(^{31}\) An approximation for the size of the refurbished ICT market is estimated assuming:
- The overall percentage of second-hand purchases is the mean of the individual and business value
- 25% of second-hand purchases have been refurbished
- The value of a refurbished unit is 30% of the value of a new unit
- The value of a second-hand unit is 15% of the value of a new unit
- The characteristics for personal computers, television sets and mobile telephones can be used as a proxy for overall computer hardware, audio visual and mobile telephone handsets sales
2.2.4.4 Environmental benefits

The environmental benefits of remanufacturing or refurbishing ICT equipment can be significant, due to the large amount of energy required to manufacture complex electronic components. Table 11 shows the environmental impact of manufacturing ICT equipment. The average lifespan of a personal computer in Malaysia is approximately five years\(^\text{32}\); this lifespan can be used as a proxy for the average lifespan of ICT equipment in general. If we assume ICT equipment is refurbished after three years and 10% of components are replaced before being used for another three years, the difference in emissions averaged over the life of the item is shown in Table 11. Refurbishment results in approximately a 10% reduction in annual emissions over the lifespan of the product.

Table 11: Environmental impact of ICT equipment

*Source: EcoInvent Lifecycle Inventory\(^\text{33}\); Aoe, 2003\(^\text{34}\); PE International, 2008\(^\text{35}\)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Life cycle emissions</th>
<th>Annual emissions (5 year life)</th>
<th>Annual emissions (6 year life with refurbishment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRT screen</td>
<td>243 kg CO(_2)e /screen*</td>
<td>49 kg CO(_2)e /screen</td>
<td>45 kg CO(_2)e /screen</td>
</tr>
<tr>
<td>Desktop</td>
<td>262 kg CO(_2)e /desktop*</td>
<td>52 kg CO(_2)e /desktop</td>
<td>48 kg CO(_2)e /desktop</td>
</tr>
<tr>
<td>Laptop</td>
<td>226 kg CO(_2)e /laptop*</td>
<td>45 kg CO(_2)e /laptop</td>
<td>41 kg CO(_2)e /laptop</td>
</tr>
<tr>
<td>LCD screen</td>
<td>319 kg CO(_2)e /screen*</td>
<td>64 kg CO(_2)e /screen</td>
<td>58 kg CO(_2)e /screen</td>
</tr>
<tr>
<td>Laser jet printer</td>
<td>70 kg CO(_2)e /printer*</td>
<td>14 kg CO(_2)e /printer</td>
<td>13 kg CO(_2)e /printer</td>
</tr>
<tr>
<td>Television</td>
<td>1000 kg CO(_2)e /TV†</td>
<td>200 kg CO(_2)e /TV</td>
<td>183 kg CO(_2)e /TV</td>
</tr>
<tr>
<td>Mobile phone</td>
<td>30 kg CO(_2)e /phone†</td>
<td>6 kg CO(_2)e /phone</td>
<td>5.5 kg CO(_2)e /phone</td>
</tr>
</tbody>
</table>

* Cradle-to-gate emissions; † Cradle-to-grave emissions

As for the vehicle components industry, without a bottom-up estimate of the volumes of refurbished ICT products, we cannot accurately calculate the environmental benefits of refurbishment. However, as an initial estimate, if we assume an average refurbished product price of RM1,000, RM250 and RM125 for a personal computer, television set and mobile


\(^{33}\) EcoInvent Lifecycle Inventory, calculated using the Impact2002+ method


\(^{35}\) PE International (2008) Environmental footprint of ICT equipment in manufacture, use, and end-of-life. Presentation held at ECOC Brussels, Belgium, Sept 23
telephone respectively, this corresponds to sales of 173,000 computers, 292,000 televisions and 153,000 mobile handsets in 2012. If an average refurbished product has a mass of 5kg, 30kg and 150g for a personal computer, television set and mobile telephone respectively, refurbishment delays the disposal of approximately 8,860 tonnes of material\textsuperscript{36} and saves 30,600 tonnes CO\textsubscript{2}e over a six year lifespan.

\subsection*{2.2.4.5 Growth potential}

The growth potential for the ICT sector in Malaysia can be estimated by comparison with the contribution from ICT refurbishment/remanufacturing in a mature remanufacturing economy. In the USA, sales of refurbished/remanufactured information technology (IT) products are estimated to make up no more than 0.5\% of total sales.\textsuperscript{3} Using this approximation, the potential size of the refurbished ICT market in Malaysia in 2012 could be RM139 million ($41.5 million).

\textsuperscript{36} 90\% of the total mass, as 10\% are assumed to be replaced during refurbishment
2.2.4.6 Case studies

Figure 10: Case study - SOLS Tech

SOLS Tech

Organization background – has been refurbishing ICT equipment for 9 months.
- Collected approx. 250 units in July 2013
- Organization also provides free IT courses to disadvantaged students
- Current stock of about 300 computers
- Has 10 staff, including some volunteers
- Provides software through the Microsoft Authorized Refurbisher and Tech Soup

Refurbishment process
- Collects end-of-life equipment from corporations and individuals
- Donated equipment undergoes component upgrade, data wiping and software installation
- Obsolete equipment is used to provide spare parts for other machines
- Software is installed, process aims for at least Windows 7 functionality

Refurbished products
- Donated to charities, or needy communities and organizations
Figure 11: Rentwise case study

Rentwise

**Company background** – has been refurbishing equipment for over 10 years
- Refurbishes approximately 1000 units per year
- Offers leasing arrangements for both new and refurbished equipment
- Equipment refurbishment is the main activity for the business
- 60 employees

**Refurbishment process**
- Equipment for refurbishing is imported from countries like the U.S. and Denmark
- All replacement components are imported
- Incoming equipment is audited and classified into one of three quality grades, from grade A (cosmetic damage) to grade C (component replacement)
- Refurbished equipment is tested and sent for quality assurance

**Refurbished products**
- Refurbishes PCs, servers, printers and network equipment
- No warranty provided, but faulty equipment is repaired or replaced within 24 hours
2.2.5 Aerospace

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>RM3.4 billion</td>
<td>RM13.4 billion</td>
<td>RM10 billion</td>
</tr>
</tbody>
</table>

2.2.5.1 Introduction and background

The global aerospace industry has an active maintenance, repair and overhaul (MRO) division. As described in Table 1, overhaul activities are typically scheduled throughout a product’s life; however, the characteristics of the overhaul process and subsequent product performance are often similar to that of remanufacturing.

There are many MRO organizations active in Malaysia, as shown in Table 12.

Table 12: MRO organizations in Malaysia

Source: [http://www.airlineupdate.com/content_subscription/mro/southeastasia/malaysia.htm](http://www.airlineupdate.com/content_subscription/mro/southeastasia/malaysia.htm)

<table>
<thead>
<tr>
<th>Name</th>
<th>MRO activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR Landing Gear Services Sdn Bhd</td>
<td>Component/systems maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
<tr>
<td>Airfoil Service Sdn Bhd</td>
<td>Engine and auxiliary power unit (APU) maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
<tr>
<td>Airod Sdn Bhd</td>
<td>Airframe heavy maintenance</td>
</tr>
<tr>
<td></td>
<td>Engine and APU maintenance</td>
</tr>
<tr>
<td></td>
<td>Component/systems maintenance</td>
</tr>
<tr>
<td></td>
<td>Avionics maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
<tr>
<td></td>
<td>Aircraft modification</td>
</tr>
<tr>
<td></td>
<td>Aircraft line maintenance</td>
</tr>
<tr>
<td></td>
<td>Helicopter MRO</td>
</tr>
<tr>
<td>CTRM Sdn Bhd</td>
<td>Airframe heavy maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
<tr>
<td>GE Engine Service - Malaysia</td>
<td>Engine and APU maintenance</td>
</tr>
<tr>
<td>GE On Wing Support – Kuala Lumpur</td>
<td>Engine and APU maintenance</td>
</tr>
<tr>
<td>Hamilton Sundstrand</td>
<td>Component/systems maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
<tr>
<td>Honeywell Aerospace Services</td>
<td>Component/systems maintenance</td>
</tr>
<tr>
<td>MAS Engineering &amp; Maintenance</td>
<td>Airframe heavy maintenance</td>
</tr>
<tr>
<td></td>
<td>Repair services</td>
</tr>
</tbody>
</table>
Unlike the other industries examined, overhaul in the aerospace sector is a highly regulated. To conduct MRO activities, an organization must receive certification from the aviation authority in the economy or region of registration for every aircraft that it processes. The certification process requires the organization to demonstrate how its standard operating procedures fulfill the legal requirements for each aviation authority and the facilities will be audited, first as part of the certification process, and subsequently to ensure ongoing compliance.

The MRO industry in Malaysia is considered to be of strategic importance to the Malaysian economy. The industry is one of those identified in Malaysia’s Economic Transformation Programme and there are incentives for investment in the industry, e.g. income tax exemption.37

### 2.2.5.2 Domestic market

Malaysia is one of the top three economies in Asia-Pacific for MRO activities, along with Singapore and Hong Kong China. In 2012, the revenue for MRO activities was divided between airframe MRO (RM1,239 million), engine MRO (RM750 million) and component MRO (RM1,404 million).38 There is expected to be a 10% growth in revenue in 2013 compared to 2012.39

### 2.2.5.3 Import market

The international nature of aerospace means that assets - and many of the aerospace companies that own them - are based overseas. All overhaul activity occurring within the domestic market will contain both core sourced locally and internationally. Overhauled core will be sent for export as part of a plane or sent to local operators. As a consequence the import market for this

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sector cannot be effectively separated from the domestic market, which contains activities for both local and international markets.

2.2.5.4 Environmental benefits
Overhaul activities within the aerospace industry are part of the normal maintenance cycle for the product. Therefore, while the product overhaul may preserve embodied material and energy, and restore in-use energy efficiency, no net environmental benefit is attributed to the overhaul process.

2.2.5.5 Growth potential
The MRO industry in Malaysia is an area of active growth, driven by growth in both the local aerospace market and the wider Asia-Pacific market. Market research suggests that in the Asia-Pacific region the demand for engine services is increasing by 8.5% per annum (p.a.), the demand for airframe services is increasing by 5.5% p.a. and the demand for airframe modification services is increasing by 6.6% p.a. All of these increases are being driven by the growth of passengers in the region, of 7-8% p.a.\(^{39}\) The current revenue for MRO activities in the Asia-Pacific region is approximately RM46.5 billion per year.\(^{39}\) MRO activities in Malaysia could not only increase their contribution to this market, but also expand its markets in Europe, the USA and the Middle East; a strategy already being pursued by some organizations.

As part of Malaysia’s Economic Transformation Programme (ETP), one of the entry-point projects for the business services sector is growing aviation maintenance, repair and overhaul services. The ambition is that, by 2020, Malaysia will be a regional hub for MRO activities, and will generate revenue of RM13.4 billion per year ($0.4 billion), and provide nearly 21,000 jobs.\(^{40}\)

2.2.5.6 Case study

Figure 12: GE case study

GE Engine Services

Company background
- Overhauls approximately 100 engines per year
- 250 highly skilled employees
- Accredited by 9 aviation authorities

Overhauled engines
- Overhauled performance is comparable with a new engine
- Warranty slightly less than for a new engine – the new engine warranty guarantees hardware durability, while the overhauled engine warranty guarantees the quality of the workmanship
- 4 to 8 years between engine overhaul
- Each engine may undergo 3 to 4 overhaul cycles during its life

Overhaul process
- Engines disassembled, cleaned, inspected, assembled, and tested on site; repair undertaken in Singapore facilities
- Engines may require disassembly into 25,000 components
- Non-destructive testing methods used to identify surface cracks in components
- Overhaul process takes between 50 and 80 days, depending on the engine type
2.3 SUMMARY AND NATIONAL ESTIMATE

The current and potential size of the market for remanufactured goods in Malaysia is summarized in Figure 13, for the four product categories investigated in this research.

Figure 13: Current and potential size of the market for remanufactured goods in Malaysia

Source: Oakdene Hollins, 2013

For the remanufacturing industry to realize the growth potential illustrated above, the industry must overcome the barriers to remanufacturing that are currently constraining it. These barriers are explored in the following section.
3 Barriers to remanufacturing

This section will explore the barriers currently facing remanufacturers in Malaysia and the challenges that may face a growing and transforming remanufacturing industry.

3.1 COMMON BARRIERS

The following provides a list of barriers that we identified that were common to all sectors of the remanufacturing industry in Malaysia:

- **Workforce skills and specialist equipment** – the skills required in remanufacturing are demanding; a remanufacturing workforce will need to develop specialist engineering skills to ensure that each individual remanufactured product is restored to its original or better functionality. Specialist test equipment is also needed to ensure that the products meet the ‘as-new’ tolerances and performance requirements. This equipment is usually either bespoke or expensive.

- **Parts proliferation** – remanufactured products are typically complex and a wide variety of parts may be used. The challenge to a remanufacturer is to maintain sufficient stock of a wide range of components to meet the market demand.

- **Cores** – maintaining a steady and sufficiently large supply of core is important for establishing a viable remanufacturing industry. Without this supply, remanufacturers cannot benefit from economies of scale or schedule their operations efficiently.

- **Customer perceptions** – for remanufactured products to gain acceptance from consumers and to generate sufficient market demand, customers need confidence in their quality. If consumers perceive remanufactured products to be high quality, with ‘as-new’ or better performance, then they may be willing to pay a premium compared to second-hand products.

- **Product and operating standards** – currently, the remanufacturing industry is largely unregulated with few standardized operating or testing procedures. Standards will allow the quality of remanufactured components to be brought up to a consistent and high level. This will provide consumer confidence and build markets for remanufactured products. It will also enable appropriate policy measures to be used to differentiate ‘genuine’ remanufactured products.

- **Industry representation** – few remanufacturing or refurbishing activities in Malaysia are represented by national trade associations. These organizations can play an important role in self-regulation of the industry and facilitating communication between the industry and policy makers.

3.2 VEHICLE COMPONENT REMANUFACTURE

The Review of the National Automotive Policy (NAP) in 2009 has two important implications for the import of automotive core for remanufacturing:
• The review advocated the gradual phase-out of imported used parts and components because of safety and environmental concerns. The first stage of this ban came into effect in June 2011 and prohibited the import of used brake linings, brake pads, batteries and tyres. 14
The updated NAP is expected to be released this year and statements from trade bodies concerning the likely content of the NAP 41 have suggested that the ban on importing used components is set to be lifted for most components, conditional on the implementation of standards for ensuring their safety. As a result, the industry is working on a framework for ensuring that safety standards are developed. 41

• A barrier to import remanufactured automotive components is the implicit assumption, voiced by automotive representatives, that remanufactured components would be classified as used components. **Error! Bookmark not defined.** While we did not observe a formal definition of this categorization in the regulations or policy we reviewed, and there are no specific tariff headings for remanufactured automotive components, re-education of industry and border officials may be necessary if Malaysia were to join the APEC Pathfinder to ensure that imported remanufactured products are categorized as ‘new’ products.

### 3.3 PRINTER CARTRIDGES

The barriers to remanufacturing of printer cartridges are mostly common between both inkjet and toner cartridges. We have identified the following barriers:

• **Compatible cartridges** – the prevalence of illegal compatible cartridges, i.e. cartridges that are infringing patents or other intellectual property, are competing directly with remanufactured cartridges.

• **Counterfeit cartridges** – the production of counterfeit cartridges reduces the supply of core for legitimate remanufacturing activities. As counterfeit producers are able to achieve a higher profit margin that remanufacturers, they can also afford to pay a higher price for core.

• **Consumer perceptions** – cartridge remanufacturers have an ongoing challenge in educating consumers as to what a remanufactured cartridge is, and building their trust in the quality of the product.

### 3.4 ICT

The main barrier from legitimate third party remanufacturers is the cost of installing legitimate software. Third party remanufacturers who install pirated software onto refurbished computers have a significant unfair advantage. This practice has been widespread, using the latest figures, 2006, an estimated RM963 million ($289 million) of revenue was lost due to software piracy. 42 Enforcing software licensing laws will benefit legitimate ICT remanufacturers.

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42 Business Software Alliance (2007) Fourth annual BSA and IDC global software piracy study
A barrier to the sale of remanufactured products to SMEs is the cost differential between refurbishment and replacement. The low replacement cost of some ICT equipment makes it harder for refurbishers to compete on price. However, there are SMEs in Malaysia for which the cost of new equipment is prohibitive, and refurbishers that provide leasing options for their customers can fill a gap in the market.

The guidelines for classifying used electrical and electronic equipment prevent the import of used ICT products over three years old; this restriction includes refurbished products. The guidelines also restrict the import of core: only ICT equipment imported for direct re-use is permitted.

### 3.5 AEROSPACE

The aerospace industry and Malaysian policy makers are actively engaged in promoting MRO services in the industry; however, there are still challenges to face. There are few barriers specific to the aerospace sector. However, several wider barriers are particularly acute for this sector. These include:

- A shortage of skilled workforce is particularly acute for this industry. MRO activities require highly skilled and well-trained personnel to undertake safety-critical operations. GE Engine Services notes that many of its employees have over 10 years of experience in the industry. The need to develop and certify highly qualified employees to meet the projected growth in demand has led to the development of an on-line platform to more efficiently examine aircraft engineering students.

- High capital equipment costs. For example, GE Engine Services is currently limited by the capacity of its engine test cell facility. It cannot test some of the most powerful engines currently in use; therefore these engines must be overhauled at other facilities. However, until there is sufficient demand for engine MRO services, it is not economic to develop a repair capability in Malaysia.

A solution to these problems will include foreign investment; the challenge is to encourage overseas investment into the industry; for example, through financial incentives.

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43 Department of Environment (2010) Guidelines for the Classification of User Electrical and Electronic Equipment in Malaysia
4 Recommendations and opportunities for expanding remanufacturing

Throughout this research, common themes emerged that could benefit the Malaysian remanufacturing industry in these - and other - product categories. Our recommendations based on these overarching themes are:

- Develop standards for both remanufactured products and remanufacturing processes. These standards can promote consistency and high quality across remanufactured products.
- Develop a universal definition for the term ‘remanufacturing’ and use this to educate consumers, producers and policy makers about the characteristics and benefits of remanufactured products.
- Encourage the formation and/or development of trade associations to represent remanufacturing industries for different product categories. These associations could facilitate the collection of industry data, which are currently lacking, and promote dialogue between industry and policy makers.
- Inform policy makers of the benefits of remanufacturing and customs officials of where remanufacturing differs from re-use and refurbishment.
- Promote the benefits of remanufactured products to procurers (in particular institutional and large corporations).

Our recommendations for the vehicle component industry are:

- Continue dialogue with policy makers to integrate the industry with the development of an End-of-Life Vehicle Directive.
- Identify market niches for promoting remanufactured components. For example, remanufactured aftermarket components could represent a cost-effective alternative to new parts, when paying for repairs to older vehicles under an insurance claim. Remanufactured
components would incur a lower ‘betterment fee’\textsuperscript{44} but would have the same functionality and warranty as a new franchise component.

Our recommendations for the printer cartridge industry are:

- Continue to educate consumers about the differences between remanufactured and refilled cartridges.
- Focus remanufacturing efforts on high value and complex cartridges, i.e. toner cartridges.
- Concentrate on preventing illegal activities in this area.

Our recommendations for the ICT industry are:

- Develop a trade association for ICT refurbishers to represent and self-regulate the industry.
- Promote the benefits of using legitimate software to consumers and encourage action against pirated software.
- Consider offering open-source platforms, e.g. open-source operating systems, as a legitimate and low-cost product offering.
- Supplement hardware offerings with value-adding services, e.g. technical support, training, leasing options.

Our recommendations for the aerospace industry are:

- Liaise with local educational institutions to ensure current and future courses are providing students with the skills necessary to enter the industry.
- Continue to promote Malaysia as a regional hub for MRO activities to foreign companies and encourage investment.
- Continue to expand the potential client base by pursuing certification from additional aviation authorities.

\textsuperscript{44} Under current motor insurance policies, when paying for repairs under an insurance claim, for vehicles under five years old, the insurer will pay for the vehicle to be repaired with new franchise parts. However, for vehicles over five years old, customers are required to pay a ‘betterment fee’ if they want their vehicle to be repaired using new parts. This ‘betterment fee’ is a percentage of the new part cost and increases with the age of the vehicle, e.g. the betterment fee for a six year old vehicle is 20%, and 30% for an 8 year old vehicle. If the customer does not want to pay the betterment fee, the vehicle will be repaired using second-hand parts.\textsuperscript{41}
5 Summary and implications for the remanufacturing Pathfinder

This report provides an overview of selected remanufacturing areas within the Malaysian economy. Part of the reason for commissioning this report was to provide evidence to Malaysian officials on the benefits of remanufacturing to their economy. This evidence is also to aid in developing a national position on joining the APEC Pathfinder on remanufacturing. This section discusses relevant points from the research.

The environmental case for remanufacturing is generally good. The carbon benefits from saving the form and function of a product are well documented. There are also significant material savings including critical raw materials (including rare earths\(^45\)). Therefore, from an environmental perspective, any efforts to increase remanufacturing should be supported. However, the economic case for supporting the Pathfinder and encouraging remanufacturing needs consideration of the impact of remanufacturing on domestic manufacture of new products.

Generally, remanufacturing is positive for an economy.\(^12\) In a developed economy, it provides a means to gain customer loyalty and minimizes capital outlay improving domestic and international competitiveness. In developing economies, it can be an enabler for products that would otherwise be out of the means of a portion of the population and maximizes the use of scarce or expensive resources. Remanufacturing also provides high quality jobs and skills.

Overall, in Malaysia, we found that the amount of genuine remanufacturing being undertaken was relatively low, with a large portion of the industry devoted to other ‘grades’ of re-use. Historically, we have seen that most re-use activities occur out of a business opportunity. Within individual companies, these activities slowly become more formalized until full remanufacturing is performed. The evidence identified within this study suggests that a similar process is happening across selected sectors of the entire Malaysian economy. It is likely that the amount of remanufacturing occurring within Malaysia will increase at the expense of refurbishment and reconditioning. Therefore, encouraging remanufacturing will help speed this process.

In Malaysia, there was no standard definition of remanufacture or remanufactured products. This led to significant market confusion. In particular, the difference between ‘remanufactured’,

\(^{45}\) Oakdene Hollins (2011) Study into the feasibility of protecting and recovering critical raw materials through infrastructure development in the south east of England
‘refurbished’ and ‘reconditioned’ was not well defined. This had a larger effect that many remanufactured products are classed as ‘used’.

Without an agreed definition of remanufactured products, imports and exports were usually classed as ‘reconditioned’, ‘refurbished’ or ‘used’. We found significant barriers to trade for products coming under these classifications; this informational barrier could be mitigated by a commitment to the re-education of policy makers, border officials and other actors that remanufactured products should be classified as ‘new’ and not ‘used’. In addition to the lack of a definition for ‘remanufacturing’, reasons for these barriers included protecting home markets and dumping of waste under the guise of re-use.

Although not fully explored within this study, the lack of clarity over definition may have additional implications for customs officials and border staff who process products into and out of Malaysia.

We found no direct evidence specifically preventing the trade, shipment or sale of remanufactured goods. Furthermore, we found little mention of remanufactured products within the legislature for the product categories investigated.

Our figures suggest that remanufacturing currently contributes RM3.8-4.0 billion ($1.2 billion) to the Malaysian economy. We estimate that this could increase to RM14.3-14.5 billion ($4.3 billion). The majority of these activities would not be affected by the Pathfinder which focuses on international trade (most of the evidence gathered was on domestic consumption and production). The benefit of the Pathfinder from Malaysia’s perspective is the possibility to open up new international markets for goods remanufactured in Malaysia. This is most advanced within the aerospace sector which operates internationally. Access to these foreign markets is a major incentive to join the Pathfinder. Remanufacturers would welcome the opportunity to export their products, particularly as they have, to date, experienced barriers in this area.

There are concerns from industry and officials that joining the Pathfinder and increasing the use of remanufactured products will have a negative effect on the sale of domestically manufactured new products. However, although counter-intuitive, remanufactured products may lead to an increase in sales of new goods rather than a cannibalization. Purchasing remanufactured goods usually lead to sales in markets not covered by new goods, cannibalizing markets such as reused components or low-quality imports. Within Malaysia, increasing remanufacturing may also have the following effects on the market:

- Displacement of the sale of imported low cost manufactured goods, which leads to a positive effect on the trade.

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46 This issue was recently discussed at eScrap conference September 2013, Orlando Fl, by Microsoft’s Sean Nicholson.
• Opening of new domestic markets where the price of new goods were too high, thus improving personal wellbeing and competitiveness of firms (deemed Positive Externalities).

Joining the Pathfinder would also encourage the development of a properly regulated remanufacturing industry and could have the additional benefit of displacing illegitimate activities by providing high quality, low cost alternatives.

Becoming a member of the Pathfinder would be a good first step to encourage remanufacturing and may lead to some of the benefits described in section 1.1. However, for the full potential of remanufacturing to be reached, several additional areas would need to be addressed (both on the national and international stage). These include:

• The development of a standard definition and expected work on remanufactured products.
• Education of policy makers and border officials on remanufactured products.
• Removal of poor practitioners from the marketplace.
• Development of robust industry representation to help legitimize the domestic remanufacturing market.

Even with these limitations and concerns, the timing for joining the Pathfinder is consistent with the Malaysian government’s commitment to the aerospace overhaul sector and the current transition and legitimization of the automotive remanufacturing industry. The APEC community could also assist in addressing some of the above concerns, for example, assisting in the identification of authentic remanufactured products through labelling, and the assurance of performance against product specifications. The Pathfinder could help shape the national debate and provide engagement with the remanufacturing community.

In summary, a key aim of this work was to help Malaysia develop a national position on joining the Pathfinder. This research shows that the nascent benefits of remanufacturing could significantly boost the Malaysian economy. However, to realize those benefits additional national measures would need to be enacted in addition to joining the Pathfinder. Joining the Pathfinder would be a positive move to help shape internal policy around addressing key issues that face the industry and could ultimately lead to the potential benefits identified in the report. As such, we would recommend that Malaysia considers developing a formalized remanufacturing industry, including joining the Pathfinder.
6 Appendix A

6.1 LIST OF ON-SITE INTERVIEWS
The following companies and organizations were visited during this study.

Table 13: Organizations visited during the study

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>GE Engine Services Malaysia</td>
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<tr>
<td>Malaysia Automotive Institute</td>
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<tr>
<td>Malaysia External Trade Development Corporation</td>
</tr>
<tr>
<td>Malaysia Institute of Transport (Universiti Teknologi MARA)</td>
</tr>
<tr>
<td>Ministry for International Trade and Industry</td>
</tr>
<tr>
<td>Motor Teknologi &amp; Industri</td>
</tr>
<tr>
<td>Prota Remanufacturing Sdn Bhd</td>
</tr>
<tr>
<td>SOLS Tech</td>
</tr>
<tr>
<td>Universiti Teknologi Malaysia</td>
</tr>
</tbody>
</table>
7 Appendix D

7.1 CRITERIA FOR THE DETERMINATION OF E-WASTE (IMPORTS)

This appendix is based on Annex A from the Guidelines for the Classification of User Electrical and Electronic Equipment in Malaysia, produced by the Department of Environment. This table presents information relevant to importing electrical and electronic equipment (exportation information is not included).

Paragraph 1 – The following categories of used electrical and electronic equipment or components are not classified as e-waste:

- “Electrical and electronic components which are not contaminated or non-dispersible form such as metal or plastic casing of computer;”

- Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) which are less than three (3) years from the date of manufactured that are functioning and destined for direct re-use, and not for recycling or recovery or final disposal;

- New and unused electrical and electronic equipment or components made in Malaysia that are returned by the importing economies as defectives items;

- New electrical and electronic equipment or components made in Malaysia that are returned as defective units for repair to the manufacturer (under warranty) with the intention of re-export;

- Blank wafers or non-patterned wafers or test wafers; and

- Off-cut lead or copper frames not contaminated with heavy metals such as cadmium, mercury, lead, nickel, chromium, copper, lithium, silver and manganese or polychlorinated byphenyl.”

Paragraph 2 – “Used electrical and electronic equipment or components is defined as e-waste if it has any of the following criteria:

- A defect that materially affects its functionality. (…)

- Physical damage that impairs its functionality or safety, as defined in the specification. (…)

- A faulty hard disc drive and a faulty Random Access Memory (RAM) and a faulty Video Card; or

- Batteries made with lead, mercury or cadmium or lithium or nickel that are unable to be charged or to hold power; or
- Insufficient packaging to protect it from damage during transportation, loading and unloading operations; or

- The appearance of the equipment or components are generally worn or damaged, thus reducing the marketability of the equipment; or

- The electrical and electronic equipment or components are destined for recycling or recovery or disposal; or

- The electrical and electronic equipment or components are discarded, or are intended or are required to be discarded; or

- There is no regular market for the used electrical and electronic equipment or components; or

- The used equipment or components are old and out dated, and destined for salvaging purpose; or

- End-of-life electrical and electronic equipment; or

- More than three years (3) from the date of manufactured (for imports); or

- Products / goods produced by partially e-waste recovery facilities.”

Table 14: Criteria for the determination of e-waste

Source: Modified from Annex A of the Guidelines for the Classification of User Electrical and Electronic Equipment in Malaysia

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Is the equipment or component covered in paragraph 1 above?</td>
<td>YES</td>
<td>The equipment or component is not categorized as e-waste and can be imported, subject to approval from the Department of Environment.</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>Go to Q2</td>
</tr>
<tr>
<td>Q2. Is the equipment or component destined</td>
<td>YES</td>
<td>The equipment is categorized as e-waste.</td>
</tr>
</tbody>
</table>
for recycling\textsuperscript{47} or recovery\textsuperscript{48} or disposal\textsuperscript{49}? & NOT ALLOWED to be imported. \\
NO & Go to Q3 \\
\hline
Q3. Is the age of the equipment or component more than 3 years from the date of manufacture? & YES & The equipment is categorized as e-waste. \\
& & NOT ALLOWED to be imported. \\
& NO & Go to Q4 \\
\hline
Q4. Is the equipment or component destined for direct re-use\textsuperscript{50}? & YES & Go to Q5 \\
& NO & The equipment is categorized as e-waste. \\
& & NOT ALLOWED to be imported. \\
\hline
Q5. Has the equipment or component been tested and found to have any fault as listed in paragraph 2 & YES & The equipment is categorized as e-waste. \\
& & NOT ALLOWED to be imported. \\
& NO & Go to Q6 \\
\hline
Q6. Has the result of the testing been documented and does not indicate any of the faults listed as in paragraph 2, and also certified by a competent authority or certified body or relevant agency in the economy of export? & YES & The equipment or component is not categorized as e-waste and can be imported, subject to approval from the Department of Environment. \\
& NO & The equipment is categorized as e-waste. \\
& & NOT ALLOWED to be imported. \\
\hline

\textsuperscript{47} Guideline definition: “removing or using the material from the manufactured equipment as part of raw materials for new products or components.”\textsuperscript{43} \\
\textsuperscript{48} Guideline definition: “any operation for the purpose of retrieval of valuable material or product from e-waste”\textsuperscript{43} \\
\textsuperscript{49} Guideline definition: “method of final disposition, final placement or destruction of e-waste”\textsuperscript{43} \\
\textsuperscript{50} Guideline definition: “any operation by which discarded electrical or electronic equipment or components are used for the same purpose for which they were conceived, including the continued use of the whole systems or components”\textsuperscript{43}
# 8 Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>APU</td>
<td>auxiliary power unit</td>
</tr>
<tr>
<td>APEC</td>
<td>Asia-Pacific Economic Cooperation</td>
</tr>
<tr>
<td>CO₂e</td>
<td>the global warming potential of a greenhouse gas expressed in terms of the amount of carbon dioxide required to produce the same effect</td>
</tr>
<tr>
<td>E-waste</td>
<td>electronic waste</td>
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<tr>
<td>ETP</td>
<td>Economic Transformation Programme</td>
</tr>
<tr>
<td>FEMPTAM</td>
<td>Federation of Engineering and Motor Parts Trader’s Association Malaysia</td>
</tr>
<tr>
<td>ICT</td>
<td>information and communication technology</td>
</tr>
<tr>
<td>IT</td>
<td>information technology</td>
</tr>
<tr>
<td>MAA</td>
<td>Malaysian Automotive Association</td>
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<tr>
<td>MAARA</td>
<td>Malaysian Automotive Recyclers Association</td>
</tr>
<tr>
<td>MAI</td>
<td>Malaysian Automotive Institute</td>
</tr>
<tr>
<td>MITI</td>
<td>Ministry of International Trade and Industry</td>
</tr>
<tr>
<td>MRO</td>
<td>maintenance, repair and overhaul</td>
</tr>
<tr>
<td>MTI</td>
<td>Motor Teknologi &amp; Industri</td>
</tr>
<tr>
<td>NAP</td>
<td>National Automotive Policy</td>
</tr>
<tr>
<td>NGO</td>
<td>non-governmental organization</td>
</tr>
<tr>
<td>OEM</td>
<td>original equipment manufacturer</td>
</tr>
<tr>
<td>p.a.</td>
<td>per annum</td>
</tr>
<tr>
<td>SME</td>
<td>small or medium enterprise</td>
</tr>
</tbody>
</table>
Units Conventional SI units and prefixes used throughout: \{k, kilo, 1,000\} \{M, mega, 1,000,000\} \{G, giga, 109\} \{kg, kilogramme, unit mass\} \{t, metric tonne, 1,000 kg\}

An exchange rate of RM1 to $0.30 has been used throughout this report.