University of Southern Queensland

Faculty of Engineering and Surveying

Recycling of Used Electronics in Singapore

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Abstract

Electronic waste is easily generated as people increasingly use electronic and electrical equipment in the daily life. Technology advances rapidly and this caused the life span of electronic products to become increasingly shorter. As a result, electronic wastes are rapidly generated in our industry and society. Electronic waste buried in landfills will cause toxins to leach into the environment. If they are incinerated, they produce noxious gases. In both ways, they pollute the environment and pose serious health threats to humans and also harm the wildlife. It will only be sustainable if electronic wastes are recycled.

This research project was carried out to assess the problem of recycling of used electronics in Singapore and the related environmental concerns. The harmful effects of electronic wastes as well as the relating problems in other countries are observed. An understanding is also made on the benefits of recycling of electronic wastes as well. Related authorities' and recycling company's information are reviewed to understand the generation, the disposal, the collection and the recycling of used electronics in the country. In an attempt to identify better solutions which could be effective to address the used electronics problems in Singapore, information is researched on global recycling of electronic waste.

Case studies were conducted to understand the management used in handling of used electronics in the companies. This provided a chance to observe the practices and subsequently identification of problems in a company. A survey of consumers was carried out to understand their attitudes and behaviours. This helped to identify the problems faced in the community to which used electronics were not actively recycled.

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Table of Contents

Abstract ..... **iii**

Certification ..... **v**

Acknowledgements ..... **vi**

List of Figures ..... **x**

List of Tables ..... **xii**

Chapter 1: Introduction **1**

1.1 Project Background 1

1.2 Outline of the Report 2

Chapter 2: Literature Review **3**

2.1 Introduction 3

2.2 Background of Recycling of Used Electronics 3

2.3 Electronic Waste in Other Countries 6

2.4 The Benefits of Recycling 10

2.5 Summary 13

Chapter 3: Methodology **14**

3.1 Introduction 14

3.2 Goal Definition 14

3.3 Scope Definition 14

3.4 Assumptions Used in Case Studies 16

Chapter 4: Singapore's Recycling **17**

4.1 Introduction 17

4.2 Singapore's Situation 17

4.3 Factors Leading to Used Electronics Generation 19

4.4 Waste Management 24
4.5 Conclusions 30

Chapter 5: The Process of Recycling in Singapore.....31

5.1 Introduction 31
5.2 The Collection of Used Electronics 31
5.3 Electronic Waste Recycling Companies in Singapore 36
5.4 Conclusions and Recommendations 41

Chapter 6: Management of Electronic Waste in Other Countries 43

6.1 Introduction 43
6.2 Management in the United States (US) 43
6.3 Management in Australia, Europe and Japan 47
6.4 Conclusions and Recommendations 50

Chapter 7: Case Studies on Companies in the Local Industry 52

7.1 Introduction 52
7.2 Methodology 52
7.3 Case Study Number 1 54
7.4 Case Study Number 2 60
7.5 Evaluation of Results 67
7.6 Conclusions 69

Chapter 8: Survey of Consumers 70

8.1 Introduction 70
8.2 Methodology 70
8.3 Results and Observations of the Survey 71
8.4 Key Findings and Recommendations 82
8.5 Conclusions 84

Chapter 9: Conclusions 85

9.1 Introduction 85

9.2 Summary of Achievements 85

9.3 Recommendations for Future Work 86

9.4 Final Conclusions 87

List of References 88

Bibliography 93

Appendix A – Project Specification 94

Appendix B – List of Computers of Manufacturing Company #2 96

Appendix C – Survey questionnaire 114

List of Figures

Figure 2.1: Young et al. Manufacturing and the Environment (1997, Vol 13, No.7, p.488)..... 6
Figure 2.2: An investigator taking a soil sample along a riverside in Guiyu, China. 8
Figure 2.3: Copper laminate (left) and IC lead frames (right) collected for recycling. 10
Figure 2.4: Operational flow chart of recycling (CH E-Recycling Pte Ltd, 2007).. 11
Figure 2.5: PGMs recovery and refining (Cimelia Resource Recovery Pte Ltd, 2007)..... 12
Figure 2.6: Copper sand (left) and bricks (right) (CH E-Recycling Pte Ltd, 2007). 12
Figure 4.1: Singapore's manmade offshore landfill - Semakau Landfill. 18
Figure 4.2: Domestic market composition by market segment, 2003 – 2006 (IDA). 19
Figure 4.3: Export market composition by market segment, 2003 – 2006 (IDA). .. 20
Figure 4.4: Home computer penetration in Singapore (IDA). 21
Figure 4.5: Number of computers at home (IDA)..... 22
Figure 4.6: Percentage of computer users (IDA). 23
Figure 4.7: NEA's representation of recycling rates by waste streams in 2005. 28
Figure 5.1: Recycling bin for paper, plastic bottles and metal cans..... 35
Figure 5.2: Recycling process of Centillion Environment & Recycling Limited, 2007. 37
Figure 5.3: Chemical process of Centillion Environment & Recycling Limited, 2007. 38
Figure 5.4: CRT recycling of Centillion Environment & Recycling Limited, 2007. 39
Figure 5.5: Incinerator of Centillion Environment & Recycling Limited, 2007..... 40
Figure 8.1: The percentage of the different age groups of the respondents. 72
Figure 8.2: The different job types of the respondents. 73
Figure 8.3: The percentage of the presence of environmental policy in the workplace. 73
Figure 8.4: Percentage of policy that addressed electronic waste. 74
Figure 8.5: Source of awareness of electronic waste recycling. 75

Figure 8.6: Ways of dealing with unwanted electronic products. 76
Figure 8.7: Attitude of respondents towards buying of electronic products. 77
Figure 8.8: Reasons for not recycling unwanted electronics. 78
Figure 8.9: Perception of recycling. 79
Figure 8.10: Responsibility for the management of electronic waste. 80
Figure 8.11: The amount consumers are willing to pay to recycle an electronic product. 81
Figure 8.12: Consumers' willingness to be involved in recycling in the future. 82

List of Tables

Table 4.1: Singapore's annual statistics, 2007. 18
Table 4.2: NEA's solid waste management data for 2004, 2005 and 2006. 26
Table 4.3: NEA's representation of waste stream data for the year 2006. 29
Table 7.1: The computers and printers used in the Production Department of Manufacturing Company #1 54
Table 7.2: The CRT and LCD monitors in the Production Department of Manufacturing Company #1 55
Table 7.3: The parts that were not in operation in the Production Department of Manufacturing Company #1 56
Table 7.4: The parts that were sent for recycling or dumped in the Production Department of Manufacturing Company #1. 57
Table 7.5: The weight of different computer parts and printers 58
Table 7.6: The computers and printers used in the Production Department of Manufacturing Company #2 61
Table 7.7: The parts that were not in operation in the Production Department of Manufacturing Company #2 62
Table 7.8: The parts that were sent for recycling or dumped in the Production Department of Manufacturing Company #2. 63
Table 7.9: Employment Statistics for 2006. 68

Chapter 1: Introduction

1.1 Project Background

Electronics have become very much an integral part of our daily life. We are increasingly engaged in using electronic products as technology advances rapidly. We can expect the pace of innovations to get even faster. This in turn leads to a shorter life span of electronic products as they become obsolete. As such, more electronic wastes are generated in our industry and society. These wastes will only add to the load on the incineration plants and landfills.

Unlike other rubbish, dumping electronic wastes in landfills poses a serious environmental threat. Electronic products like computers and cell phones contain toxins that can leak into the groundwater when buried. These harmful chemicals can poison wildlife and pose a health threat to humans as well. It is therefore not a viable solution. The best way to deal with all these concerns is to recycle electronic wastes. Besides, there are many benefits about recycling of electronic wastes.

This research project aimed to understand the problem of recycling of used electronics in Singapore and the related environmental concerns. In understanding the local recycling of used electronics, available government data and recycling companies' information are reviewed. Analyses are done to critically assess current Singaporean practice and actions are recommended for the future handling of the issue. In an attempt to better understand the situation, observations are made on the effectiveness and benefits of recycling electronic waste.

Specific problems areas, particularly the problems of collection, are identified and subsequent opportunities for improvement are suggested. This included an attempt to evaluate what proportion of used electronics is currently recycled. Going into a wider scope in understanding the problem, information are researched on global recycling of used electronics through reviewing published materials. This aimed to

find good systems that are used to address electronic wastes and relating them to the local situation.

Case studies are done on manufacturing companies to understand the practices used to manage used electronics. This included finding out the possible rate and magnitude that could be generated in the company and in turn in the industries as a whole. A survey of consumers is done to understand the attitudes and behaviours of the consumers and to find out the barriers in the community in recycling of used electronics. This included determining the extent to which they are involved now in recycling or would be willing to be involved in the future.

1.2 Outline of the Report

This dissertation begins with a brief presentation of the project background in Chapter 1. Chapter 2 reviews in detail the literature on the recycling of used electronics. The growing problem and the harmful effects of electronic waste are discussed. This included an understanding on the benefits of recycling of electronic wastes as well. In Chapter 3, the goal and scope definition of the project is covered. Chapter 4 understands the local situation, in particular the waste management and the factors leading to used electronics generation. Subsequently, the collection of used electronics and electronic waste recycling companies in Singapore are observed and discussed in Chapter 5. Chapter 6 covers the management used in dealing with electronic waste in other countries. This included relating good systems to local situation.

In Chapter 7, the case studies are presented and discussed. This provides an understanding of the practices made in the companies in handling used electronics and the rate and magnitude of these wastes that could be generated in the company and the industries. In Chapter 8, the results for the survey of consumers are presented. Observations and discussions are made. This included recommendations for improvements as well. Chapter 9 concludes the research project. Summary of achievements are presented and recommendations for future work are made.

Chapter 2: Literature Review

2.1 Introduction

This chapter introduces the background of recycling of used electronics. The related problems of electronic wastes are observed. This included an understanding of the various difficulties faced in recycling of electronic wastes. This is followed by observations made in other countries.

Subsequently, the various benefits of recycling of electronic waste are observed and discussed. And finally, the key points are summarised.

2.2 Background of Recycling of Used Electronics

Discarded used electronics or electronic waste (commonly termed in short as e-waste), are usually obsolete or irreparable electronic products. In the European Commission, Directive 2002/96/EC Waste Electrical and Electronic Equipment (WEEE), electrical and electronic equipment is considered as “equipment which is dependent on electric current or electromagnetic fields in order to work properly, and equipment for the generation, transfer and measurement of such currents and fields” [WEEE Art.3 (a)].

They are data processing, telecommunications or entertainment products which are used in private households or in businesses. These include cathode ray tube (CRT) monitors and televisions, personal computers (PCs), cell phones, laptop computers, printers, scanners, personal digital assistants (PDAs), digital cameras, MPEG-1 Audio Layer 3 (MP3) players, gaming consoles, etc. They contain toxic metals such as lead, mercury, cadmium, chromium, zinc, nickel and beryllium, as well as hazardous chemicals such as brominated flame retardant. Polluting polyvinyl chloride (PVC) plastics are also commonly used to make these products.

Electronic products like desktop computers are commonly used in both companies and at homes and they contain large amount of hazardous substances. The Straits Times – Digital Life, Singapore (April 10, 2007) reported that a CRT monitor can contain as much as 2 kg of lead. It was noted that high levels of lead exposure can damage the vital organs, leading to coma or death from lead poisoning. Keyboards which also have Printed Circuit Boards (PCBs) hence contain selenium, a bio-accumulative toxin which can cause chemical pneumonia and tachycardia, a rapid beating of the heart.

As for the Central Processing Unit (CPU), besides the large amount of PCBs in it, parts like the switches and housing of the CPU, contains neurotoxin mercury which attacks the central nervous systems and cause mental disturbances and neuromuscular changes such as twitching and muscle weakness. In addition, cadmium is also used in semi-conductors which affect the lungs and kidneys. Electronic products like computers contain so much hazardous materials that even a mouse's plastic casing contains poly-brominated flame retardants which are a persistent organic pollutant that can disrupt thyroid function.

As observed, electronic products of all kinds do contain a lot of hazardous substances and chemicals. It was noted that these substances and chemicals can be very harmful to humans, likewise to the wildlife, if the toxins escape into the environment. It is therefore important that electronic products are properly managed and safe disposals are carried out when products reached its end of life.

Electronic waste consists of large amount of plastics and metals which are non-biodegradable. If buried in landfills, the toxins will leach into the environment. Similarly, if they are sent to the incineration plants, they produce noxious gases when burnt. It was observed that in both situations, they pollute the environment and pose serious health threats to humans and also harm the wildlife. In December 2006, the UOB Kay Hian Research Pte Ltd estimated 70 % of the heavy metals found in landfills come from electronic waste.

These further emphasised the need to dispose electronic products in a safe way and the only method to do it is to recycle. In Singapore, The Waste Minimisation Unit,

now known as the Waste Minimisation Section under National Environment Agency (NEA), was set up in February 1992 to promote recycling and lead waste minimisation. NEA's Waste Minimisation Section encourages the public to follow waste management practice by the 3Rs, Reduce, Reuse and Recycle.

As observed, recycling is especially important for electronic waste and therefore more efforts will be needed to ensure that these wastes are properly collected and safely processed. In recent years, Singapore saw a rise in the number of electronic waste recycling companies. For instance, local company CH E-Recycling (CHE) Pte Ltd (www.che.com.sg), established in March 2005 has grown and even acquired International Organization for Standardization (ISO) certifications, namely ISO 9001 and ISO 14001. They collect unwanted electronics from both consumers and companies.

Although recycling services are available in quite a number of avenues, not many among the consumers are aware and collection of used electronics proved to be difficult. Recycling company CHE reported in The Straits Times – Digital Life, Singapore (April 10, 2007) that most of the materials collected comes from electronics manufacturers. In the same article, it was reported that consumers in Singapore are found to be unaware of the various green disposal avenues available to them. As observed, this would certainly be the main barrier to achieve high recycling outcome for electronic waste.

Campaign is a good way to raise awareness and to collect used electronics for recycling. In 2007, Hewlett Packard (HP) (www.hp.com) organised a campaign in Singapore to mark Earth Day and gave vouchers in exchange for selected models brought in for recycling. The campaign not only promotes electronic waste recycling but also helps aware the public that electronics harm the environment if they are not safely disposed. However, it was noted that the general response from consumers to recycle electronic waste remains weak. As the lifespan of these products get shorter, more electronic waste would be generated in the society and industry. As observed, the environmental effects of electronic waste cannot be ignored and the only solution to the problem is to recycle them. The various

problem areas should be identified and subsequently addressed so as to achieve a high recycling outcome for electronic waste.

As observed, electronic wastes have a link with the government, the manufacturers and the consumers such that each group has responsibilities and a role to play to cope with the related problems. Efforts from the recycling companies are certainly crucial to achieve high environmental outcome for electronic waste. Figure 2.1 shows the model used by Young et al. (cited in Askiner and Surendra 1998) to illustrate the interactions among the different groups who are responsible for environmental concerns. From the model, it was observed of how one group can affect the other and this understanding is important in order to achieve good cooperation to effectively deal with electronic waste problems.

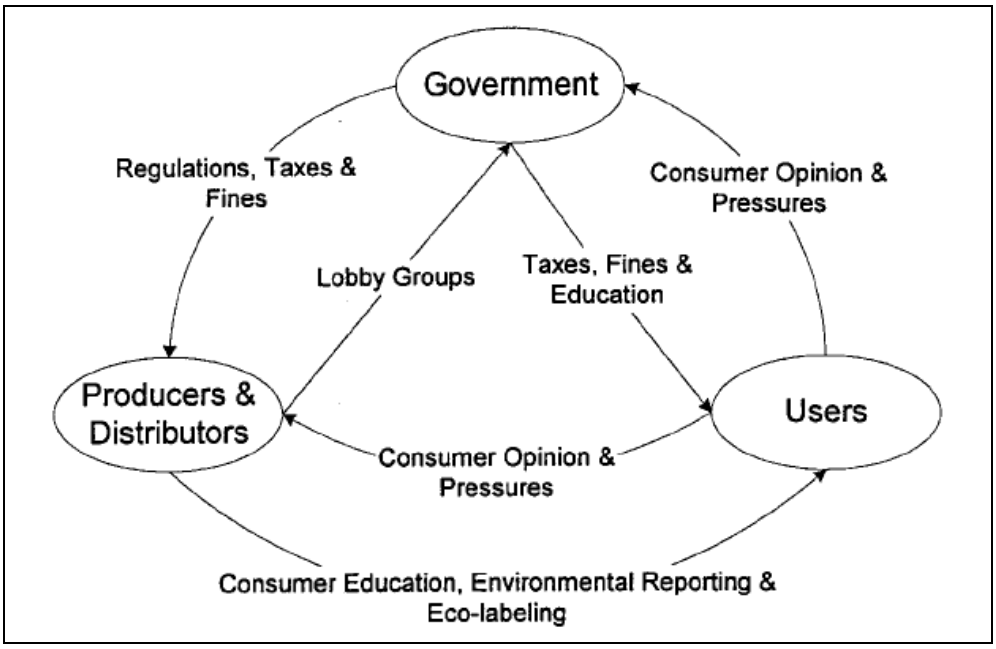


Figure 2.1: Young et al. Manufacturing and the Environment (1997, Vol 13, No.7, p.488).

2.3 Electronic Waste in Other Countries

Electronic waste is a growing problem and this is not only happening in Singapore but in other countries as well. In the United States (US), electronic wastes are the fastest growing portion of the waste stream due to the growing sales and rapid

obsolescence of electronic products. In the year 2004 to 2005, it had grown by almost 8 % even when the overall municipal waste stream volume is declining, according to the Environmental Protection Agency (EPA), US. The EPA also estimates that 2.63 million tons of electronic wastes are generated in the US in the year 2005. Of this quantity, only 12.5 % was collected for recycling and the remaining 87.5 % went to landfills and incinerators. It was noted that these figures have yet to include the millions of stockpiled televisions, PCs, monitors, etc, which are stored in basements, garages and closets awaiting decisions by the owners.

In fact, technology company Hewlett-Packard (HP) carried out a research in 2005 and found that nearly three out of four American consumers have used or unwanted electronics in their homes which they do not know how to dispose of. On the other hand, environmental organisation, Earth 911 (earth911.org), estimates that United States (US) will need to dispose, in 2007, 500 million obsolete computers that are stored over the years. It was noted that collecting of used electronics can be very difficult when there is little awareness among the consumers.

In Australia, electronic waste is also growing fast and it is more than three times faster than general municipal waste according to the Australian Bureau of Statistics (ABS), 2006. This is due to the fact that Australians are some of the highest users of new technology internationally. Over 2.4 million PCs and more than 1 million televisions are bought annually. ABS reported in the same year, in 2006, that Australia is one of the top ten countries using information and communication technology. It was ranked tenth in the world for spending per capital and fifth in the world for spending as a percentage of gross domestic product. As observed, it is therefore inevitable that electronic waste in high technology countries, like United States (US) and Australia, is one of the fastest growing waste types.

As electronic waste grows, it is important that they are well managed and safely processed. In United States (US), the Computer TakeBack Campaign (CTBC), US, estimates that the 12 % of electronic wastes that are recycled in US are handled by most firms which do not operate under strict controls and they acted irresponsibly. Only valuable metals are removed from the wastes and the remaining scraps are sent to incinerators and landfills. It was of concern to know that workers

dismantling these wastes are inadequately protected from harmful chemical compounds which posed very negative health effects.

It has been reported that many recyclers are exploiting cheap labour by sending electronic waste to developing countries like China, India and Pakistan for disassembly and processing. The Basel Action Network and Silicon Valley Toxics Coalition (cited by Marta and David 2006) estimated in a report in 2002 that as much as 50 % to 80 % of the electronic waste collected for recycling in the west of the United States was shipped to China. These wastes are being handled under horrific conditions that harmed the workers, the people and the environment. In Guiyu, China, the unwanted parts are thrown into former irrigation ditches, massive amounts are dumped along river ways and scraps are burned in open fires. Figure 2.2 shows an investigator of Basel Action Network taking a soil sample along a riverside in Guiyu, China, where loads of electronic wastes are dumped.

Figure 2.2: An investigator taking a soil sample along a riverside in Guiyu, China.

As can be seen, shipping electronic wastes overseas will not be a solution if the wastes are not properly processed in an environmentally sound manner. It is certainly incorrect to pass the problem onto another country and in most cases the poorer countries were at a disadvantage. It is also a serious concern that the workers are harmed as improper protection was provided.

CTBC also list the prison systems of the US as one of the problems of improper handling of electronic wastes. The prisons are involved in electronics recycling operations and there were inmate labourers who worked without much health and safety protections. In recent years, complaints had brought these hidden sweatshops into public view. As there were no proper recycling procedures, captive labourers and staff supervisors were at a high risk of injuries. In 2005, Bureau of Prisons (BOP) admitted in a report that prisoners and staffs in at least three recycling factories were exposed to toxics.

As observed, there are indications of improper handling of electronic wastes in different parts of the world. The improper processing harmed the workers and subsequently the environment and the people. It is both important that safe processing and safe disposal are carried out when dealing with electronic waste. This applies the same to Singapore.

Electronic waste is difficult to manage due to its large volume and the cost of managing it is always a concern for the governments, manufacturers and consumers. CTBC noted that in the United States (US), public policy has failed to effectively address the problems of electronic waste and many brand owners and manufacturers in US are dodging responsibilities to manage their products after useful life. As a result, the costs are passed onto taxpayers who are paying greatly to clean up the wastes.

As observed, the cost of managing electronic waste should be properly addressed, not only to avoid incurring a higher amount for cleaning up but more importantly to effectively solve the problem. On the whole, it was observed that electronic waste can be problematic and damaging. It is an important issue and should be properly managed in all countries, including Singapore. This meant to collect and safely recycle electronics to protect the environment.

2.4 The Benefits of Recycling

There are a few green ways to handle used electronics. They could be to upgrade, refurbish, reuse and donate. If all options are not viable, it should be sent to recycle. In fact, electronic wastes should be properly collected from different sources and sent for recycling. Recycling of electronic waste is beneficial to the environment as it helps to protect the environment from the toxins of the wastes as well as it saves resources from depleting.

The recovery process is so good that precious metals like platinum, gold and silver can be recovered! The Straits Times – Digital Life, Singapore (April 10, 2007), reported that Nokia found that more than 90 % of a cell phone can be recycled. In the course of the process, precious metals such as gold and platinum group of metals (PGMs) can be extracted from the cell phone as well. This great benefit is another encouraging reason to recycle electronic wastes. In fact, it has also helped recycling companies to profit in the process.

The electronic wastes collected in the factories of recycling companies include Integrated Circuit (IC) lead frames, copper laminates, Printed Circuit Boards (PCBs), PCB trimmings, electronic components, computers, printers, laptops, cell phones, televisions, etc. These consist of both consumers' waste and electronic waste generated by electronics companies in the course of their manufacturing process. Figure 2.3 shows the copper laminates and IC lead frames that are collected for recycling. The wide arrays of wastes collected are subsequently sent for processing.

Figure 2.3: Copper laminate (left) and IC lead frames (right) collected for recycling.

Figure 2.4 shows a typical operational flow chart of an electronic waste recycling company. At the factory, electronic products like computers and monitors are first tested for their functionality. Options for repairing and refurbishing for reuse are considered as they can be redistributed or donated to charitable organisations. If they are beyond repair, they will be sent accordingly for dismantling, de-soldering and segregation into different categories of products or materials for processing. It was noted that as a usual practice, proprietary technological products are sent for direct destruction.

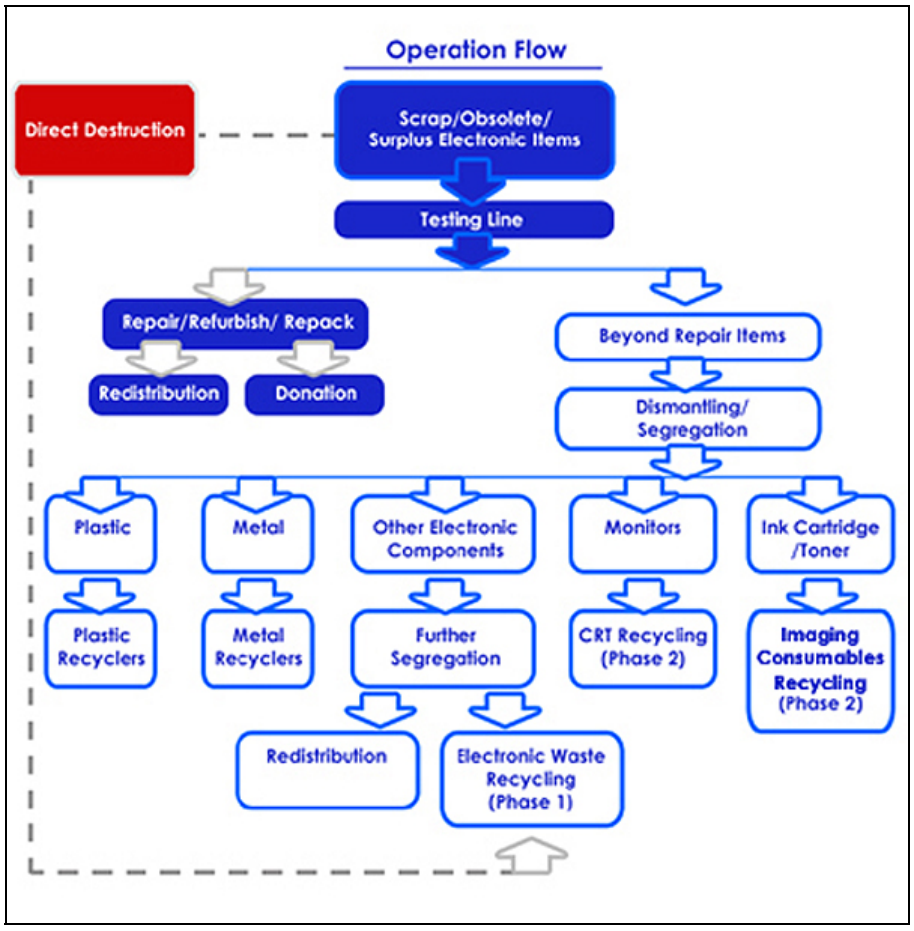


Figure 2.4: Operational flow chart of recycling (CH E-Recycling Pte Ltd, 2007).

Electronic waste recycling uses filtration systems and chemical processes. Precious metals, platinum group of metals (PGMs) and base metals can be recovered in the process and they are separated accordingly. Precious metals that can be recovered include platinum, palladium, gold, silver, copper, aluminium as well as other rare metals. Processed metals are further refined and subsequently sent to smelting

plants. PGMs requires further refining to be converted into by-products, such as gold potassium cyanide, platinum and palladium targets and salts, which are sold for reuse by the electronics industry. Figure 2.5 shows PGMs recovery and refining at Cimelia Resource Recovery Pte Ltd.

Figure 2.5: PGMs recovery and refining (Cimelia Resource Recovery Pte Ltd, 2007).

As part of the recycling process, plastics from the cases of hardware are fed into plastic recyclers. These plastics are shredded into pellets and sent to plastic moulders. In general, electronic waste recycling includes cathode ray tubes, assorted plastics, copper recovery, ferrous and non-ferrous metals. As CRTs in monitors and television are leaded glass, a hazardous material, it needs to be processed differently with special equipment. Recycling companies are able to optimise granulated fibre and construction materials like bricks can be produced. Figure 2.6 shows copper sand and bricks which are some of the materials produced.

Figure 2.6: Copper sand (left) and bricks (right) (CH E-Recycling Pte Ltd, 2007).

These days, electronic waste recycling companies engage technologies and automations to carry out the recycling processes. Besides being efficient and

effective, this has helped to minimise workers' exposure to hazardous substances. Nevertheless, care should be taken at all times and personal protection is necessary while handling these materials.

As observed, there are many benefits about electronic waste recycling. It protects the environment, saves resources in which precious materials can also be recovered and useful products can be produced. In fact, LEADOUT (cited in Marta and David 2006) reported that by using recycled materials it can saves as much as 60 % to 80 % of the energy used to produce the same virgin materials. It was also estimated that recycling of electronic waste would make it possible to save approximately 2.8 million tons of oil equivalent per year.

2.5 Summary

Electronic waste is easily generated as people increasingly use electronic and electrical equipment. Land filling them is not viable as they contain toxins that will leach into the environment when buried. Incinerating them will produce poisonous gases that pollute the air. Therefore, it is critical that these wastes are recycled.

There are various indications of electronic waste problems around the world and they can be very damaging. Electronic waste is growing and therefore good waste management is important to address the related concerns. This would require the cooperation of the government, the manufacturers, the consumers and the recyclers to effectively deal with the problems.

Electronic wastes are very hazardous and have to be handled with care even during the course of recycling. Recycling electronic waste helps to protect the environment as well as saves large amount of resources. On the whole, recycling of electronic waste is certainly beneficial to all if carried out properly.

Chapter 3: Methodology

3.1 Introduction

In understanding the various problems of recycling of used electronics in Singapore, research was done by reviewing available government and related companies information. In an attempt to further understand the problem, case studies and a survey were done. This helped to understand the industries' workplace environmental policies and also the consumers which in turn were useful to assess the current practice and subsequent recommendations for improvements.

3.2 Goal Definition

The goal definition of this particular project is to identify specific problem areas of recycling of used electronics in Singapore and understand the related environmental concerns. The results of the case studies and survey are to be used for identifying opportunities for improving current Singaporean practice at a community level for future handling of the issue. This included recommending good systems found in other countries as well.

3.3 Scope Definition

The method of research done to gain an understanding of the local situation was through reviewing of available government information and statistical data. Statistical data represents better and is useful for analysis. Area of research included the related Singapore's authorities and the major ones that were used in this dissertation included the Ministry of the Environment and Water Resources, The National Environmental Agency (NEA), Infocomm Development Authority of Singapore (IDA), Statistics Singapore and Ministry of Manpower of Singapore (MOM). Although, specific data on electronic wastes were not available by the

government, these few authorities have helped to establish an understanding of the related concerns.

Research was also done on local recycling companies through reviewing information available on the companies' website and also from published articles on the local newspapers. Major research done was on local electronic waste recycling company Centillion Environment & Recycling Limited. Similarly, information available by the recycling companies in Singapore was limited and there were no specific data of the amount of electronic waste that were collected and processed or incinerated. This proved difficult to accurately assess the situation to evaluate the proportion of used electronics that are currently recycled.

In addition to studying the situation in Singapore, the area of research was extended globally to the United States, Australia, Europe and Japan. This aimed to find good systems that are used in other countries to deal with electronic waste problems and to relate these systems to local situation.

The case studies were done to understand how companies in the local industry managed their used electronic products. 2 manufacturing companies in the electronics sector were studied. Although the understanding was aimed at electronic products in general but in these 2 case studies only computers and printers were considered. The scope was shrunk due to time and accessibility reasons. On the other hand, instead of the whole company, only a department was studied in each case. This was because the two companies are generally large and access to information was difficult and time consuming.

In an attempt to better understand the problem of electronic waste recycling, a survey of consumers was conducted in Singapore. This was to find out their attitudes and behaviour and also included an understanding of workplace environmental policies in Singapore. As surveying of industry people proved time consuming and difficult, the scope was focused mainly on consumers in the community. The work involved preparing a well structured set of questions to ask for the various targeted area of understanding. The survey also aimed to determine the extent to which consumers are involved now in recycling and would be willing

to be involved in the future. The initial target was to achieve about 100 responses but was later lowered due to time constraint and 75 responses were successfully received for analysis.

3.4 Assumptions Used in Case Studies

In the case studies, various assumptions were used mainly because specified data were not available to analyse the company as a whole. Data collection was based only on a department and only computers and printers were considered. The different stages of obsolesce of electronic products in the companies also posed a difficulty in understanding the situation as data for a limited period of time was collected.

Chapter 4: Singapore's Recycling

4.1 Introduction

This chapter introduces and understands the situation in Singapore and the related issues that stress the importance of recycling in the country. The consumption of electronic products in the domestic and export market are observed. Other related factors leading to the generation of used electronics in the country are also discussed. Finally, studies are made on the waste management data and the related recycling rates.

As there is little amount of government information available, particularly on electronic products and wastes, some broad data are used to understand the situation and identify the problems and subsequent areas of improvement.

4.2 Singapore's Situation

Singapore is a city state with limited land space. The total land area is only 704.0 square kilometres and the total population in 2007 is 4.6806 million. This makes Singapore the second most densely populated country in the world after Monaco. Singapore's population density per square kilometres is 6,369. As a land scarce country with such a high population, management of land use is very crucial to stay sustainable in the long term. Hence, land allocation for landfills is also very costly to the country and its people.

The last landfill on the mainland at Lorong Halus is closed in April 1999. Semakau Landfill, shown in figure 4.1, was developed to meet Singapore's need. It is a manmade offshore landfill which cost S$610 million. The ground covers an area of 350 hectares and has a capacity of 63 million cubic metres. It was projected in 2006 by the National Environment Agency of Singapore (NEA) to have a remaining lifespan of 35 to 40 years. This was not surprising considering the high population and the volume of waste that will be generated increasingly over the years.

Figure 4.1: Singapore's manmade offshore landfill - Semakau Landfill.

Taking into account that the current annual population growth which is at 4.4 % and the high literacy rate of the population, it was expected that more people will be engaged in using electronic products in their daily life. This would certainly lead to the increase in the volume of used electronics. As the world gets more interconnected, there will be an increasing need to engage in telecommunication services. This will inevitably brought about the generation of used telecommunication devices. One such major contributor to used electronics is the cell phone. The number of mobile phone subscribers per 1,000 population in Singapore is an amazing 1,034. If this relates to the same number of cell phones, it will be a disturbing sign as the life span of cell phone is relatively short compared to other electronic products. It can be seen how the various factors add to the importance of waste management in Singapore. The mentioned statistics are summarised in table 4.1.

Statistics	**2007**
Total population ('000)	4,680.6
Annual population growth (%)	4.4
Land area (sq km) (*For year 2006*)	704.0
Population Density per sq km (*For year 2006*)	6,369
Literacy rate (%) (*among residents aged 15 yrs & over*)	95.4
Mobile phone subscribers per 1,000 population	1,034

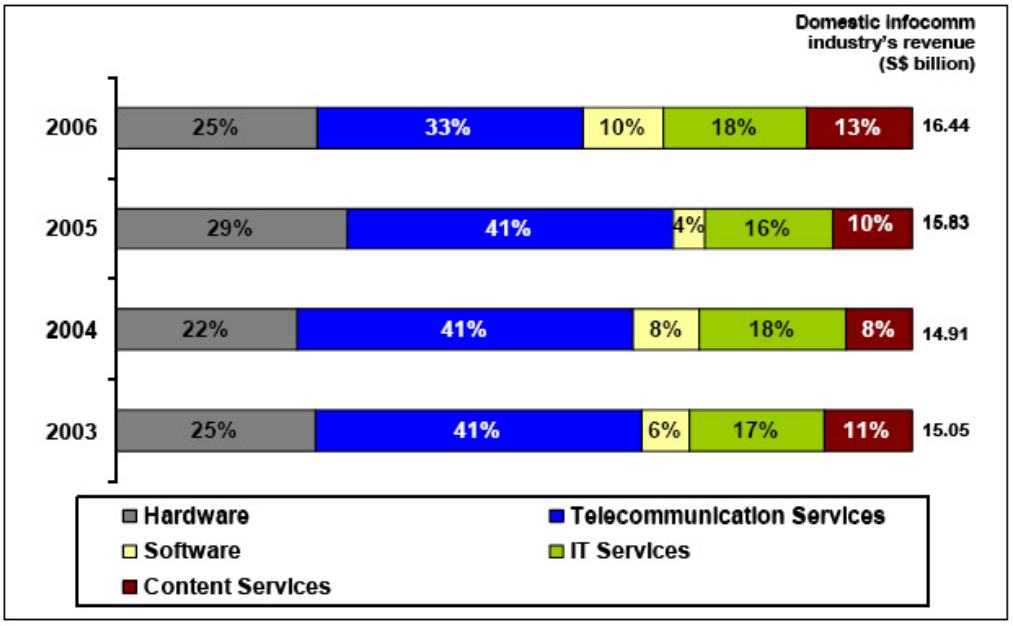
(*Source: Statistics Singapore, 2007*)

Table 4.1: Singapore's annual statistics, 2007.

4.3 Factors Leading to Used Electronics Generation

Singapore's manufacturing sector accounts for 20 % to 25 % of the country's economy. The manufacturing sector consists of Electronics, Chemicals, Precision Engineering, Transport Engineering, General Manufacturing and Biomedical Manufacturing. Among these industries, Electronics contributes the single largest portion to the total industrial output. In 2005, it was a huge 35.8 %.

The following figure 4.2 is a chart by the Infocomm Development Authority of Singapore (IDA). It shows the domestic revenue and the different market segments from 2003 to 2006. IDA's goal is to "cultivate a vibrant and competitive infocomm industry in Singapore" and it oversees the infocomm technology development, deployment and usage. IDA's hardware segment products include computers, printers, cell phones, modems, digital entertainment products, personal communication accessories, mobile enhancement products, wireless networking products, etc.



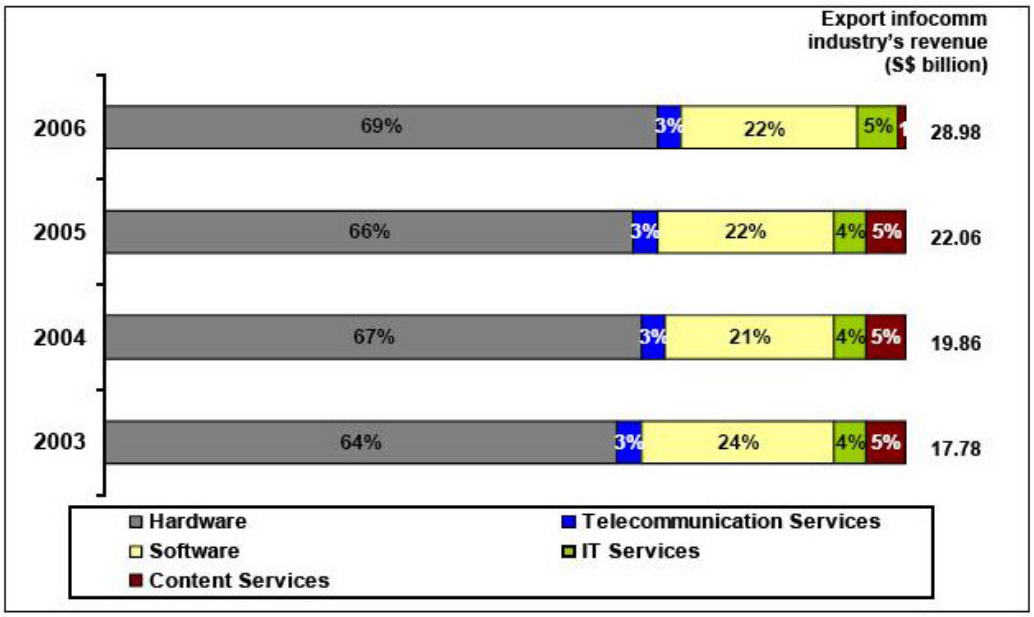
(Annual Survey on Infocomm Industry for 2006, IDA 2007, p.6)

Figure 4.2: Domestic market composition by market segment, 2003 – 2006 (IDA).

In 2006, the overall domestic market grew by 3.9 % but the hardware segment contribution saw a fall of 4 %. The revenue of the hardware segment is S$4.59

billion for 2005 and S$4.11 billion for 2006. This actual decrement in revenue could mean that less hardware were sold in 2006. The difficulty here in understanding the amount of products that were being consumed domestically is that a fall in revenue does not necessarily corresponds to a fall in quantity and a fall in quantity does not necessarily corresponds to a fall in mass. This is due to different profit margins, costs and physical attributes of electronic products. However, the overall growth of the domestic market indicates the activeness in the industry. This might lead to more purchases of hardware for new setups or for renewal purposes.

Assuming the short lifespan of these products to be 2 years, estimation could be made that a large portion of the 29 % of the hardware segment sold in 2005 will see a need to be disposed in 2007. On the other hand, it meant that in 2007, there might be a rise in demand in the hardware segment. This has lead to a pattern of rise and fall in demand being seen in the hardware segment, in figure 4.2, that a rise occurs in alternate years, in 2003 and 2005, and therefore a fall occurs in 2004 and 2006.



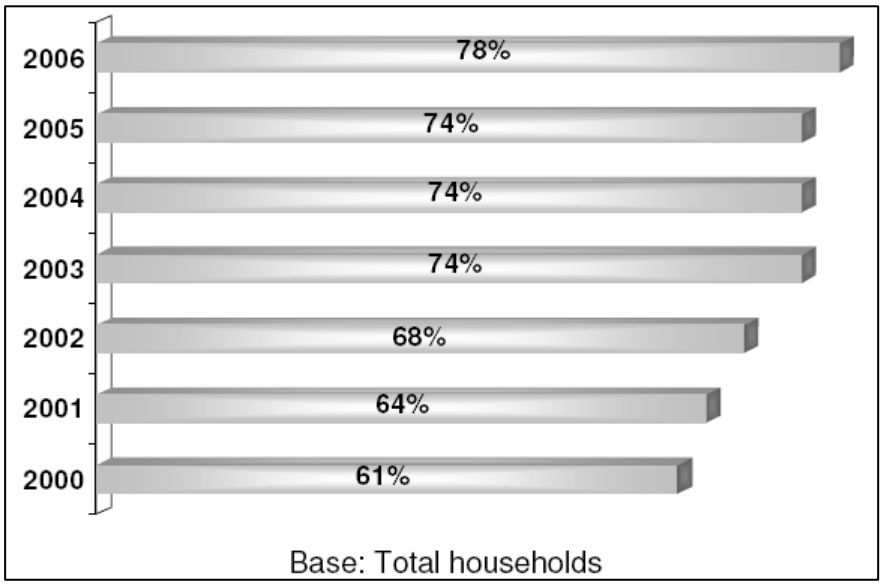
(Annual Survey on Infocomm Industry for 2006, IDA 2007, p.6)

Figure 4.3: Export market composition by market segment, 2003 – 2006 (IDA).

In the above figure 4.3, the total export revenue of the infocomm industry is studied. This is intended to gain some understanding of the relative potential amount of industrial electronic waste that could be generated during the manufacturing process.

The export revenue has increased by 31.4 % in 2006 to reach S$28.98 billion from S$22.06 billion in 2005. This growth was largely driven by the hardware segment, which is observed to be the biggest contributor to the annual infocomm export revenue since 2003. This expanding export in the hardware segment signifies the potential increase in electronic wastes in the industry. Proper waste management should be in place to take care of the wastes generated by the manufacturers in the factories.

In the next portion of this section, the number of computers was gauged in the households and the percentage of computer users for different age groups were observed. This is to better understand the usage behaviour and the extent of usage of computers among the resident population in Singapore. This information could then be used as a guide to estimate the amount of used computers that will be generated as a result. These used computers will eventually add onto the bulk of electronic wastes. Annual surveys were done by IDA in Singapore. In 2006, the data collection was done via face-to-face interviews conducted from October to November. A total of 2,500 households and 2,810 individuals were interviewed.



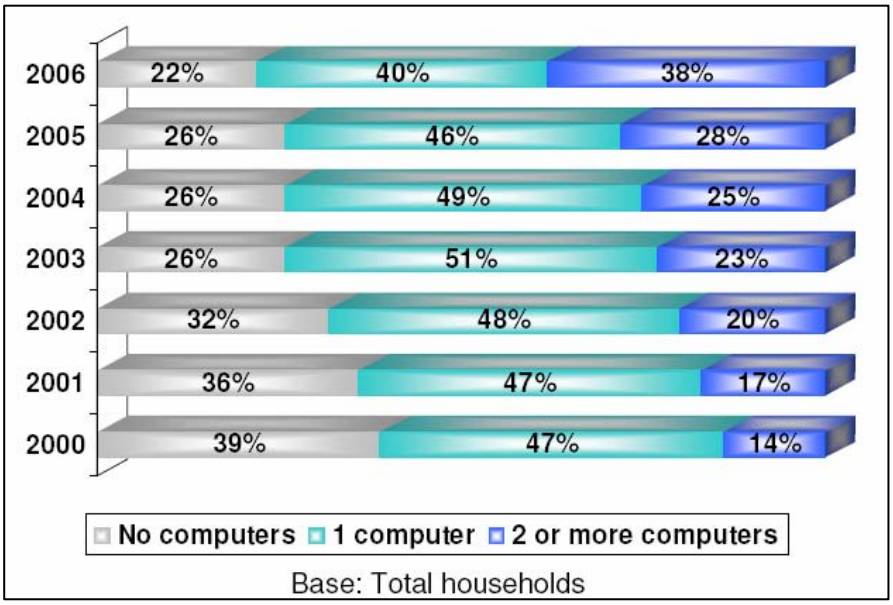
(2006 Annual Survey on Infocomm Usage in Households and by Individuals, IDA 2007, p.2)

Figure 4.4: Home computer penetration in Singapore (IDA).

Figure 4.4 above shows the home computer penetration in Singapore. From the survey, an estimated 78 % of the total households in Singapore had at least one

computer (desktop/laptop) at home in 2006. This is a 4 % increase from 2005 after staying stagnant at 74 % for 3 years since 2003. Looking at the results over the years, it is definite that the penetration rate will continue to rise, therefore indicating an increased engagement in technological products.

The following figure 4.5 shows the results of the survey for the number of computers in the households in Singapore. The chart shows a representation of 3 different categories, 'no computers', '1 computer' and '2 or more computers'. As for households with 2 or more computers, there was an increase by 10 percentage points from 28 % in 2005 to 38 % in 2006. It is noted that the percentage of households with 2 or more computers were increasing since year 2000 and the largest annual increment was in 2006.

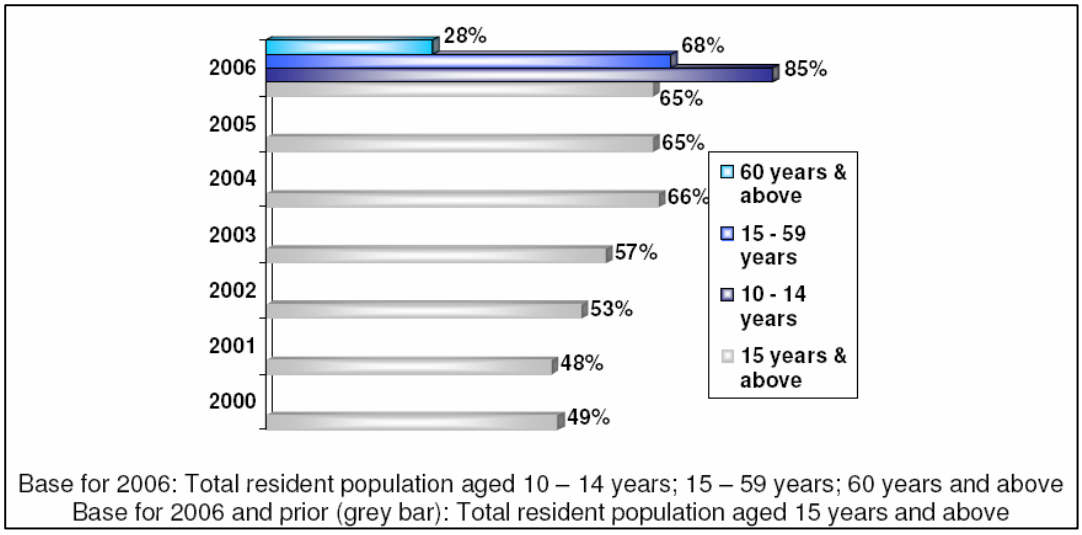


(2006 Annual Survey on Infocomm Usage in Households and by Individuals, IDA 2007, p.3)

Figure 4.5: Number of computers at home (IDA).

These days, a computer acts as a 'main brain' for almost all personal electronic products ranging from MP3 players to sophisticated pocket PCs. Once an electronic device is linked up, a computer can be used for data storing, viewing, downloading, transferring, printing and editing. From this understanding, it is expected that an increase in computers in the households will most likely indicate an increase in other electronic products and computer peripherals that will eventually see more used electronics originating from the domestic over the years.

Next, the percentages of computer users for different age group were identified in figure 4.6. There were 4 different age groups used in 2006. They were ‘10 to 14 years’, ‘15 to 59 years’, ‘60 years and above’ and lastly ‘15 years and above’ which were represented in all other years as well. It is deduced from the survey that computer usage is more common among the young. 85 % of the population aged 10 to 14 years is computer users, compared to 68 % for the 15 to 59 years age group and 28% for the 60 years and above age group. This is because computers are used in schools in modern education for students starting at a young age. On the whole, the proportion of computer users aged 15 years and above remained at 65 % in 2006. This figure will bound to increase as the years passed by based on the high percentage of young computer users.



(2006 Annual Survey on Infocomm Usage in Households and by Individuals, IDA 2007, p.5)

Figure 4.6: Percentage of computer users (IDA).

A point of concern here is that elderly computer users might face a difficulty in recycling when their computers have reached its end-of-life and needed to be disposed. Various possible barriers to recycling could be the physical ability of the elderly to move the heavy parts, the accessibility and the cost of recycling services. If recycling proves difficult, the unwanted computers were usually left unattended or stored at home. As seen, a rather significant 28 % among the elderly population, 60 years and above, are computer users. To achieve satisfactory waste management, concerns for the elderly should be addressed in all areas.

4.4 Waste Management

The total amount of waste being disposed in Singapore had increased at an alarming rate over the past 30 years. NEA categorised waste disposed as the sum of the total waste incinerated and the total waste land-filled. Back in 1970, it was 1,300 tons a day but by the year 2000, it had already gone up to 7,600 tons a day (Ministry of the Environment and Water Resources). Finally, successful results of waste management were seen in 2004 when the amount being disposed in a day fell to 6,795 tons (Ministry of the Environment and Water Resources). Even at this rate, NEA estimates that a new incineration plant would be needed in every 5 to 7 years. In addition, a 350 hectare landfill would be required in every 25 to 30 years.

Some calculations were made to understand the rate and comparisons were made to the population growth. Due to limited available data, the amount being disposed in a day in 2000 to 2003 is assumed to be constant at 7,600 tons, 0 % increment.

The overall increase in the amount being disposed in a day (1970 to 2003):

$$\left(\frac{7600-1300}{1300}\right)\times 100 = 484.62 \text{ \% } \textit{increase over 33 years}$$

From Statistics Singapore, the population in 1970 is 2.0745 million and the population in 2003 is 4.1861 million.

The overall increase in population (1970 to 2003):

$$\left(\frac{4.1861-2.0745}{2.0745}\right)\times 100 = 101.79 \text{ \% } \textit{increase over 33 years}$$

$$\left(\sqrt[33]{\frac{101.79+100}{100}}-1\right)\times 100 = 2.15 \text{ \% } \textit{increment in a year}$$

By comparison, it is observed that from 1970 to 2003, the overall increase in percentage in the amount being disposed in a day, 484.62 %, were far much higher than the overall increase in percentage in the population, 101.79 %. This indicates that there is a high possibility that the overall amount of waste disposed can be

reduced further, much more than the amount achieved in 2004. It is also noted that the annual average percentage increase in population is much lower than the current growth rate from 2006 to 2007, which is 4.4 %. This is a worrying prospect for the country if waste management is unable to effectively reduce the amount of waste disposed at a higher rate of population growth.

Table 4.2 shows NEA's solid waste management over the past 3 years from 2004 to 2006. Firstly, the total waste generated is understood to be the sum of the total waste recycled, total waste incinerated and total waste land-filled (as defined in point 1 of table 4.2). Secondly, as in the earlier portion of this section, waste disposed is categorised as the sum of the total waste incinerated and the total waste land-filled. Some calculations were made to understand these 2 terms.

Total waste generated in 2006:

2.66 *(total waste recycled)* + 2.33 *(total waste incinerated)*
+ 0.23 *(total waste land-filled)* = 5.22 *million tons*

Total waste disposed in 2004:

1.41 *(total domestic waste disposed)*
+ 1.07 *(total non-domestic waste disposed)* = 2.48 *million tons*

is equal to:

2.26 *(total waste incinerated)*
+ 0.22 *(total waste land-filled)* = 2.48 *million tons*

Total waste disposed in 2004 in a day:

$\frac{2.48 \times 10^6}{365} = 6795$ *tons* (as stated in the earlier portion of this section)

From table 4.2, it is observed that the total non-domestic waste disposed had increased from 1.07 million tons in 2004 to 1.13 million tons in 2005. However, this figure dropped in 2006 to 1.10 million tons. Looking at the total domestic waste disposed, the figure had stayed constant at 1.41 million tons in 2005 but rose to 1.46 million tons in 2006. The total waste disposed for both domestic and non-domestic had actually increased over the 3 years from 2.48 million tons in 2004 to 2.54

million tons in 2005 (2.42 % increase) and finally to 2.56 million tons in 2006 (0.79 % increase). This is a relatively small increase comparing with the total amount of waste generated. However, it is discouraging as it is not long after some results were seen in 2004 before the amount starts increasing again. This is not a good indication of the waste management and it meant more should be done to lessen the amount of waste incinerated and land-filled.

Solid Waste Management	Unit	2004	2005	2006
% of population with access to waste collection services	%	100	100	100
Total waste generated[1]	mil tons/yr	4.79	5.01	5.22
Total waste recycled	mil tons/yr (%)	2.31 (48%)	2.47 (49%)	2.66 (51%)
Total waste incinerated	mil tons/yr (%)	2.26 (47%)	2.27 (45%)	2.33 (45%)
Total waste landfilled[2]	mil tons/yr (%)	0.22 (5%)	0.27 (6%)	0.23 (4%)
Total domestic waste disposed	mil tons/yr	1.41	1.41	1.46
Total domestic waste disposed per capita	kg/day/person	0.91	0.89	0.89
Total non-domestic waste disposed	mil tons/yr	1.07	1.13	1.10
Total energy produced from incineration	MWh	962,601	938,284	954,237
Remaining landfill lifespan	years	35-40	35-40	35-40

[1] Total waste generated = Total waste recycled + Total waste incinerated + Total waste landfilled
[2] Total waste landfilled includes non-incinerable waste such as construction and demolition waste, used slag and treated sludge and excludes incineration ash generated from waste disposed through incineration

(Key Environmental Statistics 2007, Ministry of the Environment and Water Resources 2007, p.6)

Table 4.2: NEA's solid waste management data for 2004, 2005 and 2006.

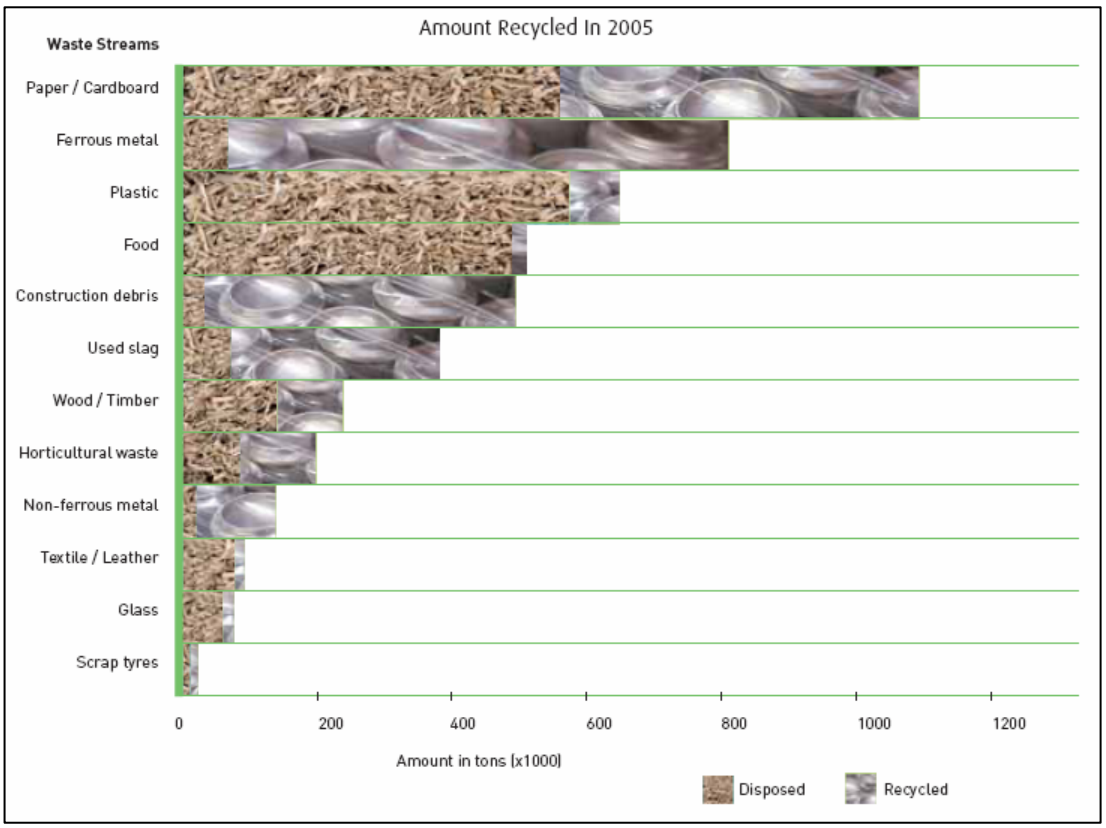
A more appropriate way to analyse waste management here is to use percentage base on the overall waste generated for comparisons over the years. The actual weight is useful in understanding the volume that goes to the incineration plants and

landfill such that concerns like the sustainability of these facilities could be analysed. In 2005, the total waste incinerated has dropped from 47 % in 2004 to 45 %. In contrast, the actual physical weight of the total waste incinerated has actually grown from 2.26 million tons in 2004 to 2.27 million tons in 2005. This is due to the total waste generated that saw a rise over the years. The percentage of total waste incinerated stood stagnant at 45 % in 2006. Again, the actual physical weight is noted to have increased to 2.33 million tons.

The total waste generated has increased from 4.79 million tons in 2004 to 5.01 million tons in 2005, a 4.6 % increase. In 2006, the figure has gone up by 4.2 % to 5.22 million tons. These percentage increases are very much in line with the 4.4 % population growth which indicates a rather acceptable amount of waste generation. Another factor to be concerned with is the total waste land-filled. The total waste land-filled has increased from 0.22 million tons in 2004 to 0.27 million tons in 2005. A positive result is seen in 2006 when the figure fell to 0.23 million tons. This meant that the projected life span of the landfill could be prolonged if wastes are properly managed. Wastes that are land-filled consist of construction and demolition waste, used slag and treated sludge but exclude incineration ash generated from waste disposed through incineration (as defined in point 2 of table 4.2).

The ultimate focus of waste management is the total amount of waste recycled. The amount of waste recycled will in turn affect the amount of waste incinerated and land-filled. The essential process of recycling that forms the overall recycling rate differentiates good waste management from bad ones. In 2004, the overall recycling rate was 48 %. It has increased by 3 percentage points to 51 % in 2006. This is a positive outcome. Although results were seen, it was felt that the situation is still not considered comfortable. New estimates by NEA in 2007 still reflect the need for additional incineration plants, only to be reduced from one in every 5 to 7 years to one in every 7 to 10 years. If the total waste land-filled continues to fall at the rate 14.8 %, seen in 2005 to 2006, the projected life span of Semakau Landfill will be increased from 25 - 30 years to 35 - 40 years, an approximated extension of 10 years.

In figure 4.7, the different waste streams and the amount recycled in 2005 are shown on a chart. It is noted that an individual category for electronic waste is not available here. As observed in the earlier chapters, the compositions of electronic wastes are mainly metal, plastic and glass. Therefore, attention was placed on these 3 types of material so as to achieve an assumption of what amount of electronic waste was recycled.



(The Singapore Green Plan 2012, Ministry of the Environment and Water Resources 2006, p.43)

Figure 4.7: NEA's representation of recycling rates by waste streams in 2005.

As observed from figure 4.7, there are 2 categories of metal that are represented on the chart. They are ferrous metal and non-ferrous metal. The overall amount of ferrous metal that was recycled in 2005 is very high. This is the same case for non-ferrous metal. However, the overall amount of plastic and glass that were recycled in the same year is significantly small.

In another representation by NEA, for 2006, the recycling rates by waste streams were put up on a table in table 4.3. The recycling rates for the different waste streams were placed in descending order. These different waste streams make up

the total waste generated in 2006. As observed from the table, ferrous and non-ferrous metal were among the top few materials with high recycling rates that are over 80 %. It is expected that the amount of plastic and glass recycled in 2006 remained significantly low. Table 4.3 shows the rate to be 12 % for plastics and 10 % for glass. This meant that a major portion of the waste were incinerated or otherwise land-filled.

Waste Stream	Amt of Waste Generated (mil tons/yr)	Amt of Waste Recycled (mil tons/yr)	Recycling Rate (%)
Construction Debris	0.62	0.60	98
Ferrous Metal	0.73	0.66	91
Used Slag	0.47	0.42	89
Non-ferrous Metal	0.09	0.07	82
Scrap Tyres	0.02	0.02	81
Paper/Cardboard	1.12	0.57	51
Horticultural Waste	0.23	0.09	38
Wood	0.22	0.08	37
Plastics	0.66	0.08	12
Glass	0.06	0.01	10
Food	0.54	0.04	8
Others	0.24	0.02	6
Textiles	0.09	0.004	4
Sludge	0.13	0.00	0
Total	5.22	2.66	51

(Key Environmental Statistics 2007, Ministry of the Environment and Water Resources 2007, p.7)

Table 4.3: NEA's representation of waste stream data for the year 2006.

The lack of available government information posed a difficulty here to understand the source of generation of the waste streams, particularly if they were from electronic wastes and if they were generated domestically or non-domestically. It therefore also fails to indicate if there is a problem in managing used electronics either in the industries or with the domestic. This can be important for proper management of electronic wastes especially when it is almost certain that electronic wastes will continue to rise through the years. Nevertheless, the significantly low recycling rates of plastic and glass clearly indicates that there is a lot more room for improvement regardless of the source of waste generation.

Another concern regarding good waste management is the controlling of the possibility of exportation of used electronics. In 2003, Singapore's neighbour, Indonesia banned the import of used electrical and electronic products to protect their local industry and their environment. This has caused a fall in businesses in Singapore for the used electronic goods dealers as shipping to a further poor country in the region might not be as profitable. Although business opportunities through exportation are limited, it does not mean that export of used electronic products is forbidden in Singapore.

4.5 Conclusions

Various factors are pointing to the inevitable increase in electronic wastes in the industry and society as Singapore progresses with the world. Singapore's constraint of a densely populated, highly urbanised city with limited land space makes proper waste management an imperative. More importantly, electronic wastes are harmful and they require proper disposal.

Although there is a good representation of recycling rates for different waste streams but there is not any tabulated figure for electronic wastes with the government. This might meant a lack of emphasis in NEA and likewise for the community. In a world that the importance of recycling of electronic wastes is gaining awareness, a separate set of data for electronic wastes should be available with NEA for monitoring the management in Singapore. This would be useful to effectively deal with concerns of electronic wastes ranging from possible exportation to assisting the elderly properly dispose their unwanted electronic products.

Chapter 5: The Process of Recycling in Singapore

5.1 Introduction

This chapter understands the collection of used electronics in the country and the related problems are identified and discussed. This included an understanding on the current extent of involvement by the government, the manufacturers and the recycling companies.

Electronic waste recycling companies and their recycling processes are observed and discussed. This generally provides an understanding on the technologies used and the effectiveness of the processes. And finally, conclusions are made of the current situation and subsequent recommendations for improvements are also suggested.

5.2 The Collection of Used Electronics

The generation of electronic wastes can be from all sources in the country. This meant that not only companies in the electronics sector but all other companies including those in the industrial areas, in the business districts and even those in the neighbourhoods are possible generators of electronic wastes. It was noted that internet cafes which are increasingly common in neighbourhoods are capable of generating large amount of waste computers.

Besides generation from companies, electronic waste also comes from organisations like hospitals, institutions, as well as charities. These basically include medical equipment, computers and non-working electronic products that were donated to the charities. In addition, households are a large source of electronic wastes as a wide range of electrical and electronic equipment is use by the residents. It is therefore important that all sources of electronic wastes are properly disposed and collected for recycling.

Companies that require disposal of electronic products can either send them to the recycling companies or request for collections. There is a list of electronic waste recycling companies available on National Environment Agency's (NEA) website and these companies accept a wide range of electronic products. Among the 8 companies listed, 3 indicated that they provide collection services and 1 stated that their company does it on contractual basis. It was observed that the number of recycling companies in Singapore is not a lot and only half of these companies provide collection services. Moreover, those that do collect electronic waste only provide their services for commercial and industrial areas and fees are charged accordingly. On the whole, based on the circumstances, it was observed that the responsibility in ensuring proper disposals of electronic waste lies mainly on the companies and the various organisations.

On the other hand, residents as consumers can contact the Town Council for removal services of bulky electrical and electronic items from their households. There is also a list available on NEA's website that the residents may contact for their unwanted electronic products to be collected for reuse or recycling through various companies. There are a total of 19 companies listed. It was noted that these are not recycling companies but rather service providers as collectors and traders of used electrical and electronic equipment. These service providers do not charge a fee to collect. Moreover, reimbursements are done according to items and there are also companies who do not set a minimum quantity to provide collection services. It was observed that, on overall, the assistance and services provided for the residents to dispose electronic waste for recycling or reuse are much better than those provided for companies and they are generally adequate.

However, it was noted to be a problem that information is only available on the internet and there were little publicity about collection of electronic waste from the households. It was thought and expected that most residents would not search for recycling avenues on the internet prior to disposing of their electronic wastes. And one would probably do when he or she is an environmentally conscious consumer who is committed to protect the environment. This lead to the understanding of consumers' awareness, on the harmful effects of electronic waste and also the benefits of recycling of these wastes, could be the key to achieve high recycling

outcome. Conversely, it meant that in this case, where much reliance is on the residents to source for green avenues for disposals, would most likely result in residents' unawareness or feeling it to be a hassle which would eventually, create large amount of improper disposals of unwanted electronics.

In Singapore, there are also rag-and-bone men, junk dealers, who go around the neighbourhoods to do collections from door to door of old items and offering little amount of money in return. The items that they collect include used electrical and electronic equipment but only functional ones are accepted. These collections are subsequently sold to second hand dealers. Generally, used electronic goods dealers place their products to be sold in the local second hand market. There are some who does dismantling of used electronics as well and subsequently selling the parts to recycling companies.

The practices of the rag-and-bone men was considered to be not beneficial to the situation as only functional electronics would be collected. In fact, most consumers who have unwanted electronics, which are still useful, would normally sell them directly to second hand dealers like Cash Converters or advertise them on the internet to sell to other users which in these ways will fetch them a better price. Usually, only the older functional electronics get sold to the rag-and-bone men by the residents. It can be seen that the presence of the rag-and-bone men does practically no help to deal with electronic wastes generated by residents.

Residents and companies can also donate to charitable organisations used electronic products. One of these organisations is The Salvation Army (SA). SA accepts all kinds of electronics including spare parts as donations. Donors can drop their unwanted items at SA's donation bins and there will usually be a large amount of non-functional electrical and electronic items that are collected. SA subsequently sorts out the non-functional devices and sends them for recycling. Useful items which are in functional conditions are resold at inexpensive costs at Red Shield Industries (RSI) Family Thrift Stores and the proceeds are used to support SA's social and community activities. It can be seen that charities are capable of generating large volumes of electronic wastes and it is important that they have good waste management to dispose hazardous wastes in a proper way. It was also

observed that electronics recycling companies' source of materials can be from charities as well and these materials are largely contributed by residents and companies.

Manufacturers who are generators of electronic products are seen as a group who are responsible for the management of electronic waste. In Singapore, various technology companies are playing their role to clean up their own e-waste by accepting return of used products from their customers. In an effort to improve the situation of the rapid increase in the number of used cell phones, Nokia has a 'take back' programme here which allows customers to return old cell phones of all brands free of charge, including accessories like batteries, to send them for recycling or safe disposal.

PC manufacturer Dell is offering in Singapore free pick-up service of their unwanted Dell-branded computers and peripherals for recycling so as to help control the problem of obsolete PCs from stacking up. Hewlett Packard (HP) has its own recycling program in Singapore to provide its customers an avenue for disposal in an environmentally responsible way. Although HP's recycling program accepts end-of-life HP and non-HP computers and printers, the program requires signing up and is only available to HP customers. In addition, minimum pick up volume is stated as part of its conditions in providing collections.

As observed, most of the 'take back' programs available are by reputable companies and there are not a lot of manufacturers who provide these recycling programs in Singapore. These programs are sometimes unsatisfactory and certainly insufficient to deal with the related waste electronic products.

There are several recycling programs by NEA which cover areas in the housing estates, in the condominiums, private apartment estates, industrial areas as well as schools. Recycling bins like the one shown in figure 5.1 are placed in these areas. However, these bins are generally meant for recycling of paper, plastic bottles and metal cans. Even at the industrial areas, only wood waste and glass are the additional collections. No efforts were observed to collect electronic wastes in a similar manner. NEA is also coordinating with recycling companies to collect

fortnightly, door to door, materials from the residents to recycle. Similarly, electronic wastes are not included. From the various observations, it can be seen of the little emphasis that NEA has placed on electronic waste recycling.

Figure 5.1: Recycling bin for paper, plastic bottles and metal cans.

On the whole, the collection of electronic waste for recycling in Singapore was observed to be incomplete and unsatisfactory. Discouraging factors were observed in various areas relating to systems of collections from both companies and consumers. Cost of collections and consumers' awareness are also deterring factors. It was observed that a major responsibility lies on consumers to search and arrange for recycling of their electronic waste. Much self-reliant actions were thought to be needed of the consumers and it may not be the way to achieve high recycling outcome of electronic waste.

Efforts were considered to be generally poor by the government, the manufacturers and recycling companies to provide effective collections of electronic waste from all the different sources. The extent of coverage by the recycling companies to collect electronic waste in the country is rather limited. If a system like those for collecting general waste could be in place to readily collect used electronics, for recycling or reuse, but on a less frequent basis, the problems of electronic waste would be addressed and high environmental outcome would be achieved. However, such a system would not be easy to implement and would generally take a long time.

5.3 Electronic Waste Recycling Companies in Singapore

In this section, the practices and processes of recycling of used electronics of a company in Singapore, Centillion, are observed and discussed. This provides an understanding on the situation and also the effectiveness of recycling of used electronics. A few other electronic waste recycling companies in Singapore are also featured here for comparisons and discussions.

Centillion Environment & Recycling Limited, formerly known as Citiraya Industries Limited, is listed on the Singapore Exchange (SGX). Centillion recycles electronic waste and sells the extracted materials in the open market. It has joint venture with recycling giant Veolia Environmental Services Asia Pte Ltd, a unit of Veolia Environment of France. It has operations not only in Singapore but also in Wuxi, China and Wales, United Kingdom (UK). The company has a CRT recycling plant in UK and is also constructing a recycling plant in China for electronic waste recycling and precious metal recovery. Centillion, one of the most successful electronic waste recycling company in Singapore, made revenue of S$15.099 million and a profit (before income tax) of S$14.098 million in 2006 for all its operations (Centillion Environment & Recycling Limited Annual Report, 2006, p.11).

As observed from this electronic waste recycling company, it was determined that recycling of electronic wastes can be very profitable. This was based on the revenue and profit (before income tax) that the company made in 2006. The total expenses, before income tax, of the company were only an approximated S$1 million over S$15.099 million revenue made. This is a very positive outcome. It is very encouraging that a well managed electronic waste recycling company not only helps to protect the environment but also make profits in the process. Centillion is certainly a good model for other recycling companies as it has shown that it is able to achieve both its environmental and financial objectives.

Centillion’s recycling plant in Singapore has the facilities to perform the entire recycling process of electronic waste from collection to the recovery of the precious metals. Materials that are collected were dismantled and subsequently segregation

was done. Figure 5.2 shows the various technological recycling processes used in the recycling plant of Centillion. Sampling procedures are carried out to determine the metal content of the customers' materials. In the laboratory, chemical leaching is carried out on representative samples to determine the precious metal content. As precious metals are imbedded in electronic components and materials, they need to be processed at the Mechanical Plant before they can be recovered. At the Mechanical Plant, crushing, shredding and milling machines break the materials down into power form. Different crushers are used to handle different loads, throughput and material type.

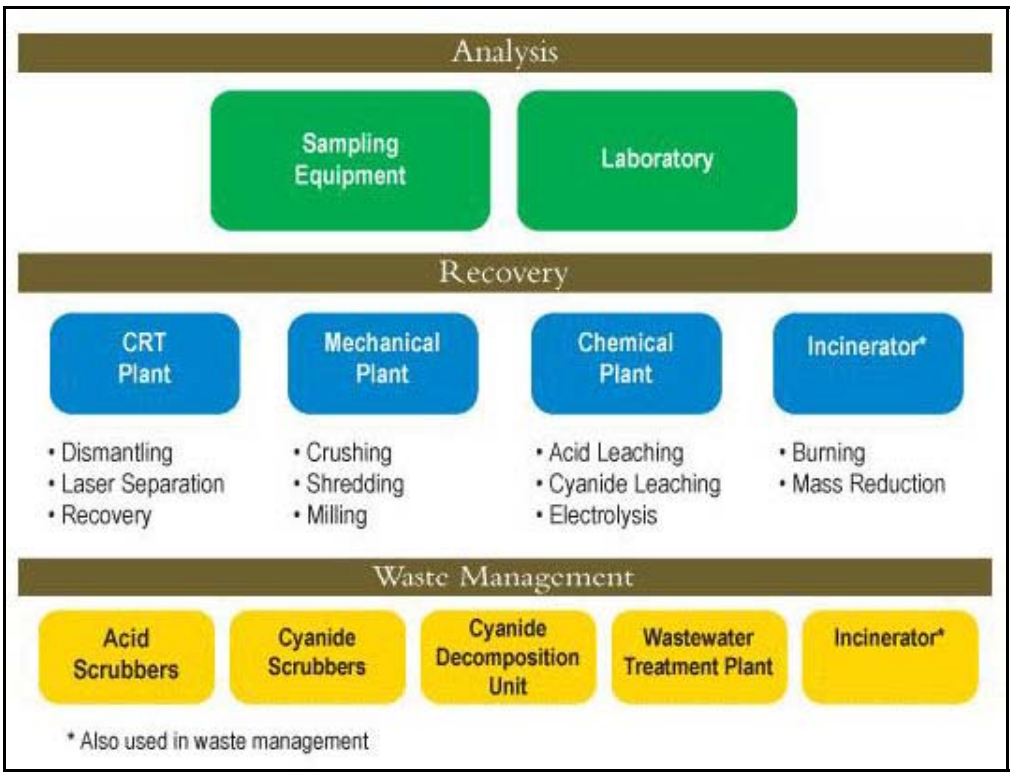


Figure 5.2: Recycling process of Centillion Environment & Recycling Limited, 2007.

From the point of collection of electronic wastes to the destruction of the materials, it was noted that the company did not attempt to separate materials for options like reuse or refurbishing such that products' useful life could be extended. It could be that such processes are not profitable and could also be difficult to implement, especially on a large scale. In addition, the outcome would usually not be productive as most material comes in broken and old. However, if separation is

done at the point of collection, it would then be easier for such options to be carried out. In fact, a smaller electronic waste recycling company in Singapore, CH E-Recycling Pte Ltd, does it as part of its recycling process.

Some precious metals which cannot be liberated by physical means have to undergo chemical processes to be recovered from the electronic materials. At the Chemical Plant, acid leaching is first performed. Materials are fed into a tank, as shown in figure 5.3, where they are dissolved and subsequently precious metals are extracted by selective precipitation. Secondly, cyanide leaching is done to remove gold from the materials and gold saturated solution is produced as a result. Lastly, electrolysis is processed to recover gold from gold saturated solutions.

Figure 5.3: Chemical process of Centillion Environment & Recycling Limited, 2007.

Although not much information was provided on Centillion's website, it was observed that the chemical processes to recover precious metals are in fact very complex and highly confidential. Another electronic waste recycling company in Singapore, R2 Japan, which provides recovery and refining services of precious metals has its technologies developed in their Research and Development facility in Japan. They claim that their technologies are constantly being improved to be cost effective and environmentally friendly.

It is great that recycling companies are improving their processes to achieve optimum output and at the same time doing it in an environmentally safe way. The recovery process of precious metals could be the most critical process in recycling of electronic wastes as it might determine how effective the overall recycling is. However, the highly confidential nature of the processes might meant that some other recycling companies could be lagging behind and processing in a less green manner and recovering less useful materials from their recycling processes.

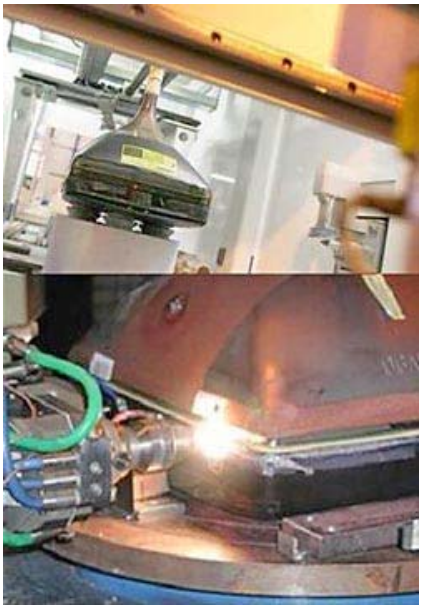


Figure 5.4: CRT recycling of Centillion Environment & Recycling Limited, 2007.

Centillion has its CRT Plant situated in Hirwaun, South Wales of UK and does it CRT recycling there. Figure 5.4 shows the CRT recycling in process. It is able to achieve 100 % clean separation and recovery of CRT's panel and funnel glass with zero contamination. It was observed that effective results can be achieved in CRT recycling. More than 92 % of glass mass is recovered and more than 98 % of total mass sent for recycling are recovered in Centillion's CRT Plant (Centillion Environment & Recycling Limited, CRT Plant, 2007). The plant's cutting processes are fully automated and thus reduce exposures to the workers and safely remove toxics. This is certainly a good outcome as one of the most harmful electronic parts, the CRT, can also be safely processed with the use of technology and highly effective results are achieved at the same time.

Figure 5.5 shows the incinerator used in the company. Incineration is used for mass reduction and it is sometimes necessary prior to liberation of precious metals as some materials like filters, rags and wipes, cannot be effectively crushed or chemically stripped. It was noted that among other processes, incineration is also used for the company's in-house waste management. From these observations, it was felt that improvements should be made in their processes such that incineration would not be required at all, therefore making the recycling greener.

Figure 5.5: Incinerator of Centillion Environment & Recycling Limited, 2007.

As part of Centillion's waste management, acid scrubber system is used to oxidise and neutralise fumes from the chemical processes. Similarly, cyanide scrubber system treats the fumes that are released by cyanide leaching and electrolysis processes. At the cyanide decomposition unit, cyanide in solutions is reduced by Ultra-violet Oxidation Unit to an appropriate level. Finally, the Wastewater Treatment Plant, which collects wastewater from all the laboratories and chemical processes, removes heavy metals present in the wastewater by pH adjustment, coagulation and flocculation. It was observed that proper waste management is in place in the recycling company to capture and treat all hazardous substances to prevent them from escaping to the environment. These systems are certainly necessary for safety and environmental concerns.

From the study made on the electronic waste recycling company, Centillion Environment & Recycling Limited, a better understanding was achieved of electronic waste recycling. Comparisons were also made with other recycling companies which gave a better understanding of the situation. Technologies and automations are used to achieve optimum results and proper waste management makes the whole process safer. As noted, it can be profitable, safe and effective.

In fact, the recovery can be very effective as seen in other recycling companies in Singapore as well. Enviro-Hub Holdings are able to recover about 3.5 kg of precious metals from 1 ton of copper scrap. In addition, they are also able to refine copper cathodes to at least 99.95 % purity (UOB Kay Hian Research, 2006). On the other hand, Cimelia Resource Recovery Pte Ltd is able to recover about 1 kg of gold from 5 tons of electronic waste (UOB Kay Hian Research, 2006).

5.4 Conclusions and Recommendations

In the previous sections, the collection of electronic waste in Singapore for recycling were seen and discussed. This was followed by a study on the processes of recycling and also recycling of used electronics in general. On the whole, it was observed that the electronic waste recycling companies in the country have good technologies and good standards to carry out effective and safe recycling. Moreover, the profitable nature was definitely one important reason that would encourage more developments and establishments in electronic waste recycling. The main problem lies on the systems of collections and it is therefore important that improvements are made so that more electronic waste can be recycled.

As observed, the current practice in collection of electronic waste was unsatisfactory. There was no proper control in the system of collections by the government to effectively collect used electronics for either reuse or recycling. This could be worsening as there are quite a lot of collectors and traders of used electronics around. 19 such companies are listed on NEA’s website. As these companies are not recycling companies, their primary objective could be to profit through reselling of the collected used electronics rather than selling their materials

to recycling companies which would probably earn them a lower profit. This could create problems if non-useful parts are mishandled and not send for proper disposal by recycling. Therefore, their actions are important and the government should control and award licenses accordingly. It will also be good if they can be representatives of recycling firms such that used electronics are effectively collected for reuse, refurbishing or recycling.

There are deterring factors like cost and minimum quantity for collections that might result in companies putting aside arrangements for recycling. There should be more coordination between the government and the electronic waste recycling companies such that better system for collections can be implemented in the country. This would mean absorbing the cost of collections and providing more efficient collection services. In a place like Singapore, which is a small city state with good infrastructure, collection should not be the barrier to achieve high recycling outcome for electronic waste.

It was observed that ‘take back’ programs by manufactures are few in the country and they are generally not effective. More publicity and participation is required. There should be more cooperation between manufacturers and recycling companies so as to make ‘take back’ programs a more common way of collection hence achieving better outcome.

Chapter 6: Management of Electronic Waste in Other Countries

6.1 Introduction

This chapter understands the various methods that are used globally to deal with the electronic waste problem. This aimed to provide a wider understanding of the extent electronic wastes are managed in other countries. Observations are made in the United States (US), Australia, Europe and Japan. This included comparisons with Singapore and relating of good systems to the local situation.

Finally, conclusions are made of the local situation and subsequent recommendations for improvements are also suggested.

6.2 Management in the United States (US)

In this section, the different methods that are used to deal with the electronic waste problem in the US are observed and discussed. Comparisons are also made with Singapore and subsequently relating good systems to the local situation.

In the US, the State and Federal environmental agencies has regulated that selected electronic products must be treated as hazardous waste if intended for disposal. Toxicity Characteristic Leaching Procedure (TCLP) is one of the test techniques that are used in the country to determine if the products are hazardous or non-hazardous. CRT monitors which usually contain about 1.8 to 3.6 kg of lead fail TCLP tests for toxicity (www.ewaste.com). Other electronic materials like PCBs that are found in computers and cell phones were noted to frequently fail TCLP tests.

The New York State (NYS) Department of Environmental Conservation (DEC) Regulation requires that these hazardous products should be disposed of in an environmentally sound manner. The regulation also requires that recycling facility must be on file with the DEC. It was observed that even donated equipment must be functional and for continued use and penalties may apply for non-compliance of the regulation.

Donating used electronics is a way to extend the products' life span but Regional Computer Recycling and Recovery (RCR & R) in US reported that in many cases, the equipment is not in working condition or lacks certain upgrades. In fact, many schools, churches and non-profit organisations end up engaging recycling companies to collect donated equipment.

As observed, there is regulation in the US to prevent improper disposal of certain electronic wastes and tests are used to identify hazardous electronic products. Conversely, regulation and test like these could not be found in Singapore to particularly address electronic wastes. Regulation could be a good way to deal with the problem. This meant that it is an offence to even dispose small amounts of electronic waste in general waste collections. However, there is no guarantee that regulation would work. It would only put a pressure on those who are aware, especially the companies. It was thought that educating could still be the best way to deal with the problem in the long term.

Charities usually receive large amount of non-functional electronic equipment and this is observed in Singapore as well. This could be the result that the public do not know what to do with their used electronics and thought that it might be useful to the charities. As seen in US, regulation is implemented to stop the problem. This could be considered strict but would be good as it saves large amount of time spent on checking and sorting. It would probably be more appropriate that charities inform their donors of the items that they would like to receive.

The Extended Producer Responsibility (EPR) is a waste management strategy in which manufacturers take responsibility of their products to manage them in an environmentally sound manner when they become obsolete and unwanted.

Manufacturers are in fact held accountable for meeting goals in source reduction, electronic products recovery, reuse and recycle. The end of life cost of electronic products will be internalised in the manufacturing process and can be reflected in product prices. This was noted in the US, a fee ranging from US$6 to US$10, depending on the product size, are charged at the point of purchase for certain electronic devices for recycling.

In the US, the expense of collecting, managing and disposing hazardous e-waste and waste sites clean up is borne by the taxpayer-funded government programs. The Computer TakeBack Campaign (CTBC), US, observed that EPR helps push manufacturers to assume responsibilities of these costs, thus aiming to relief the financial liability of the government and the taxpayers. CTBC believed that manufacturers will be more concerned about designing products that will last longer, be more useful and upgradeable. This also included concerns like easy to disassemble and recycle so as to keep waste costs to a minimum.

As observed, EPR is a positive policy that would probably create a better recycling system and improve the situation of electronic waste. EPR would probably help to address most of the problems of an electronic product right from the start at the designing or manufacturing stage and therefore bring about manufacturing of greener electronics. This will certainly be an effective way to deal with electronic waste problem. In fact in 2006, the Ministry of the Environment and Water Resources of Singapore noted that there are various ways of implementing EPR as seen in other countries like Australia, New Zealand and Germany that range from fully voluntary, fully mandatory, to a mix of both. However, none were implemented. Singapore's government should consider and try ways of implementing such policy so as to hold the manufacturers responsible for their products and would generally help to improve the situation. At the same time, costs issues, to a certain extent, would be addressed.

In US, in the year 2005, about 10 % of shareholders supported As You Sow (AYS), proposal that eventually brought Apple Computer to announce that it was revamping its 'take back' and recycling program. AYS is a non-profit promoting corporate social responsibility that represents shareholders. It was observed that

there is not much activity from non-profit organisations in Singapore to actively promote awareness in electronic waste recycling. Shareholders generally play a major role in large companies. This was observed to be important in manufacturing companies as they can support the study of ways to improve or to set up ‘take back’ and recycling programs of used electronics, as seen in the case of Apple Computer. It is therefore essential that awareness is raised in all areas including this group who has direct connection with the manufacturers.

Another situation in the US worth learning is that The University of California (UC) adopts guidelines for purchasing greener electronic products and recycling them. The university encourages manufacturers to provide ‘take back’ services and to recycle their electronic wastes. As a large university and the first in US to adopt such guidelines, environmental groups like CTBC observed that it could be setting an impact on how electronic products are manufactured and recycled.

It is good effort by the university to adopt guidelines for purchasing greener electronic products and recycling them. The universities in Singapore could work in a similar way to set a standard here for the manufacturers. This would certainly be beneficial as not only does it help to protect the environment, it also helps to raise awareness among the students. It would be better if other institutions and schools throughout the country follow such guidelines for purchases and disposals.

The Electronic Product Environmental Assessment Tool (EPEAT), initiated by the Environmental Protection Agency (EPA), US, was developed and launched in July 2006. EPEAT is a tool to assist consumers evaluates and selects electronic products according to a list of preferred environmental attributes. The manufacturers can register their products with EPEAT which has mandatory and optional criteria for different status of bronze, silver and gold.

EPEAT is a good development that will help consumers to better understand their electronic products. As there is currently no such tool in Singapore, it would be useful to the environmentally conscious consumers if a similar one could be implemented. This would also create competition among the manufacturers to achieve better environmental standards for their products. However, for such a

system to be effective, it would have to cover a majority of electronic products which is most likely difficult and time consuming for the manufacturers.

On the whole, it was concluded that there were much more Singapore could do to address electronic waste problems and also to achieve a high outcome of electronic waste recycling. This could also mean that Singapore could be lagging behind other countries in its efforts to deal with electronic waste. The comparisons showed that there is a lack of regulation, policy, non-profit environmental groups' activity, academic activity and environmental assessment tool in the country. As observed, there are quite a few methods in US which will be useful and the possible ways of implementations should be studied by the government to improve the situation in Singapore.

6.3 Management in Australia, Europe and Japan

In this section, the situations in other countries are observed and discussed. This provides a wider understanding of the various methods that are used globally to deal with the electronic waste problem. Similarly, this includes comparisons with Singapore and relating of good systems to the local situation.

In Australia, household products that are corrosive, toxic, ignitable or contain reactive ingredients are categorised as Household Hazardous Waste (HHW). Such products are advised by the government to be handled with care and to be disposed in a safe manner. These include electronic products like batteries, cell phones, televisions and computers. In Singapore, waste electronic products are not categorised as hazardous waste nor are the harmful effects warned by the National Environment Agency (NEA) on their website or through pamphlets. This inevitably would make the public feel safe with these products and in turn would cause them to be unconcerned about disposing them safely. This should not be the situation. NEA should in fact ensure residents' awareness on electronic waste and some level of categorisation is seen as necessary.

In an attempt to raise awareness about electronic waste recycling in Australia, a computer collection pilot program, Recycle IT!, was conducted in western Sydney from November 2002 to April 2003 by the Australian Information Industry Association (AIIA) and the Sustainability Programs Division of the New South Wales (NSW) Department of Environment and Conservation. The campaign was successful and about 57,000 kg of electronic products were collected.

It was observed that there is no major campaign in Singapore to promote awareness on electronic waste recycling. The most recent campaign conducted to collect unwanted computers and peripherals was by Hewlett Packard (HP). The campaign was to mark Earth Day which falls on April 22, however it was only for a short period of 5 days. There should be more participation by manufacturers in Singapore and large scale campaigns should be conducted to set an impact that would effectively raise awareness among the consumers.

In Australia, the NSW Government introduced the Extended Producer Responsibility (EPR) policy in 2001 through the Waste Avoidance and Resource Recovery Act 2001. The policy is to ensure that producers take physical or financial responsibility for the environmental impacts of their products. Subsequently, the EPR Priority Statement 2004 was developed. There were 16 listed 'wastes of concern' and 9 of them were of priority focus. Computers, televisions and nickel cadmium (NiCad) batteries were among the nine priority focus. EPR Priority Statement 2005-06 was later introduced and it replaces EPR Priority Statement 2004. Electronic products are still included under the new priorities and they are computers, mobile phones and televisions.

As observed, the priority list could be useful to address hazardous waste products and to put the industries aware of it. It was noted that in this case, electronic products are always among the priorities and this indicates the importance of proper disposal of electronic products. In Singapore, EPR is not practiced but if a priority list of hazardous wastes is available, it would serve as a good guide for the industries.

The Australian Mobile Telecommunications Association (AMTA) runs a successful mobile phones and batteries recycling program in Australia. The life span of a mobile phone is very short, an average of 18 months according to the AMTA. In 2005, the AMTA estimated that about 1.5 million mobile phones have been collected and recycled through its Mobile Phone Industry Recycling Program (MPIRP). The recycling program has help to reduce electronic waste in the country and also to protect the environment.

There should be some large scale mobile phones recycling going on in Singapore as well. The fast replacement rate further emphasised the importance of doing so. However, the mobile phones recycling programs in Singapore have low publicity and the responses were poor. The Straits Times reported in April 2007 that Nokia noted only 2 per cent of used mobile phones are recycled through their 'take-back' program in Singapore. The company research later also found out that almost half of all used mobile phones are still being kept at home. More efforts should be put in to make recycling programs productive.

In Australia, a relatively new, industry-led organisation with a focus on managing environmental issues in the consumer electronics sector is the Product Stewardship Australia Ltd (PSA) (www.productstewardship.asn.au). It is a non-profit organisation. It works with the companies to facilitate establishments of product stewardship schemes so as to collect and recycle used electrical and electronic equipment and ultimately control the problem of electronic waste. The product stewardship generally offers a collaborative approach and sharing of responsibilities among the related parties.

The product stewardship is an alternative method that could be used in Singapore to control the problem of electronic wastes. The approach is fair and all related parties might see the benefits of establishing such schemes. If establishments are made, the problems of the related electronic products would be well taken care of and on the other hand, high recycling outcome would be achieved.

In Europe, the WEEE Directive (Waste Electrical and Electronic Equipment) was passed in 2003 and it covers all countries in the European Union (EU). The key

components include producers financing reuse, recycling and disposal of all electronic waste equipment that they put on the market after 2005. The manufacturers must also meet a certain collection rate and recycling rates are specified and will increase over time. Products must be designed for dismantling and recovery as well. The WEEE Directive was accompanied by a second law, the Restriction on Hazardous Substances (RoHS) Directive which says that the use of substances like lead, cadmium and mercury must be phased out by July 1, 2006.

In Japan, the Law for Promotion of Effective Utilisation of Resources was passed in 2001. This covers consumers owned computers, monitors and some other products as well. It mandated business in certain sectors to take on recycling initiatives and incorporate 3Rs, Reuse, Reduce and Recycle, into their business model. It also included a 'take back' fee for purchase of new equipment after 2003, in which the fee is paid to the manufacturers.

As can be seen, the situation for both Europe and Japan are rather stringent. EU countries have laws that mandate manufacturers to achieve high environmental standards of their products through green manufacturing and good designs. Recycling goals are even set for the manufacturers to achieve as well. In both Europe and Japan, the end of life management of electronic products are mandated to be taken care of by the manufacturers as their systems to deal with electronic waste and to protect the environment. Singapore is definitely way far behind these countries in setting environmental laws to address electronic waste.

6.4 Conclusions and Recommendations

By observing some of the systems in other countries, in this case in the US, Australia, European Union and Japan, an understanding was achieved. This also provided a chance to compare with the situation in Singapore. It was concluded that Singapore's controls and efforts on electronic wastes are generally poor.

In the observations, various methods were found to be good in other countries and could be effective for dealing electronic waste in Singapore. The first step to begin

with could be to categorise electronic waste with some level of importance. This could be followed by setting a policy regarding the management of electronic waste that would be useful as a guide and also as an important notice to both companies and consumers. It was also noted that Extended Producer Responsibility (EPR) is widely used in other countries and this could mean that it is the most effective way of addressing the problems of electronic waste. Ways of implementation should be considered by the authorities and it could also be a solution to the problem of collection of electronic waste in the country.

There are quite a number of non-profit organisations in other countries which help to push for better environmental standards. Singapore needs to raise the level of awareness and encouragement so as to see similar activities happening locally. This could probably also start from schools and universities. National Environment Agency (NEA) should also work with more manufacturers so that more campaigns and ‘take back’ programs can be conducted in the country, probably on a longer period. This would not only help to collect electronics for recycling but also an effective way of promoting awareness. On the whole, there are much more that can be done in Singapore to effectively address electronic waste and methods to do it should be explored on a wider basis.

Chapter 7: Case Studies on Companies in the Local Industry

7.1 Introduction

In this chapter, case studies were conducted on two companies in the local industry to gain an understanding on the system of management used in dealing used electronic products. The data collected from these companies were focused on only computers and printers.

This included a study on the amount of computers and printers that were used, stored, disposed and recycled over time. Assumptions were made to widen the scale of understanding. The results obtained from the 2 case studies were subsequently used to relate to the manufacturing industry and all other sectors as well. This was intended to understand the possible magnitude of electronic wastes, like computers and printers, that were disposed in the industries of Singapore.

7.2 Methodology

The task was to collect information for studies on how companies in the local industry managed their used electronics. In the case studies, two manufacturing companies in the electronics sector were studied. As the wide range of electronic products in these two companies was considered too huge for the case studies, it was shrunk to focus only on computers and printers. This was considered as a good way to build the understanding of how these two companies on overall handled their used electronic products, since computers and printers are usually present in large numbers in a typical company and they are electronic products with significant mass.

As the two companies are generally large and access to various information were difficult and too time consuming, data was collected only for a department in each

company and they are both the Production Department. The Production Department is usually one of the biggest departments in a company that have big space area and large number of employees. Hence, it is usually in this area of a company where the largest amount of electronic products is equipped.

Nevertheless, investigations with only the management of computers and printers, in these two cases, were seen as constructive and meaningful as it was thought that by being able to properly manage these common electronic products would meant that more expensive and sophisticated ones were much more well taken care of. On the other hand, if a big department had been able to manage its electronic products properly, it would also mean that other smaller ones are of better standards of management. Therefore, the analysis of data for the computers and printers in the production department was taken to be an important step to understand the company as a whole, in the situation that information on a smaller scale was being collected.

Subsequently, the understanding of how the two companies dealt with used computers and printers was further used to relate to the possible generation of used computers and printers in the industries in Singapore. Specific points for the data collection which ceased in mid October 2007 for these two companies were as follows.

- Total number of computers and printers which were in operation.
- Total number of computers and printers that were stored which were meant for reuse or to be disposed.
- Total number of computers and printers that were sent for recycling over a specified period of time.
- Total number of computers and printers that were not recycled and were thrown into general waste collections.

The two manufacturing companies are both reputable multi-national companies which have offices and factories over the world. For each company, a set of data was collected in one of the factories situated in Singapore. Representatives of the respective companies were approached for the above mentioned information. Background information of the respective companies which were useful in

supporting the case studies was also obtained. The results of the two companies were combined and then averaged out to obtain a mean which was ultimately used to gauge the possible amount of disposal of computers and printers in the local industries.

7.3 Case Study Number 1

The factory of the manufacturing company that this first case study was conducted was a relatively new 8 years setup. It was ISO 14001 certified for its environmental, health and safety standards. There were about a total of 450 employees in this company in Singapore. The management of the physical computers and printers were carried out by the respective departments. New purchases were based on the department's budget and end of life products were sent for recycling biannually. These requests were however approved by both the Finance and Information Technology (IT) Department. The networking and software setup and maintenance of the terminals were normally performed by the IT Department.

Production Department Computers & Printers

	LOCATION	CPU	Monitor	Keyboard	Mouse	Network Laser Printer	Ink Jet Printer	Label / Barcode Printer
1	Kitting	1	1	1	1			1
2	Assembly XY (PDC)	1	1	1	1		1	
3	Assembly MI	1	1	1	1			
4	Test Station 1a PU (PDC)	1	1	1	1	1		
5	Test Station 1b	2	2	2	2			
6	Test Station 3a CAL	1	1	1	1			
7	Test Station 3b	2	2	2	2			
8	Test Station 5a MHS (PDC)	1	1	1	1			
9	Test Station 5b	2	2	2	2			
10	Test Station 8a TM (PDC)	1	1	1	1	1		
11	Test Station 8b	2	2	2	2			
12	Test Station 10 BOND (PDC)	1	1	1	1			
13	Test Station 11 CUST (PDC)	1	1	1	1			
14	Test Station 12 PBD (PDC)	1	1	1	1	1		1
15	Scope Room Shear	2	2	2	2			
16	Scope Room Pull	2	2	2	2			
17	Scope Room Ball Measure	4	4	4	4	1		
18	Scope Room View	2	2	2	2			
19	Offices	11	11	11	11	2	1	
Total number in operation		**39**	**39**	**39**	**39**	**6**	**2**	**2**

Table 7.1: The computers and printers used in the Production Department of Manufacturing Company #1.

The number of computers and printers that were used in the Production Department of this manufacturing company were collected as shown in table 7.1. It was a collection of the computers and printers at different locations in the department and the total figure was tabulated as the total number in operation. There were 39 computers which were desktops and a total of 10 different printers. It was noted that none of the computers and printers in the production line were in non-working condition.

The Production Department of this company functioned 24 hours a day on three shifts and there were a total of about 180 staffs in this department. This was a large number comparing with the total number of computers in operation. It was also noted that these terminals were turned on 24 hours a day to run the production and only turned off when the staffs rest on Sundays or on public holidays. This certainly affects the life span of the computers and printers which will likely result in a higher rate of replacement. A high replacement rate of electronic products in the factory further emphasised the importance of proper electronic waste management of the company.

CRT and LCD Monitors

	LOCATION	CRT Monitor	LCD Monitor
1	Kitting		1
2	Assembly XY (PDC)	1	
3	Assembly MI	1	
4	Test Station 1a PU (PDC)	1	
5	Test Station 1b	2	
6	Test Station 3a CAL	1	
7	Test Station 3b	2	
8	Test Station 5a MHS (PDC)		1
9	Test Station 5b	2	
10	Test Station 8a TM (PDC)	1	
11	Test Station 8b	2	
12	Test Station 10 BOND (PDC)		1
13	Test Station 11 CUST (PDC)	1	
14	Test Station 12 PBD (PDC)	1	
15	Scope Room Shear	2	
16	Scope Room Pull	2	
17	Scope Room Ball Measure	4	
18	Scope Room View	1	1
19	Offices	4	7
	Total in Operation	**28**	**11**

Table 7.2: The CRT and LCD monitors in the Production Department of Manufacturing Company #1.

In the department, there were two different types of monitors used and they were recorded as shown in table 7.2. It was observed that there were a total of 28 CRT monitors and 11 LCD monitors which were replacements done over the past 2 years. As the factory was setup 8 years ago, it was determined that all the initial purchase of CRT monitors was replaced. This also meant that the 28 CRT monitors in operation were likely to be second purchases based on an estimated life span of 4 to 5 years. It could have been even shorter as they were operating under such high usage. This meant the same for other computer parts and printers in the production line.

In the next table 7.3, the different parts that were not used in the department were recorded. These parts were kept in the store room for two purposes. There were functional and non-functional ones which were kept for reuse and disposal respectively. It was noted that disposal meant removal from the premises in which the company chose to do it by requesting collections by the recycling firms.

Parts not in operation (October 2007)

	PURPOSE	CPU	Monitor	Keyboard	Mouse	Network Laser Printer	Ink Jet Printer	Label / Barcode Printer
1	Used Parts (Functional, **pending reuse**)	2	5 (CRT)	0	0	0	0	1
2	Used Parts (Non-functional, **pending disposal**)	0	3 (CRT)	2	0	0	0	0
Total number not in operation		**2**	**8**	**2**	**0**	**0**	**0**	**1**

Table 7.3: The parts that were not in operation in the Production Department of Manufacturing Company #1.

There were 2 central processing units (CPUs), 5 CRT monitors and 1 printer that were stored for reuse. These CPUs were bought 3 years ago and they were of lower performance. They were replaced when their operating speed were considered too slow for its specific task. However, they were kept as spares in the department and were there for more than 6 months. As for the 5 CRT monitors, they came about when there was an upgrade of monitors, from CRT to LCD ones, for the office

computers of senior staffs and supervisors about a year ago. The label/barcode printer that was out of warranty was removed from the line 2 years ago as it was not functioning properly. A calculation showed that about 5 % of CPUs, 13 % of monitors and 10 % of printers of the total number in operation were stored for reuse. These amounts could have been lesser if efforts were made by the various departments to co-ordinate the possible allocations of these electronic parts.

There were also 3 CRT monitors and 2 keyboards which were required to be disposed. These parts were about 4 years old and they were consolidated in the store room for the next recycling collection at the end of the year. This is a positive effort of the department and the company where unwanted electronic parts were systematically organised for proper disposal at fixed periods.

Parts disposed from Jan 2007 to Jun 2007

	PURPOSE	CPU	Monitor	Keyboard	Mouse	Network Laser Printer	Ink Jet Printer	Label / Barcode Printer
1	Sent for **recycling** in July	3	4 (CRT)	3	0	0	1	0
2	Thrown with general waste (**Not recycled**)	0	0	0	6	0	0	0
	Total disposal	**3**	**4**	**3**	**6**	**0**	**1**	**0**
	Estimated years old of disposed parts	4	4	4	3	NA	3	NA

Table 7.4: The parts that were sent for recycling or dumped in the Production Department of Manufacturing Company #1.

On table 7.4, the parts disposed over a 6 months period from January 2007 to June 2007 were listed. They were either part sent for recycling or part thrown into general waste collections. These parts had a short life span of 3 to 4 years. Of the total disposal, 6 computer parts, the mice, were thrown into general waste bin and therefore not recycled. It was told that these parts were small and hence not considered for recycling by the department. On the other hand, other parts were considered too bulky to be thrown into general waste bins and hence requested collections by the recycling companies which were also the appropriate way of disposal. It was noted that dumping of all kinds of wastes is illegal in Singapore.

The following table 7.5 shows the weight of typical computer parts and printers. These data were collected from the specifications of the products in the various brand companies' websites. As the weight of keyboard and mouse were not available, the weight of a standard keyboard and mouse were literally taken and recorded. From these data, a calculation was made to understand what percentage by weight of the total parts disposed that were not being recycled

Parts	Model	Weight
Computer (Desktop)	Fujitsu ESPRIMO P5100	8.3 kg
Computer (Laptop)	Fujitsu LifeBook C1410	2.8 kg
Monitor (CRT)	ViewSonic E70B 17" CRT Monitor	15.0 kg
Monitor (LCD)	Samsung 720N 17" LCD Monitor	4.4 kg
Keyboard	Logitech Deluxe 104 Keyboard	1.05 kg
Mouse	Logitech Optical Mouse	0.15 kg
Printer (Ink Jet)	Canon Photo Printer Pixma iP1800	3.31 kg
Printer (Laser Jet)	HP LaserJet P2015dn Printer	11.02 kg

Table 7.5: The weight of different computer parts and printers.

Total weight of parts disposed (in half a year):

$$(3\times 8.3)+(4\times 15)+(3\times 1.05)+(1\times 3.31)+(6\times 0.15)=92.26\ kg$$

Total weight of parts disposed that were not recycled (in half a year):

$$6\times 0.15=0.9\ kg$$

Percentage by weight of parts disposed that were not recycled:

$$\frac{0.9}{92.26}\times 100=0.98\ \%$$

As calculated, the approximated percentage of parts disposed that were not recycled was 0.98 %. This amount was small as it was only contributed by the 6 mice. Other unwanted computer parts and printers might be considered too big to be easily

disposed in general waste bins in this case. However, there were other small sized electronic products in the company ranging from multimeters to electronic gauges and if every department practiced such disposal in the company, numerous amounts of small sized electronic products will not be recycled. A calculation indicated that it could be an approximated 4.5 kg of mouse that will not be recycled in a year in the company.

Estimated weight of parts disposed that will not be recycled (in the company in a year):

$$\frac{0.9}{180} \times 450 \times 2 = 4.5\ kg$$

Estimation was made to see the amount of waste contribution of computers and printers that will be disposed in the company in a year based on the rate that 180 employees had produced 92.26 kg of electronic waste consisting of computers and printers in half a year. This meant that 1.03 kg of computers and printers will be disposed by an employee in a year.

Estimated weight of computers and printers disposed by an employee (in a year):

$$\frac{92.26}{180} \times 2 = 1.03\ kg$$

Estimated weight of computers and printers disposed by 450 employees in the company (in a year):

$$1.03 \times 450 = 463.5\ kg$$

It was calculated to be a total of 463.5 kg that would be disposed in the company in a year. This was a considerable amount. Although the assumption was based on a high usage rate of the Production Department, it was however only consisting of computers and printers. It can be seen from this assumption of the magnitude that computers and printers are capable of generating and which is why they have always been considered as one of the major contributors of electronic waste.

On the whole, the management of computers and printers during the products' life span and after its end of life was generally very good. It was observed that controls were in placed from purchasing to disposal of these products. This had brought about a high recycling rate seen in this rather restricted scale of case study. However, the company seems to lack the effort of educating its employees on the benefits of recycling even though it was ISO 14001 certified. Their employees were obviously unsure of the value and importance of recycling of electronic wastes. This should not be the situation. After all, the company is a manufacturer in the electronics sector hence has the responsibility to play a part in dealing with electronic wastes and therefore set a good example.

7.4 Case Study Number 2

In the second case study, a similar way was used to understand the practices of the company in dealing computers and printers, particularly with the end of life management. The factory under study was 23 years old and there were various changes in the production lines over the years. As such, the Production Department had a mixture of computers and printers ranging from close to end of life ones to newly purchased ones.

The company was also an ISO 14001 certified company and there were a total of 1400 employees in Singapore. The management of computers and printers was department based. A specific staff administered the management in the department and liaised with the Finance Department. New purchases were requested through written documents justifying the requirements and approvals were given by the Finance Department. The company engaged a contractor to collect their used materials which included electronic wastes, waste chemicals, metal scraps, plastics packaging and carton boxes. The service provider would subsequently sort out the wastes and sent them to respective recyclers.

The Production Department of this company had two production lines and the computers and printers used in the department were recorded on table 7.6. There were a total of 44 computers and 36 different printers. It was noted that the

proportion of printers to computers were much higher compared to the company in the first case study. This was because there were a significant number of staffs who had personal desk jet printers. This probably meant that the printers were running on a lower efficiency during its useful life span compared to a network printer which had shared access.

Production Department Computers & Printers

	LOCATION	CPU	Monitor	Keyboard	Mouse	DeskJet Printer	Network Laser Printer	Label / Artwork Printer
Production Line #1								
1	PCBA Test Station #1	1	1	1	1			
2	PCBA Test Station #2	1	1	1	1			
3	PCBA Test Station #3	1	1	1	1			
4	LCD Testing Station	1	1	1	1			
5	Upper Module Assy Station	1	1	1	1			
6	Lower Module Assy Station	1	1	1	1			
7	Pre-Burn-In Station	1	1	1	1			
8	Post Burn-In Station	1	1	1	1			
9	Final Test Station	1	1	1	1	1		
10	Label Printing Station	1	1	1	1			3
11	Cal Cert Printing Station	1	1	1	1		1	
12	CD Writing Station	1	1	1	1			
13	CD Artwork Printing Station	1	1	1	1			1
14	Order Integration Station	1	1	1	1			
15	Debug station #1	1	1	1	1	1		
16	Debug station #2	1	1	1	1	1		
17	Debug station #3	1	1	1	1	1		
18	RMA Station	1	1	1	1			
19	Line leader's table	1	1	1	1	1		
Production Line #2								
1	Front-End Board Pre-test	1	1	1	1			
2	Backend Board Pre-test							
3	Unit Assembly	1	1	1	1			
4	Cal Test Station	1	1	1	1	1		
5	Final Test Station	1	1	1	1			
6	Box Content List Printing	1	1	1	1		1	
7	Label Printing Station							2
8	CD Verification Station	1	1	1	1			
9	Order Integration Station	1	1	1	1		1	
10	Line leader's table	1	1	1	1			
11	Offices #1	7	7	7	7	7	2	
12	Offices #2	10	10	10	10	10	2	
	Total in operation	**44**	**44**	**44**	**44**	**23**	**7**	**6**

Table 7.6: The computers and printers used in the Production Department of Manufacturing Company #2.

There were a total of 42 staffs in the department which consisted of 23 operators and 19 other staffs of different positions. This number was small as the company

had a major portion of its employees in its design services for its operations in Singapore. Production operated 12 hours a day and the computers and printers were usually left turned on overnights. Although the department used both CRT and LCD monitors, there were no specific records on the number of different types of monitor used.

From the following table 7.7, there were 6 sets of computers that were not in operation. Of which, 3 sets were kept for reuse and another 3 were pending disposal. The contractor was normally asked to collect the computers and printers meant for disposal when there was a considerable amount accumulated. As the contractor visited the company to collect all kinds of used materials on a frequent basis, disposal of computers and printers were generally convenient. It was learned that disposal of computers were usually done in sets by the company. This was because it was easier for accounting especially for upgrade purposes and also because purchases for computers in sets were offered at a better price.

Parts not in operation (Start of Aug 2007 to end of Sep 2007)

	PURPOSE	CPU	Monitor	Keyboard	Mouse	DeskJet Printer	Network Laser Printer	Label / Artwork Printer
1	Used Parts (Functional, **pending reuse**)	3	3	3	3	0	0	0
2	Used Parts (Non-functional, **pending disposal**)	3	3	3	3	0	0	0
	Total number not in operation	**6**	**6**	**6**	**6**	**0**	**0**	**0**

Table 7.7: The parts that were not in operation in the Production Department of Manufacturing Company #2.

The number of computers stored for reuse was 3 sets which were about 7 % of the ones in operation. Options for reuse in other departments were not practiced. One reason told was that these used computers were probably not welcomed as they were usually considered obsolete. In the 2 months, from the start of August to the end of September, after the last collection of disposal by the contractor, 3 sets of computer were replaced in the production lines and awaiting disposal. This was a

fast rate of replacement as upgrading of terminals was in progress. The computers were about 4 years old. Two had performances which were undesirable and not upgradeable. One was not functioning properly and was replaced as it was considered irreparable by their technical staffs. It was however noted that spares were not easily available in the market for these old computers.

In the next table 7.8, the amount of parts disposed was observed for a period of 7 months, from January 2007 to July 2007. A total of 9 computer sets were disposed and all were sent to recycling via the contractor. None of the parts disposed were thrown into general waste collections and these parts were estimated to be 4 years old. This was a 20.5 % disposal of computers over the operating ones in a 7 months period. A calculation was made to find out the total weight of computers that were disposed based on the data on table 7.5.

Parts disposed from Jan 2007 to Jul 2007

	PURPOSE	CPU	Monitor	Keyboard	Mouse	DeskJet Printer	Network Laser Printer	Label / Artwork Printer
1	Sent for **recycling**	9	9	9	9	0	0	0
2	Thrown with general waste (**Not recycled**)	0	0	0	0	0	0	0
	Total disposal	**9**	**9**	**9**	**9**	**0**	**0**	**0**
	Estimated years old of disposed parts	4	4	4	4	NA	NA	NA

Table 7.8: The parts that were sent for recycling or dumped in the Production Department of Manufacturing Company #2.

Weight of one set of computer (desktop with CRT monitor):

$$8.3 + 15 + 1.05 + 0.15 = 24.5\ kg$$

Total weight of computers that were disposed in the department (in 7 months):

$$24.5 \times 9 = 220.5\ kg$$

Possible weight of computers and printers disposed in the department (in a year):

$$\frac{220.5}{7} \times 12 = 378\,kg$$

As expected, the calculated amount of weight that was disposed in the 7 months period was a significant 220.5 kg and it will be a likely 378 kg in a year. This could be even more considering that in a 2 months period, from the start of August to the end of September, 3 computers were already awaiting disposal. This rate was 1.5 computers a month compared to 9 sets in 7 months which was 1.29 computers in a month.

The estimated amount of disposal of computers and printers per employee in the department was calculated to be 9 kg in a year. This was a big difference from the company in the first case study which was 1.03 kg per employee per year. If this rate was used to calculate the amount of disposal in the company, it would be an enormous 12,600 kg of computers and printers disposed in a year. Again, in this case, only computers and printers were considered and would be an even greater amount when all kinds of used electronics were included.

Estimated weight of computers and printers disposed by an employee (in a year):

$$\frac{378}{42} = 9\ \ kg$$

Estimated weight of computers and printers disposed by 1400 employees in the company (in a year):

$$9 \times 1400 = 12{,}600\ \ kg$$

It was revealed by the Finance Department that S$800,000 of computers in the company, excluding printers, valued at purchased price was scrapped in the year 2006. They were similarly collected by the contractor for recycling and these computers were removed from the company's account. These were computers used by employees of the company in Singapore alone. In fact, all of these parts were out of warranty. Most had passed their useful life and were of zero depreciated value. If

the average purchased price of a computer were taken to be S$3000, it meant that a vast 266 number of computers were disposed.

An approximated weight of 266 computers:

$$24.5 \times 266 = 6{,}517\ kg$$

This approximated total weight of disposal of computers in 2006 was however lower than the approximation, 12,600 kg, based on the Production Department replacement rate from January 2007 to July 2007. A list, updated in mid September 2007, of computers of the company for its operations in Singapore was provided by the Finance Department as shown in Appendix B. Unfortunately, a list for printers could not be obtained. There were a total of 634 computers. A count of the type of computers showed that 165 were laptops and the rest 469 were desktops computers. Laptops were 26 % of the total computers used. Laptops are increasingly popular with business users and consumers because of their portability and these days, laptops are capable of high performance as well.

Estimated percentage of replacement of computers in year 2006:

$$\frac{266}{634} \times 100 = 41.96\ \%$$

A calculation showed that 41.96 % of computers were being replaced in the past year, assuming that the total number of computers were the same as those in September 2007. This indicated that upgrading of computers was not happening only in the Production Department but also in most other departments of the company. An observation made from the list of computers showed that there were computer models with processor as old as Pentium or Pentium II which indicated that they were at least 9 years old. Intel Pentium Processors and Pentium II Processors were manufactured in 1993 and 1997 respectively. These could be unused computers left unattended on the desk or in some corners of other departments which do not see a need for replacement or a consideration for recycling.

The different departments seemed to have a double standard of management of these products. On the other hand, there were also new models with good specifications. All these suggested that the company could be dealing with a big mass of obsolete computers and resolving the problem that would likely take two and a half years period based on the percentage of replacement seen in 2006.

Estimated weight of computers disposed by an employee (in year 2006):

$$\frac{6{,}517}{1400} = 4.655 \ kg$$

Estimated average weight of computers disposed by an employee (from Jan 2006 to Jul 2007):

$$\frac{4.655 + 9}{2} = 6.83 \ kg$$

The calculation above shows the average weight of computers disposed by an employee in a year was 6.83 kg. This figure was arrived at based on various assumptions and the intention was to gain a fairer understanding at the constraint of information provided. It was observed that this figure was more than 6 times of that seen in the first case study. However, it was also noted from the studies that this company was carrying out major upgrading of computers.

On the whole, the management of the computers and printers in the company was generally very good. Purchasing of computers and printers seems rather strict in this company based on the procedure observed. As for end of life management, they had a contractor to take care of the used materials in the company which had all disposal carried out in an intended safe manner. The engagement of a contractor proved helpful for such a big company and especially so when there was a major replacement of computers going on in the company. However, it was not clear what additional processes were done by the contractor, besides sorting, before sending the wastes to the respective recyclers.

One such service provider in Singapore which was found in the internet was Starpal Pte Ltd but there was not much information mentioned on their website. In ensuring

safe disposals were carried out, it was hoped that the company did check out their contractor prior to engaging them. Otherwise, the consequences would be damaging if the large amount of hazardous wastes were not properly handled and not fully sent for processing in a safe way.

7.5 Evaluation of Results

From the 2 case studies, an understanding was achieved of the various happenings that were going on in the companies. Both companies had measures in place to take care of unwanted computers and printers in their premises. They had appropriate ways of disposal of these electronic wastes. The law had probably put a pressure on them as well because they could not simply dump these wastes. These companies focused were big, reputable and ISO 14001 certified ones. This could mean that many other smaller companies in the industry do not have such standards of electronic waste management. To achieve good waste management in the company, it was observed from the case studies that it should be done with the right intention and understanding.

From the case studies, some of the results obtained were used to relate to the overall manufacturing sector to investigate the possible amount of electronic waste contribution by computers and printers. A step was taken to further understand a possible magnitude of generation of these electronic wastes in Singapore's industries as a whole. These were especially meaningful with the absence of official data on electronic wastes from the government.

Table 7.9 shows the employment statistics for different sectors in Singapore with a total of about 2.5 million in employment. Manufacturing industry's employment was a significant 20.7 % of the whole. These figures were useful in achieving the results through the calculations shown.

Employment Statistics	2006
Employment as at Year-end ('000)	2,495.90
Employment by Sector as at Year-end (%)	100
Manufacturing	20.7
Construction	10.2
Services	68.4
Others	0.7

(Source: Ministry of Manpower of Singapore, 2007)

Table 7.9: Employment Statistics for 2006.

Mean weight of computers and printers disposed by an employee (based on the 2 case studies):

$$\frac{1.03+6.83}{2} = 3.93 \ \textit{kg in a year}$$

Estimated weight of computers and printers disposed in the manufacturing industry:

$$\left(\frac{20.7}{100} \times 2{,}495.90 \times 10^3\right) \times 3.93 = 2{,}030.44 \ \textit{tons in a year}$$

Estimated weight of computers and printers disposed in all different industries in Singapore:

$$\left(2{,}495.90 \times 10^3\right) \times 3.93 = 9{,}808.89 \ \textit{tons in a year}$$

The results from the 2 case studies were used to obtain an average amount of computers and printers disposed by an employee in a year. In fact, with the different stages of obsolesce in the two companies and a resulting different volumes of replacements and waste generation, an average of the two would mean a more balanced rate was achieved. As calculated, it was 3.93 kg in a year. The estimated electronic waste contribution by computers and printers alone, in the manufacturing industry, was a huge 2,030.44 tons in a year.

If all other industry sectors had the same rate of generation, there would be an approximated 9,808.89 tons of waste computers and printers generated in a year in the country. This was calculated to be 0.19 % of the 5.22 million tons of total waste generated in 2006 (Ministry of the Environment and Water Resources of Singapore, 2007). It should be noted that this amount was a contribution by only computers and printers and had yet to include those generation from the domestic.

It was expected that this amount would add up to be enormous when electronic products of all kinds were considered. These products ranged from small MP3 players purchased by consumers to huge computer servers used in businesses. Waste electronics like IC lead frames and PCBs generated in the course of manufacturing were certainly a concern as well. The actual total volume of electronic wastes generated in Singapore could well be 10 times this amount. This would mean 2 % of the total wastes generated by the population in a year were electronic wastes. It is therefore important that proper measures were in placed to dispose electronic wastes in an environmentally sound manner.

7.6 Conclusions

The case studies done were helpful in achieving some data for consideration and understanding. Two different styles of waste management in a company were observed and they were generally very good. Although limited information was acquired from the companies and smaller scopes of studies were done, the results achieved provided an opportunity to relate to Singapore as a whole and to obtain various estimates as well.

The generation of electronic wastes is an ongoing process as long as the world engages in technology. It was observed how the magnitude of these wastes would add up in a company and in turn in the industries. It is therefore crucial that regardless of the size and weight of the electronic wastes generated, proper disposal should be carried out for all of these hazardous wastes.

Chapter 8: Survey of Consumers

8.1 Introduction

A survey was conducted aimed at understanding the behaviour and attitude of the consumers towards electronic waste recycling. This included a study of the workplace environmental policies of the consumers. Efforts were also made to determine the extent of consumers' current involvement in recycling and their willingness to be involved in the future.

This chapter introduces the methodology of the survey and presents the results. Problems are identified and discussed. And finally, conclusions are made about the overall results and key findings of the survey are specified.

8.2 Methodology

The survey was conducted to understand the behaviour and attitude of the consumers towards recycling of electronic waste in Singapore. Although the main scope of study was on consumers, efforts were also made to understand the environmental policies in the workplaces of the respondents. This allowed an opportunity to find out what was the standard of environmental management systems that were in place, in the industries, in particular if electronic wastes were addressed.

The questionnaire created also included an attempt to find out the awareness of the respondents on electronic waste recycling. The survey provided an understanding of their perception of recycling in general as well. The structuring of the questions of the survey was especially important to achieve an effective questionnaire that would yield accurate and useful information from the respondents. This was done with care and professional advice was sought for improvement.

The questionnaire was as shown in Appendix C and there were a total of 12 questions. A space was also included for other comments. This was especially useful for respondents who had strong views regarding the topic. Tick boxes were chosen for the answers as it was considered a helpful method for the respondents in answering. In addition, it was a convenient and quicker way of responding. It was noted that long surveys and written response questionnaires would normally result in rejections when approached.

The consumers for the survey that were approached consist of family, relatives, friends and colleagues. There were also strangers like shoppers who were approached as well. This was intended to achieve a wider range of diverse opinions from people of different backgrounds and age. The survey was conducted from 10 September 2007 to 7 October 2007 in Singapore. More responses were actually intended to establish a better understanding but time was a constraint. Nevertheless, 75 responses were successfully received and constructive discussions are made in the following sections. Majority of the data collection was conducted face to face while only a few were done via emails. This was because it was felt that there was a need for elaboration of the questions that will be helpful to the respondents in providing the correct responses, therefore making the survey as productive and as accurate as it can be.

8.3 Results and Observations of the Survey

In this section, individual questions and results of the survey are discussed. The answers of the 75 respondents are represented on charts. This provides a better understanding which aided discussions and comparisons on the whole.

First of all, an understanding was established on what percentages of the different age groups of the respondents were comprised of. Figure 8.1, shows that the majority were from the younger age groups with 38 % from age group ‘21-30’ and 37 % from age group ‘31-40’. This was good as this majority were groups that are possibly the most active in engagement in electronic products and their attitudes and actions are important to achieve a high environmental outcome for electronic waste.

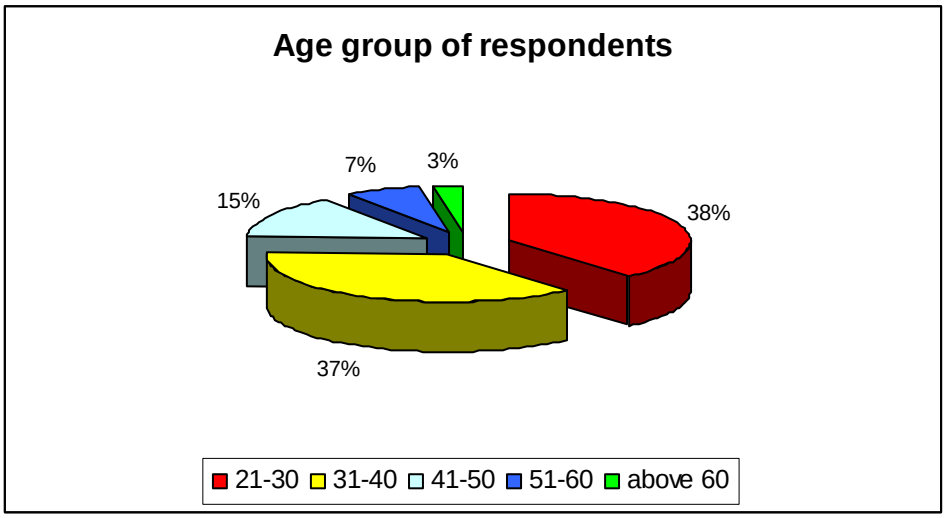


Figure 8.1: The percentage of the different age groups of the respondents.

One of the questions was to understand the job type of the respondents they were in. The representation is shown in figure 8.2. This allowed an understanding on the percentages of the different job types of the respondents were comprised of. This was subsequently useful in analysing the results, understanding that a majority 64 % worked in the manufacturing sector. There were 2 unemployed who formed 3 % under 'other'. They were noted to be the elderly who were also in the age group 'above 60'.

It was thought that the job type would affect one's attitude and actions towards recycling of electronic waste. Similarly, in this survey, the overall results in each targeted point of understanding could have a connection to the manufacturing sector since it was the largest area that the respondents were employed in. Electronic products like computers and printers are present in great numbers in businesses of all nature, hence all workplace environmental policies and employees' behaviour are important to protect the environment as a whole. While virtually everyone is an electrical and electronic product user, a good understanding of the value of recycling of electronic waste should be spread throughout the industries and the resident population.

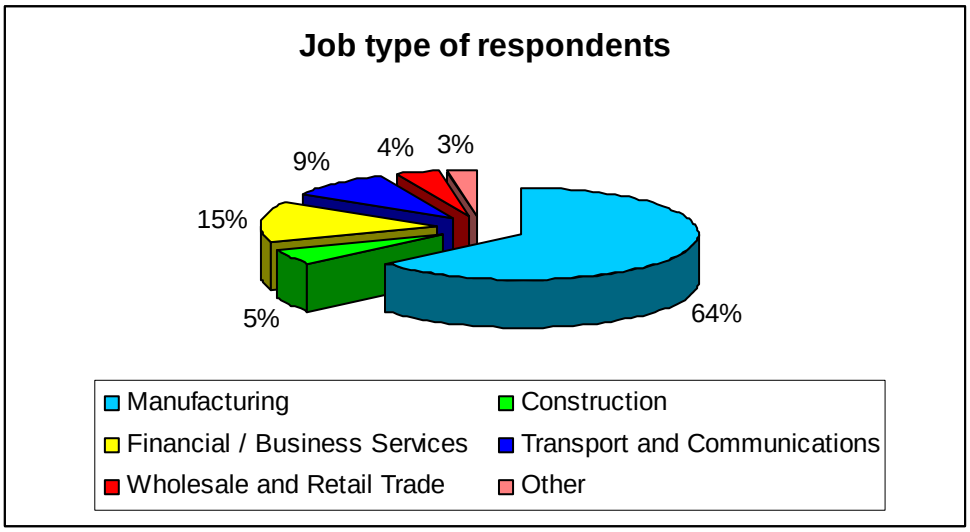


Figure 8.2: The different job types of the respondents.

The 73 respondents who were employed provided a chance to observe the standard of the environmental management in the industries in general. 68 % of them indicated that there was an environmental policy in their workplace. This was a positive indication. The representation of the results is as shown in figure 8.3.

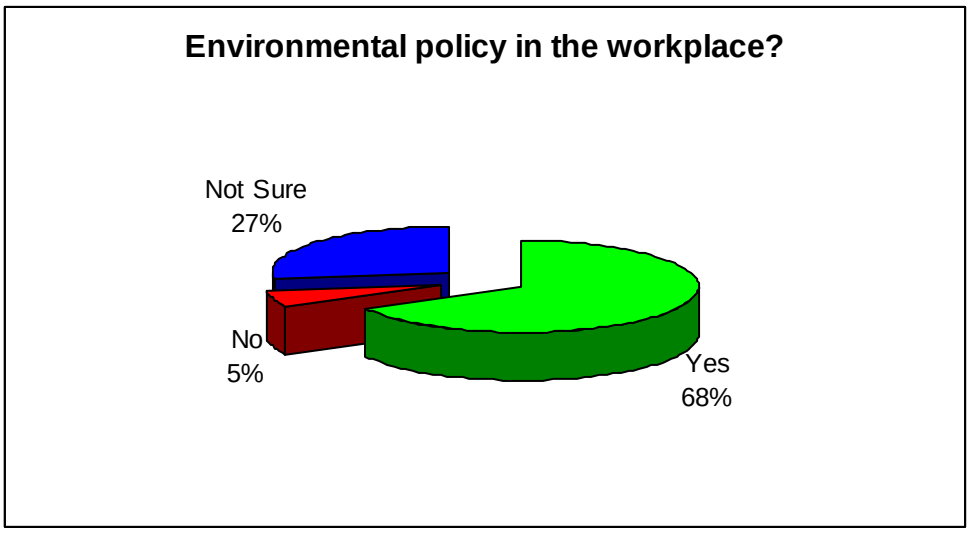


Figure 8.3: The percentage of the presence of environmental policy in the workplace.

A substantial 27 % were not sure if their company had such a policy. This should not be the case. If a company have such a policy, it was of importance to spread the policy to the employees at all levels hence making sure that everyone was aware of

it and acted accordingly. Conversely, it meant that the 27 % was more unlikely to have an environmental policy in their workplace. While the remaining 5 % confirmed with a 'No', an assumption could be made here to suggest negatively that about 30 % had no environmental policy in their workplace.

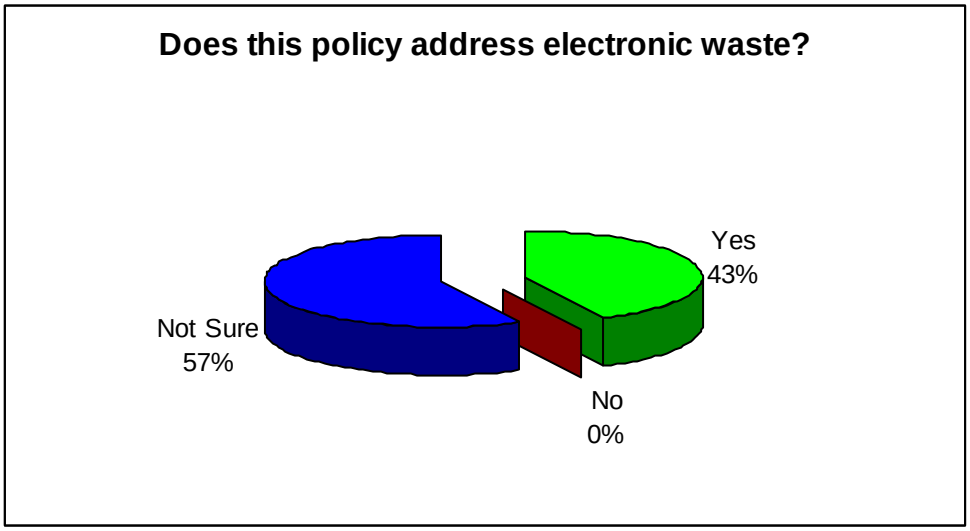


Figure 8.4: Percentage of policy that addressed electronic waste.

In figure 8.4, the percentage of policy that addressed electronic waste in the workplace is shown. This chart representation was based on the 49 people, the 68 %, who responded having an environmental policy in their workplace. However, only 43% among them were able to specify that their workplace environmental policy did address electronic waste. None of them responded 'No'.

It was discouraging to know that the majority, 57 %, were not sure about the environmental policy in their workplace. Various methods could be used to ensure employees' awareness of the company's environmental policy like through specific training, signage and during orientation. These are some commonly used procedures in companies to disseminate important information and they can be applied to effectively spread environmental policy as well.

Figure 8.5 shows the respondents' awareness about electronic waste recycling that came about through the various sources. 75 responded and it was of concern that 16, or rather 21 %, were not aware at all. Awareness can generally come from all

sources ranging from media to academic and more should be raised to ensure consumers awareness of electronic waste recycling. None indicated it was the manufacturer. It can be seen from this point that more efforts should come from the manufacturer. After all, they are generators of electronic products and should be responsible in doing its part by educating when their products were released in the market.

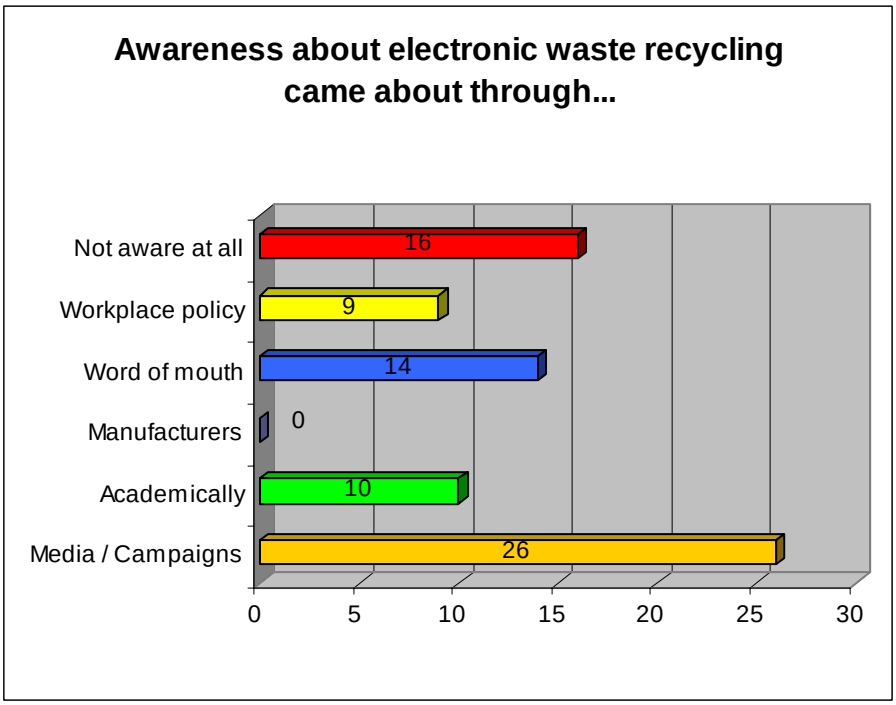


Figure 8.5: Source of awareness of electronic waste recycling.

A large number of them, 26 consumers, which were also 34.7 % of the total indicated ‘Media / Campaigns’. This could perhaps be the best way as people from all walks of life will be able to receive the related information. Another channel could be to educate academically such that more in the society will be informed through formal education. In this case, a relatively low 10 people indicated ‘Academically’. It was also discouraging that a few engineering graduates when asked if their awareness came academically rejected and mentioned that their courses did not cover such issues. ‘Workplace policy’ had a low 9 indications and the remaining 14 came from word of mouth which probably was spread from those who were more concerned about protecting the environment.

In the next figure 8.6, the various ways that the consumers chose to deal with unwanted electronic products were represented on a pie chart. The responses received were intended to be reflective of the most usual way that an individual chose when there was an unwanted electronic product in the household. Among the 75 respondents, a large 37 % indicated ‘Dispose’ and most said they discarded bulky items like computers by placing them next to general waste bins. This was not beneficial as it meant that the electronic items will most likely not be recycled.

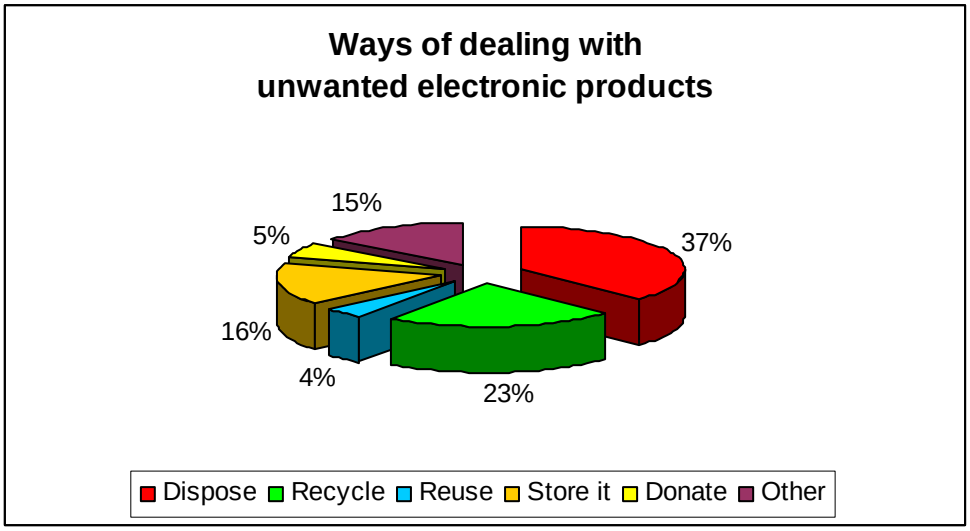


Figure 8.6: Ways of dealing with unwanted electronic products.

There was a considerable 16 % that indicated ‘Store it’. Some reasons given of why they did not consider sending them for recycling were either that they were unaware of the avenues and had left them unattended or that they simply kept them just in case these items might come handy one day. 15 % that indicated ‘Other’ said that their electronic items were usually replaced and sold before they were obsolete or otherwise sold cheaply if there was not much demand for it. It was noted that Singapore’s consumers have a high demand for new technological products which resulted in a fast replacement rate and also a wide market for second hand products.

The remaining responses were positive indications which included ‘Recycle’, ‘Reuse’ and ‘Donate’. However, the total percentage of these 3 categories only made up to be a small 32 %. This suggested a poor contribution by the consumers in dealing with electronic wastes. It was noted that the respondents comprised of a

majority who were in the manufacturing sector, a 64 % among the 73 who were employed. However, the results do not reflect that they knew the general importance of handling hazardous wastes.

Efforts were also made to understand the attitude of the consumers towards buying of electronic products. Figure 8.7 shows the results. 34 of them felt that the reliability was the main concern. In environmental point of view, a reliable electronic product will not breakdown easily thus helped in generating less harmful wastes on overall. 19 chose 'Energy saving accredited' which respondents felt was important as a cost cutting measure in electricity usage in their households. 2 said that upgradeable features were important as it helped to prolong their electronic products' life span. This was helpful to the environment as longer life spans will result in lesser quantity of products being used over the years therefore generating less electronic wastes.

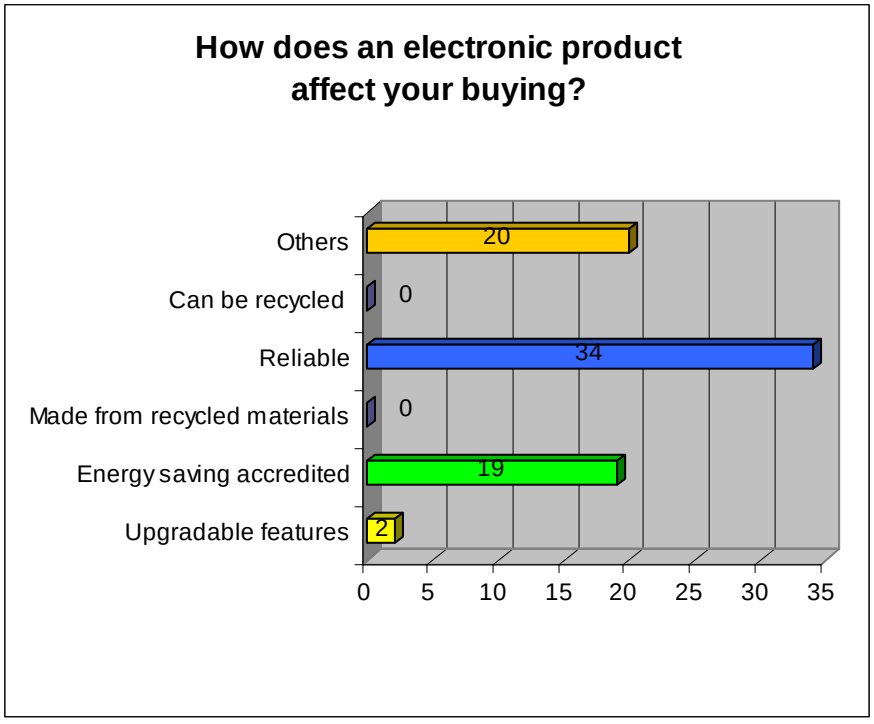


Figure 8.7: Attitude of respondents towards buying of electronic products.

There were also 20 who gave reasons under 'Others'. Of the twenty, 12 said that the design of the products was their main concern, 5 responded that they bought their

devices based on their functions and capabilities while 3 others chose their purchases based on price. It was observed that none felt that electronic products that can be easily recycled or made from recycled materials were of priority to them. It was understandable since the range of 'green' electronic products is quite limited. But as more are manufactured in the future, it was hoped that the responses will be good so that less damage will be caused to the environment.

Figure 8.8 shows the bar chart of the results of the reasons that the consumers gave for a past occasion which they did not recycle unwanted electronics. A large number of them, 31, were not aware of the avenues. In fact, National Environment Agency (NEA) had advised the residents to contact the Town Council for removal services and there is also a list of companies on the internet that the residents may contact.

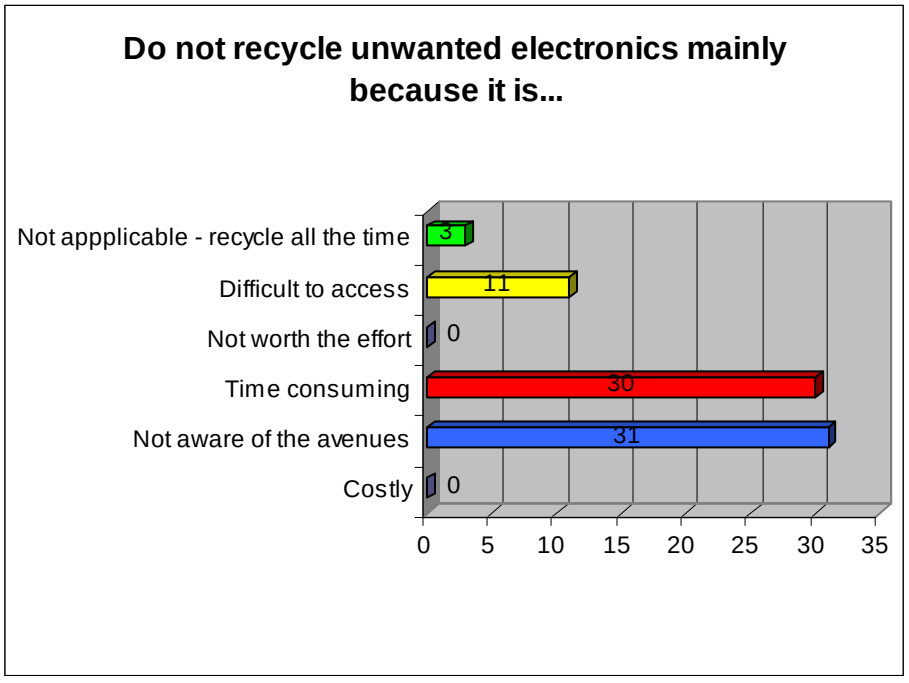


Figure 8.8: Reasons for not recycling unwanted electronics.

There were 30 who felt that it was time consuming and 11 indicated that recycling services were hard to access. Only 3 thought that they recycle all the time. Fortunately, none felt it was not worth the effort and none indicated that it was costly. It was noted that most recycling services were provided free of charge to the

consumers. In addition, reimbursements were done by some companies according to the items collected.

Having studied the consumers' attitude and behaviour in related electronic waste recycling, an understanding was also established of their perceptions of recycling in general. The results were as shown in figure 8.9. The majority 77 % viewed recycling mainly as being beneficial for the environment which in fact is the most basic purpose. 8 % of the total consumers felt that it was a time consuming process but still worth the effort of doing it to protect the environment.

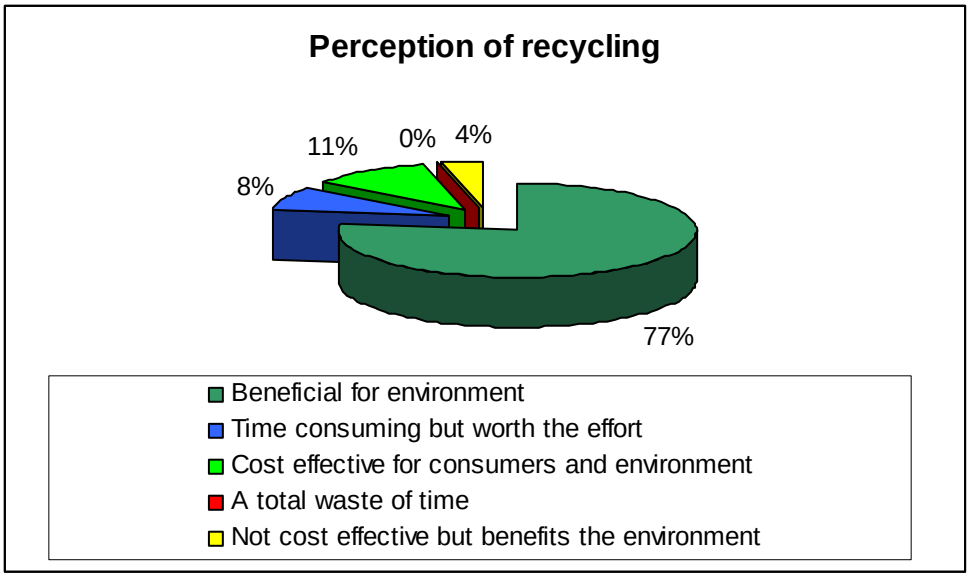


Figure 8.9: Perception of recycling.

11 % viewed it differently and felt that it was more than just protecting the environment but also cost effective for both the consumers and the environment. This is true as recovered materials are cheaper and it will also be in the long term as resources get depleted over the years. For the environment, it will be cost effective when no specific effort was required to clean up wastes that were improperly disposed. If high recycling rate was achieved, landfills will have a lesser load and therefore less management will be needed thus spending less cost in the process.

Fortunately, none felt that recycling was a total waste of time. However, there was 4% who thought that recycling was not cost effective but still beneficial to the

environment. It was noted that this is not true as even the recycling companies are profiting in the process. It will be beneficial to the public if more information on cost of recycling was reported through the media. In Section 5.3, electronic waste recycling company Centillion's profitable recycling business was observed.

In the next pie chart in figure 8.10, the views of the respondents regarding the responsibility of the management of electronic waste were represented. It was observed that a large 62 % of the consumers believed that the government has the main responsibility. It was noted from this that the public had a strong dependence on the government to deal with electronic waste. However, there was a 27 % who assured that it is everyone's responsibility and everyone has a part to play to deal with electronic waste. It was observed that electronic waste has an association with everyone: the government, the manufacturers and the consumers. Therefore, to attain high environmental outcome for electronic waste, everyone is responsible and has an own role to play and contribute.

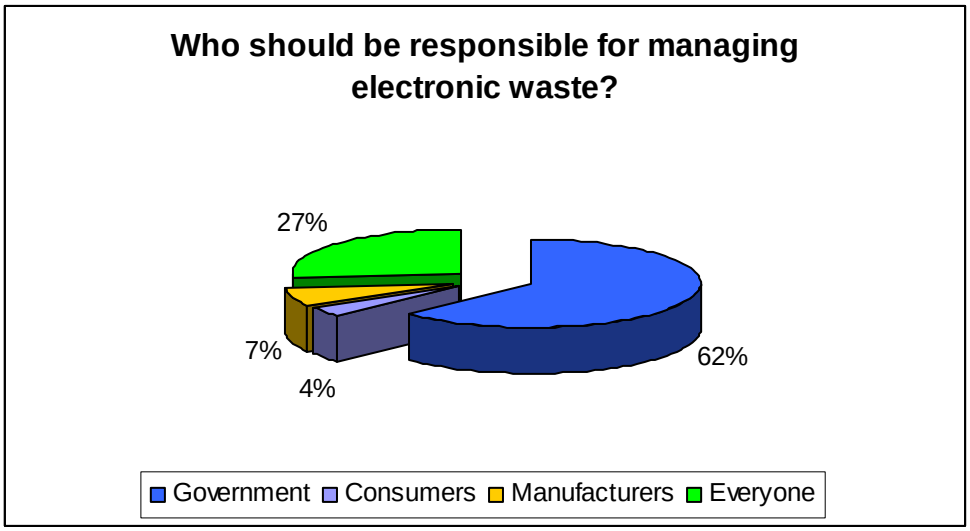


Figure 8.10: Responsibility for the management of electronic waste.

Only 7 % felt that the manufacturer who is the generator should be responsible while 4 % responsibly put it on themselves to dispose end of life products in an environmentally sound manner. It was noted that there was little pressure from the consumers, the public, to put the responsibility on the manufacturers. This could

also be the reason why there were not a lot of ‘take back’ programs by the manufacturers to recycle used electronics.

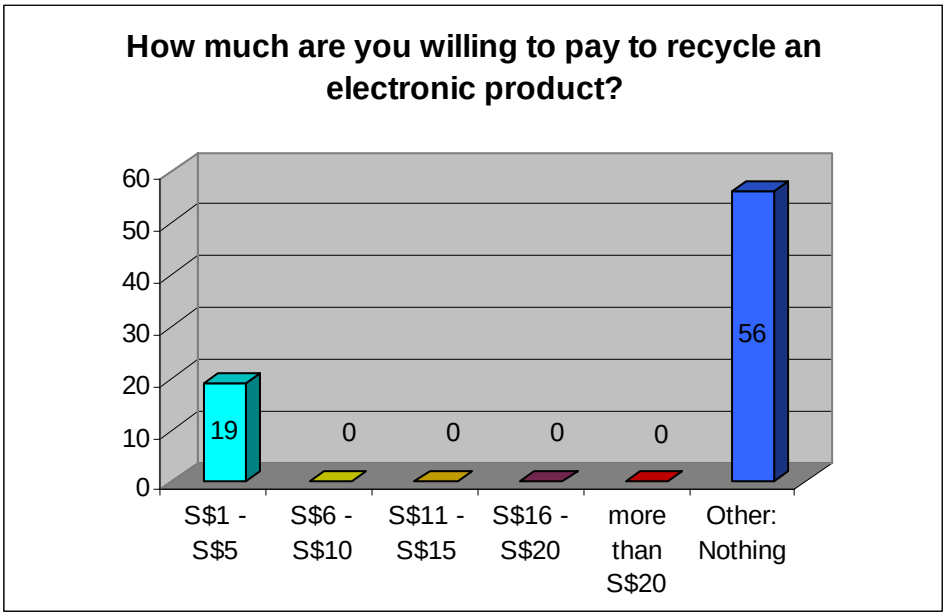


Figure 8.11: The amount consumers are willing to pay to recycle an electronic product.

The next chart in figure 8.11 shows the amount consumers were willing to pay to recycle an electronic product in general. This could be needed in the situation when recycling companies no longer make profits or if a high environmental outcome for electronic waste was required. As determined from the results, the majority 56 of them indicated that they will pay nothing. This could be that they felt that the current situation was comfortable to them and had not thought of paying to recycle electronic products. However, there were still a minority, 19 of them, that viewed an ‘S$1-S$5’ amount was reasonable if such a need arises for a meaningful cause. It was also found that an S$1-S$5 range was the maximum that the consumers were willing to pay. Overall, the consumers were not prepared to pay to recycle. It was observed that in other countries, consumers were usually required to pay to recycle electronic devices. It was noted that in the US, a fee ranging from US$6 to US$10, depending on the product size, is charged for certain electronic devices for recycling.

Finally, to round up the survey, an understanding of consumers' willingness to be more involved in recycling of electronic products in the future was achieved and results were as shown in figure 8.12. Among the 75 respondents, 21 were certain that they would be more involved in the next 5 years. The majority 51 were not very sure but still though positively that they will probably be more involved. There were also a small number, 3 of them, that indicated they do not know. On the whole, consumers' attitude towards recycling in the future was positive.

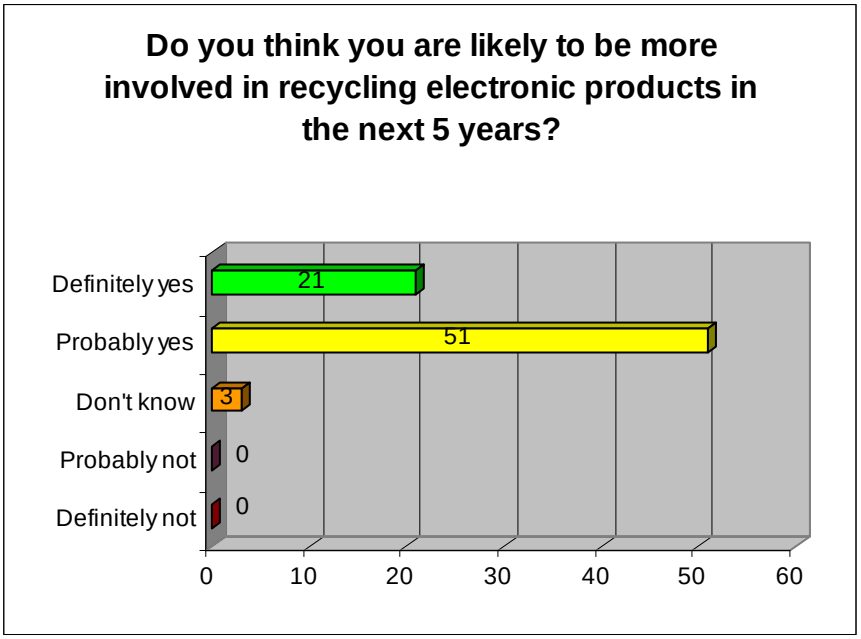


Figure 8.12: Consumers' willingness to be involved in recycling in the future.

8.4 Key Findings and Recommendations

In the previous section, the questionnaire and the results that reflected the attitudes and behaviours of the consumers were seen. From the consumers, information relating to environmental policy in the workplace was also studied. The results were represented on charts and subsequently discussed. From the results of the survey, problems were identified and it was concluded that the various aspects relating to recycling of electronic waste were generally unsatisfactory.

It was found that there were indications that workplaces lacked the presence of environmental policy and also environmental policy that did not address electronic waste. This was worsening by the fact that employers failed to ensure employees' awareness of the presence of these policies which resulted in a considerable number who were unsure of their workplace policies. Another area that lacked awareness was regarding avenues to recycling services. This had probably caused the consumers to dispose their electronic products with general waste and storing of used equipment as well.

Although information on collectors of electronic waste was listed on NEA's website, these would probably be unavailable to the elderly as a majority of the elderly are not computer users. More assistance should be provided to them to discard their electronic products especially bulky items. This could probably start off by distributing pamphlets in different languages to them and ensure their awareness on electronic waste recycling. It was noted that there is a considerable number of the senior residents who do not understand English.

Recycling of electronic products were reflected to be time consuming and difficult to access by the consumers. This generally suggested that recycling was inconvenient. It could be that collection points were far of access and could also be that procedures were long and a hassle. It was pointed out by a few respondents that there were no collection bins in the neighbourhood, like those for plastics, metal and paper, where one could conveniently place their unwanted electronic products in it. This could also be helpful to achieve a high recycling outcome of electronic waste.

The overall consumers' perception of recycling were very good which certainly is a good starting point to do more by educating the consumers on the benefits of recycling of electronic waste. It is important that the consumers understand the harmful effects of electronic waste as well. This could also bring about less reliance on the government to manage these wastes. Similarly, an aware consumer would choose to purchase 'greener' electronic products or from companies who are active in organising 'take back' programs for recycling. This will create a competition among the manufacturers to achieve better environmental managements.

An overall good waste management will incur less cost hence the possibility of a cost contribution from the consumers will be lessened. The outlook for the future in managing electronic waste appeared to be good with a large majority of consumers that indicated positively. This was encouraging and constant improvements in waste managements were equally essential to achieve an overall high environmental outcome.

8.5 Conclusions

The survey conducted had certainly provided a lot of information regarding the attitudes and behaviours of the consumers, even though there were only 75 respondents. This would probably not be the accurate representation of the population in Singapore. However, it definitely gave a chance to identify where most of the problems are in electronic waste recycling.

The survey had also allowed an understanding on the workplace environmental policies. It was meaningful to conduct the survey face to face which provided a chance to interact with the consumers and to receive valuable opinions of the current situation. On the whole, when everyone is equipped with a better understanding on electronic waste recycling, it will be beneficial in attaining better cooperation and coordination, between the government, the manufacturers and the consumers and ultimately to achieve high recycling outcome for electronic waste.

Chapter 9: Conclusions

9.1 Introduction

This chapter introduces the summary of the various achievements of the research project done. Following that, recommendations are made for future work which would be constructive as a follow up to the topic. And finally, the overall conclusions are drawn for the research project.

9.2 Summary of Achievements

A literature review was done to understand the background of recycling of used electronics. This included observations of the harmful effects of electronic wastes, the growing problem of it which also noted the situations and problems happening in other countries. An understanding was established on the benefits of recycling of electronic wastes as well.

The information research was done thoroughly on Singapore's authorities to find specific data on electronic wastes and recycling of it but was in vain. There was no available data on it. As such, broad data was used to understand the generation, the disposal, the collection and the recycling of used electronics in the country. Similarly, little data was available by the recycling companies therefore it did not provide an adequate understanding on the collection, the processes which included the resources used and effectiveness, the disposals and the various related costs.

The situations and systems were studied in other countries as well. This certainly provided a wider understanding of the problems and managements. This was useful in identifying better solutions which could be effective to address the used electronics problems in Singapore. In fact, a thorough review of information in this area should be made so as to achieve a better understanding, not only on the well

designed systems but also on the consequences and results of these systems in the short and long term. However, time was the limiting factor in this case.

Case studies were conducted to understand the management used in handling of used electronics in the companies. This had helped to observe the practices made and the identification of problems in a company. The results of the case studies were used to understand the rate and magnitude of used electronics that could be generated in a company and in turn in the industries as a whole.

A survey of consumers was carried out which mainly focused in understanding the attitudes and behaviours of the consumers. This had helped to identify the problems faced in the community to which used electronics were not actively recycled. The survey also touched on the workplace environmental policies which gave an understanding of the possible standard of waste managements in the industries.

9.3 Recommendations for Future Work

As various limiting factors were encountered during the course of this research project, the following recommendations for future work can be carried out.

From the observations made in the process of recycling of electronic waste in the companies, there are indications that the material recovery processes, that is the chemical processes, could probably be energy intensive and usage of toxic chemicals are definitely included. The processes are complex and it would be constructive if an environmental impact assessment were done on the recycling processes to investigate if it is energy and resource exhaustive and ultimately whether it is worthwhile to recover materials with such processes.

The case studies made only covered a very small range of electronic products, that is computers and printers, and it did not cover electronics materials that were generated in the course of manufacturing by electronics manufacturers. A study could be made particularly on these materials as they can amount in very large quantities in the factories. This would also include an attempt to find out the

practices carried out by manufacturing companies in handling them and also the related environmental concerns.

9.4 Final Conclusions

On the overall, the research project was able to meet most of the objectives set. It was able to identify the various problem areas of recycling of used electronics in Singapore and understand the related environmental concerns.

Literature researches conducted have broadened the understanding and were useful in analysing and improving the situation. Understanding the various recycling processes of electronic waste had made the study more complete. Through checking local practices has helped to identify the related problem areas and understand the need for improvements.

Case studies done were although limited had helped to establish an understanding of the practices of the manufacturers in Singapore. The survey of consumers was meaningful as it gave an insight understanding of the related problems faced in the community. The various observations made in this research project had enabled constructive suggestions for improvement for the community in future handling of the issue.

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Appendix A – Project Specification

University of Southern Queensland
Faculty of Engineering and Surveying

ENG4111 / 4112 Research Project
PROJECT SPECIFICATION

FOR: **TAN Heng Tsin Stanley**
TOPIC: Recycling of Used Electronics in Singapore
SUPERVISOR: David Parsons
SPONSORSHIP: Own

PROJECT AIM: The project aims to understand the problem of recycling of used electronics in Singapore and the related environmental concerns.

PROGRAMME: **Issue B, 18 Oct 2007**

1. Understand the local recycling of used electronics through recycling companies and the National Environment Agency.

2. Identify specific problem areas and subsequent opportunities for improvement. This will include an attempt to evaluate what proportion of used electronics is currently recycled.

3. Investigate the effectiveness of recycling processes of used electronics and in particular the problems of collection.

4. Conduct a survey of consumers and, if possible, industry people, to determine the extent to which they are involved now in recycling or would be willing to be involved in the future.

5. Research information on global recycling of used electronics through reviewing published materials and relating good systems to local situation.

6. Conduct case studies on companies to illustrate the management used in handling used electronics and relating the various problems to Singapore as a whole.

7. Critically assess current Singaporean practice and recommend actions for the future handling of the issue.

8. Write and submit a dissertation.

As time permits:

9. Research information on ISO14000 management standards for organisations, in particular the handling of electronic waste.

AGREED: _____ (Student) _____ (Supervisor)

_____ / _____ / _____ _____ / _____ / _____

Co-examiner: _____

Appendix B – List of Computers of Manufacturing Company #2

List of Computers of Manufacturing Company #2

Operations 1

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP BRIO PIII 866	Desktop	HP
2	HP EVO D510 P4,7.5GHZ	Desktop	HP
3	HP BRIO BA600 PIII-550 MHZ	Desktop	HP
4	HP COMPAQ EVO D220 MICROTOWER W/15"CRT	Desktop	HP
5	IBM A51 SERIE3S W/17" CRT	Desktop	IBM
6	IBM LENOVO THINKCENTRE E-SERIES TOWER W/17 CRT	Desktop	IBM
7	COMPAQ Evo D320	Desktop	HP
8	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR+ RAM	Desktop	IBM
9	PCS PII-233 MT 32 MB SD-RAM SYSTEM	Desktop	
10	IBM COMPAQ DESKTOP PC	Desktop	IBM
11	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
12	IBM THINK CENTRE 'A' SERIES TOWER W/15' CRT	Desktop	IBM
13	HP EVO D510, P4 2GHZ, 256MB DDR RAM, 40GB HDD	Desktop	HP
14	IBM A51 SERIE3S W/17" CRT	Desktop	IBM
15	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
16	IBM A51 SERIE3S W/17" CRT	Desktop	IBM
17	HP EVO D380 (MT)	Desktop	HP
18	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
19	IBM ThinkCentre A50 W/15" LCD	Desktop	IBM
20	HP COMPAQ DX2000 MT AP WITH 17"CRT	Desktop	HP
21	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
22	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
23	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
24	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
25	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
26	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
27	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
28	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
29	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
30	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
31	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
32	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
33	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
34	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
35	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP

Operations 1 (continue)

36	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
37	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
38	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
39	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
40	HP COMPAQ DX2000 (DESKTOP PC)	Desktop	HP
41	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
42	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
43	COMPRO P5-200MMX CPU/PRNTR	Desktop	
44	VISION VRIO PII -300A CELERON	Desktop	
45	INTEL PENTIUM NOTEBK WITH MODEM	Laptop	
46	LAPTOP - HP OMNIBOOK XE2-PIII-500MHZ	Laptop	HP
47	LAPTOP - HP OMNIBOOK XE2-PIII-500MHZ	Laptop	HP
48	IBM THINKPAD T42	Laptop	IBM
49	IBM Thinkpad R-Series 128MB Flask Disk	Laptop	IBM
50	HP BRIO INTEL PIII-700MHZ	Desktop	HP
51	IBM THINKCENTRE A51 SERIES TOWER W/17"' CRT	Desktop	IBM
52	IBM THINKPAD	Laptop	IBM
53	HP COMPAQ NX8220	Laptop	HP
54	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
55	WILLS PRO P111 450/64	Desktop	
56	IBM ThinkCentre "A" Series Tower w/15"TFT	Desktop	IBM
57	LAPTOP -COMPAQ PRESARIO 1508	Laptop	HP
58	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
59	IBM THINKCENTRE "A" SERIES TOWER W/15' CRT	Desktop	IBM
60	IBM NETVISTA A40 DESKTOP C/W IBM 17" MONITOR	Desktop	IBM
61	DESKTOP PC - THINKCENTRE E50 TOWER W/17 CRT	Desktop	IBM
62	IBM THINKCENTRE "A" SERIES TOWER W/14' CRT	Desktop	IBM
63	IBM THINKPAD R52	Laptop	IBM
64	IBM THINKCENTRE "A" SERIES TOWER W/17' CRT	Desktop	IBM
65	IBM THINKCENTRE A51 SERIES TOWER	Desktop	IBM
66	NOTEBOOK-IBM LENOVO THINKPAD T43, 2668-AY6	Laptop	IBM
67	HP EVO D220 MICROTOWER WITH 17" CRT	Desktop	HP
68	HP BRIO BA600 PIII-550MHZ	Desktop	
69	COMPAQ EVO D220 MICRO TOWER	Desktop	HP
70	COMPAQ EVO D220 MICROTOWER	Desktop	HP
71	IBM THINKCENTRE A50 SERIES TOWER W/17' CRT	Desktop	IBM
72	DESKTOP-IBM LENOVO THINKCENTRE A52+17"CRT MONITOR	Desktop	IBM
73	COMPRO P90 SYSTEM (CEO1687)	Desktop	HP
74	HP VECTRA VL420	Desktop	HP
75	IBM LENOVO THINKCENTRE A52,8297-A53	Desktop	IBM
76	IBM LENOVO THINKCENTRE A52,8297-A53	Desktop	IBM
77	IBM LENOVO THINKCENTRE A52,8297-A53	Desktop	IBM
78	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
79	HP VECTRA VL420	Desktop	HP
80	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP

Operations 1 (continue)

81	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
82	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
83	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
84	HP COMPAQ DX2000 MT W/LCD	Desktop	HP
85	IBM THINK CENTRE A30 MICROTOWER W/17 TFT MONITOR	Desktop	IBM
86	HP PCD220/MICRO-ATX TOWER MODEL	Desktop	HP
87	HP BRIO BA410 PIII-733MHZ	Desktop	HP
88	IBM THINKCENTRE A SERIES W/ 15" CRT	Desktop	IBM
89	HP COMPAQ DX2000 MT W/17" TFT	Desktop	HP
90	HP COMPAQ NX5000	Desktop	HP
91	IBM THINKCENTRE A30-MICRO TOWER	Desktop	HP
92	IBM A51 TOWER W/17" CRT MONITOR	Desktop	IBM
93	COMPRO 485 CPU(CEO1727)	Desktop	
94	P5-75MIT CPU(CEO1783)	Desktop	
95	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
96	IBM LENOVO THINKCENTRE E-SERIES TOWER W/17 CRT	Desktop	IBM
97	IBM A51 SERIES TOWER W/17" TFT MONITOR	Desktop	IBM
98	DESKTOP-DX2100 MT MODEL (3YRS, NBD ONSITE)	Desktop	HP
99	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR+ RAM	Desktop	IBM
100	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR+ RAM	Desktop	IBM
101	IBM THINK CENTRE 'A' SERIES TOWER W/ 15' CRT	Desktop	IBM
102	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
103	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
104	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
105	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
106	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
107	IBM THINKCENTRE A50 SERIES TOWER W/17' CRT	Desktop	IBM
108	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
109	IBM THINKPAD T43 (NOTEBOOK)	Laptop	IBM
110	HP BRIO PIII866	Desktop	HP
111	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
112	IBM THINKCENTRE A SERIES	Desktop	
113	IBM LENOVO THINKCENTRE E-SERIES TOWER W/17 CRT	Desktop	IBM
114	IBM A51 TOWER W/17" CRT MONITOR	Desktop	IBM
115	IBM A51 SERIE3S W/17" CRT	Desktop	IBM
116	HP BRIO BA410 PIII-733MHZ	Desktop	HP
117	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
118	IBM LENOVO THINKCENTRE E-SERIES TOWER W/17 CRT	Desktop	IBM
119	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR+ RAM	Desktop	IBM
120	IBM ThinkPad T42	Laptop	IBM

Operations 1 (continue)

121	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
122	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
123	HP PII-300 MULTIMEDIA SYSTEM	Desktop	
124	HP EVO D220 COMPUTER(DESKTOP)	Desktop	HP
125	HP COMPAQ EVO D220 MICROTOWER(W/ 15" CRT)	Desktop	HP
126	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
127	HP COMPAQ EVO D1220 MICROTOWER W/15 CRT	Desktop	HP
128	HP BRIO BA410 PIII-733MHZ	Desktop	HP
129	NOTEBOOK-IBM LENOVO X60 T2400+UPGRADE RAM,WARRANTY	Laptop	IBM
130	NOTEBOOK	Laptop	
131	HP COMPAQ EVO D220 MICROTOWER W/ 17" CRT	Desktop	HP
132	HP BRIO PIII 866	Desktop	HP
133	HP BRIO PIII 866	Desktop	HP
134	HP BRIO BA600 PIII-550MHZ	Desktop	HP
135	HP PC D220 P IV-2.4Ghz	Desktop	HP
136	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
137	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
138	DESKTOP - IBM LENOVO THINKPAD R(52) SERIES	Laptop	IBM
139	DELL INSPIRON 7500 LAPTOP	Laptop	Dell
140	HP VECTRA VL420 - ROBERT TAY	Desktop	HP
141	IBM THINKPAD R SERIES	Laptop	IBM
142	COMPAQ N800V NOTEBOOK	Laptop	HP
143	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
144	IBM THINKCENTRE "A" SERIES TOWER W/15' CRT	Desktop	IBM
145	HP COMPAQ EVO D220 MICROTOWER(W/ 15 CRT MONITOR)	Desktop	HP
146	IBM LENOVO THINKCENTRE E50 TOWER 17" TFT MONITOR+	Desktop	IBM
147	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
148	IBM THINK CENTRE 'A' SERIES TOWER W/ 15' CRT	Desktop	IBM
149	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
150	WILLS PRO 7500/64 MODEL 4300 PIII SERIES	Desktop	
151	SNC PENTIUM III-500MHZ	Desktop	
152	SNC PENTIUM III-500MHZ	Desktop	
153	HP COMPAQ DX2000MT	Desktop	HP
154	HP EVO D510 (SMALL FORM FACTOR MODEL)	Desktop	HP
155	HP BRIO BA600 PIII-550 MHZ	Desktop	
156	HP/ COMPAQNEVO N1000V NOTEBOOK	Desktop	HP
157	IBM THINKCENTRE "A" SERIES TOWER W/14' CRT	Desktop	IBM
158	IBM Think Centre A Series Tower W/15" TFT	Desktop	IBM
159	IBM THINKCENTRE "A" SERIES TOWER W/17" LCD	Desktop	IBM
160	HP DX2000 MT MODEL (3 YEARS,NBD ONSITE)	Desktop	HP
161	HP BRIO PIII 866	Desktop	HP
162	IBM THINK CENTRE "A" SERIES TOWER W/15" TFT	Desktop	IBM
163	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
164	HP DX2000 MT MODEL (3YRS, NBD ONSITE)	Desktop	HP
165	IBM Think Centre A Series Tower W/15" CRT	Desktop	IBM

Operations 1 (continue)

166	LAPTOP - HP XEIII OMNIBOOK	Laptop	HP
167	HP VL420 CPU ONLY	Desktop	HP
168	IBM A51 SERIES TOWER W/17"CRT DESKTOP	Desktop	IBM
169	IBM THINKPAD R SERIES W/ 1 YEAR WARRANTY	Laptop	IBM
170	HP COMPAQ EVO D220 MICROTOWER(W/ 15" CRT)	Desktop	HP
171	HP BRIO BA410 PIII-733MHZ	Desktop	HP
172	IBM A51 SERIES TOWER W/17" CRT	Desktop	IBM
173	PCI-DIO-96 & PCI-GPIB AND NI-488.2M	Desktop	HP
174	IBM A51 SERIES TOWER W/17' CRT	Desktop	IBM
175	HP VECTRA PENTIUM IV PC @ B5004 -1ST FL	Desktop	HP
176	HP VECTRA VL420-INTEL PENTIUM 4	Desktop	HP
177	HP BRIO BA410 PIII-733MHZ	Desktop	HP
178	DESKTOP PC	Desktop	
179	IBM A51 SERIES TOWER W/17" CRT	Desktop	
180	IBM A51 SERIES TOWER W/17" CRT	Desktop	
181	HP COMPAQ EVO D220 MICROTOWER W/17' CRT	Desktop	HP
182	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
183	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
184	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
185	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
186	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
187	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
188	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
189	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
190	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
191	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
192	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
193	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
194	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
195	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
196	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
197	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
198	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
199	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
200	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
201	COMPAQ DX2000 MT AP (SLV)	Desktop	HP
202	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
203	IBM THINK CENTRE"A" SERIES TOWER W/15' TFT	Desktop	IBM

Operations 2

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	COMPAQ Evo D320	Desktop	
2	COMPAQ Evo D320	Desktop	
3	COMPAQ Evo D320	Desktop	
4	COMPAQ PC EVO D220 ST	Desktop	
5	HP VECTRA VL400 DESKTOP PC	Desktop	HP

Operations 2 (continue)

6	HP EVO D510 (CMT)	Desktop	HP
7	COMPAQ Evo D320	Desktop	
8	COMPAQ Evo D320	Desktop	
9	COMPAQ Evo D320	Desktop	
10	COMPAQ PC EVO D220 ST	Desktop	
11	COMPAQ PC EVO D220 ST	Desktop	
12	COMPAQ EVO D220 MICROTOWER	Desktop	
13	IBM ThinkCentre A Series W/17" CRT-256MB DDR RAM	Desktop	IBM
14	IBM ThinkCentre A Series W/17" CRT-256MB DDR RAM	Desktop	IBM
15	IBM ThinkCentre A Series W/17" CRT-256MB DDR RAM	Desktop	IBM
16	IBM ThinkCentre A Series W/17" CRT-256MB DDR RAM	Desktop	IBM
17	HP EVO D220 MICROTOWER WITH 17" CRT	Desktop	HP
18	HP EVO D220 MICROTOWER WITH 17" CRT	Desktop	HP
19	HP EVO D220 MICROTOWER WITH 17" CRT	Desktop	HP
20	HP COMPAQ EVO D220 MICROTOWER W/ 17" CRT	Desktop	HP
21	HP COMPAQ EVO D220 MICROTOWER W/ 17" CRT	Desktop	HP
22	HP COMPAQ EVO D220 MICROTOWER W/ 17" CRT	Desktop	HP
23	HP OMNIBOOK XE III (LAPTOP)	Laptop	HP
24	IBM Thinkpad T-Series with 60GB External Hard disk	Laptop	IBM
25	HP COMPAQ NC8230 NOTEBOOK PC 64MB BASE UNIT	Laptop	
26	LAPTOP - HP Omnibook 6050	Laptop	HP
27	IBM Thinkpad T-Series with 60GB External Hard disk	Laptop	IBM
28	LAPTOP - HP EVO N1000V	Laptop	HP
29	IBM NETVISTA A40 DESKTOP- TRANSFER FR VENTECH	Desktop	IBM
30	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
31	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
32	HP PC DC7100	Desktop	HP
33	HP PC DC7100	Desktop	HP
34	HP PC DC7100	Desktop	HP
35	IBM ThinkCentre A Series Tower w/17"CRT Normal	Desktop	IBM
36	IBM A51 TOWER + PHYSICAL DATA TRANSFER	Desktop	IBM
37	HP OMNIBOOK XE III (LAPTOP)	Laptop	HP
38	IBM THINKPAD (Re) SERIES	Laptop	IBM
39	IBM THINKPAD R-E SERIES	Laptop	IBM
40	NOTEBOOK - THINKPAD T43	Laptop	IBM
41	NOTEBOOK - THINKPAD T43	Laptop	IBM
42	HP OMNIBOOK XE III (LAPTOP)	Laptop	HP
43	HP COMPAQ NX9010 NOTEBOOK	Laptop	HP
44	IBM ThinkPad R-Series	Laptop	IBM
45	IBM ThinkPad R-Series	Laptop	IBM
46	HP NOTEBK NC4200(WIN XP PRO O/S)&UPGRADE HD TO 80GB	Laptop	HP
47	HP NOTEBK NC4200(WIN XP PRO O/S)&UPGRADE HD TO 80GB	Laptop	HP
48	LAPTOP - HP NC4200 NOTEBOOK (3YRS, NBD ONSITE)	Laptop	HP
49	IBM NETVISTA A20 DESKTOP	Desktop	IBM
50	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP

Operations 2 (continue)

51	HP COMPAQ DX2100MT-MICROSOFT WIN XP PRO	Desktop	HP
52	HP COMPAQ DX2100MT-MICROSOFT WIN XP PRO	Desktop	HP
53	HP COMPAQ DX2100MT-MICROSOFT WIN XP PRO	Desktop	HP
54	DESKTOP-HP COMPAQ DX2100MT-MICROSOFT WIN XP PRO	Desktop	HP
55	DESKTOP-HP COMPAQ DX2100MT-MICROSOFT WIN XP PRO	Desktop	HP
56	HP Business Notebook NX5000	Laptop	HP
57	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
58	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
59	HP Business Notebook NX5000	Laptop	HP
60	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
61	IBM THINKPAD PORTABLE T60	Laptop	IBM
62	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
63	FUJITSU NOTEBOOK S6130	Laptop	Fujitsu
64	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
65	FUJITSU NOTEBOOK E4010N	Laptop	Fujitsu
66	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
67	INTEL PENTIUM III 550 MHZ PROCESSOR	Desktop	
68	PENTIUM II CPU	Desktop	HP
69	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
70	HP COMPAQ DC7100 CMT BASE UNIT	Laptop	HP
71	L1702 17" TFT MONITOR	Desktop	
72	FUJITSU NOTEBOOK E4010N	Laptop	Fujitsu
73	DELL OPTIPLEX GX270 SMALL MINITOWER	Desktop	Dell
74	FUJITSU NOTEBOOK E4010N	Laptop	Fujitsu
75	HP COMPAQ DC7100 CMT BASE UNIT	Laptop	HP
76	L1702 17" TFT MONITOR	Desktop	
77	IBM THINKPAD PORTABLE X60 & OFFICE 2003 SB W/SP2	Laptop	IBM
78	FUJITSU NOTEBOOK E4010N	Laptop	Fujitsu

Quality Assurance (QA) Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP PC P166 MHZ	Desktop	HP
2	HP PC P166 MHZ	Desktop	IBM
3	HP PC P166 MHZ	Desktop	HP
4	HP PC P166 MHZ	Desktop	HP
5	HP PC P166 MHZ	Desktop	HP
6	HP PC P166 MHZ	Desktop	HP
7	HP PC P166 MHZ	Desktop	HP
8	HP BIRO BA410 PIII-733MHZ	Desktop	HP
9	HP BRIO P3-1 GHZ	Desktop	HP
10	HP VECTRA VL400 DESKTOP PC	Desktop	HP

Quality Assurance (QA) Department (continue)

11	HP VECTRA VL400 DESKTOP PC	Desktop	HP
12	HP VECTRA VL420	Desktop	HP
13	HP VECRA VL420 - (SEE LONG TEXT)	Desktop	HP
14	HP EVO D510 (CMT) P 4	Desktop	HP
15	HP COMPAQ EVO D220 MICROTOWER W/ 17"CRT	Desktop	HP
16	HP COMPAQ EVO D220 MICROTOWER W/ 17 CRT	Desktop	HP
17	IBM THINKCENTRE A51, 160GB SERIAL ATA HARDDISK	Desktop	IBM
18	IBM THINKCENTRE A51, 160GB SERIAL ATA HARDDISK	Desktop	IBM
19	IBM THINKCENTRE A51, 160GB HARDDISK, CRRW DVD ROM	Desktop	IBM
20	LAPTOP - IBM THICKPAD R31 -	laptop	IBM
21	LAPTOP - HP COMPAQ EVO N1000V	laptop	HP
22	HP COMPAQ NOTEBOOK NX9010	laptop	HP
23	IBM THINKPAD R SERIES	laptop	IBM

Reliability

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP P166 PC	Desktop	HP
2	HP P166 PC	Desktop	HP
3	HP P166 PC	Desktop	HP
4	HP P166 PC	Desktop	HP
5	HP PC P166	Desktop	HP
6	HP PC P166	Desktop	HP
7	SNC PIII-500C PU 64MB RAM	Desktop	HP
8	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
9	HP BRIO PIII	Desktop	HP
10	HP VECTRA VL800 DESKTOP INTEL PIV	Desktop	HP
11	HP VECTRA VL400 DESKTOP INTEL PIII	Desktop	HP
12	LAPTOP - HP OMNIBOOK 6050	Laptop	HP
13	HP VECTRA VL 420	Desktop	HP
14	HP VECTRA VL420	Desktop	HP
15	HP VECTRA VL420	Desktop	HP
16	HP VECTRA VL420	Desktop	HP
17	HP EVO D510 (CMT)	Desktop	HP
18	HP EVO D510 (CMT)	Desktop	HP
19	HP EVO D 510 (CMT)	Desktop	HP
20	HP EVO D 510 (CMT)	Desktop	HP
21	DESKTOP P-3 550MHZ	Desktop	HP
22	DESKTOP P-3 550MHZ	Desktop	HP
23	DESKTOP P-3 550MHZ	Desktop	HP
24	DESKTOP P-3 550MHZ	Desktop	HP
25	DESKTOP P-3 550MHZ	Desktop	HP

Reliability (continue)

26	HP EVO D510 PENTIUM 4 1.7Ghz	Desktop	HP
27	HP EVO D510 (CMT)	Desktop	HP
28	HP EVO D510 (CMT)	Desktop	HP
29	HP EVO D510 (CMT)	Desktop	HP
30	COMPAQ EVO D510 SMALL FORM FACTOR	Desktop	HP
31	HP EVO D510 (CMT) P 4	Desktop	HP
32	HP EVO D510(CMT) P4 2GHZ, INTEL 845G, 256MB DDRRAM	Desktop	HP
33	HP VECTRA VL-420 DT - P7295A	Desktop	HP
34	HP VECTRA VL-420 DT - P7295A	Desktop	HP
35	17" CRT MONITOR HP VECTRA VL-420 DT - P7295A	Desktop	HP
36	17" CRT MONITOR HP VECTRA VL-420 DT - P7295A	Desktop	HP
37	HP/COMPAQ EVO NOTEBOOK N800V	Laptop	HP
38	HP/COMPAQ EVO NOTEBOOK N800V	Laptop	HP
39	HP/COMPAQ EVO NOTEBOOK N800V	Laptop	HP
40	IBM THINKPAD R SERIES	Laptop	IBM
41	HP DX2000MT W/17" CRT+ ADOBE ACROBAT S/W	Desktop	HP
42	DX2000 MT MODEL (3 YRS,NBD ONSITE)	Desktop	HP
43	DX2000 MT MODEL (3 YRS,NBD ONSITE)	Desktop	HP
44	NOTEBOOK-IBM LENOVO THINKPAD R(e) SERIES	Laptop	IBM
45	HP EVO D510 (CMT)	Desktop	HP
46	LAPTOP - HP EVO 800V	Laptop	HP
47	LAPTOP - HP EVO 800V	Laptop	HP
48	HP EVO D510 (CMT)	Desktop	HP

Facility Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP BRIO BA410 PIII-733MHZ	Desktop	HP
2	HP COMPAQ DX2000MT MODEL (3YRS, NBD ONSITE)	Desktop	HP
3	IBM THINKPAD LAPTOP	Laptop	IBM
4	LAPTOP - HP OMNIBOK XEIII	Laptop	HP
5	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
6	LAPTOP -COMPAQ EVD 1000N	Laptop	HP

IQC Procurement

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	DATAMINI TURBO XT	Desktop	
2	DATAMINI TURBO XT	Desktop	
3	DATAMINI AT COMP COMPUTER	Desktop	

IQC Procurement (continue)

4	DCM 386/20 COMPUTER	Desktop	
5	DCM 386/20 COMPUTER	Desktop	
6	INTEL PII-333 MHz WITH UPGRADING	Desktop	
7	HP BRIO PIII 866	Desktop	HP
8	HP BRIO PIII 866	Desktop	HP
9	HP VECTRA VL 420	Desktop	HP
10	COMPAQ EVO D220 MICROTOWER	Desktop	
11	COMPACT DATAMINI TURBO AT	Desktop	

Purchasing

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP BRIOBA600-650MHZ 64MB	Desktop	HP
2	HP BRIOBA600-650MHZ 64MB	Desktop	HP
3	HP BRIO BA410 PIII-733MHZ	Desktop	HP
4	HP BRIO BA410 PIII-733MHZ	Desktop	HP
5	HP BRIO PIII 866	Desktop	HP
6	HP BRIO INTEL PIII-1GHZ, USB DATA TRANSFER CABLE,	Desktop	HP
7	HP OMNIBK XE2-PIII 500MHZ	Laptop	HP
8	LAPTOP - HP OMNIBOOK XE2 PIII-450MHZ	Laptop	HP
9	LAPTOP - IBM THINKPAD R	Laptop	IBM
10	LAPTOP - COMPAQ PRESARIO 1508	Laptop	HP
11	IBM THINKPAD R52 WITH 15" XGA	Laptop	IBM
12	THINKPAD T43, 2668-AY6	Laptop	IBM
13	HP BRIO BA600 PIII-550 MHZ	Desktop	HP
14	HP COMPAQ EVO D220 MICRTOTOWER	Desktop	HP
15	HP COMPAQ EVO D220 MICROTOWER(W/ 15" CRT)	Desktop	HP
16	TNN PENTIUM-133 CPU(CEO1942)	Desktop	HP
17	EDO P-200MMX CPU C/W PRINTER	Desktop	HP
18	HP BRIO PII-233	Desktop	HP
19	HP BRIO BA600 PIII-550MHZ	Desktop	HP
20	HP BRIO BA410 PIII-733MHZ	Desktop	HP
21	HP VECTRA VL400 DESKTOP INTEL PIII	Desktop	HP
22	HP VECTRA VL 420 FOR NEW BUYER	Desktop	HP
23	HP COMPAQ D220 MICROTOWER W 15" CRT	Desktop	HP
24	IBM ThinkCentre A Series w/17" CRT	Desktop	IBM
25	IBM ThinkCentre A Series w/17" CRT	Desktop	IBM
26	IBM A51 TOWER W/17" CRT MONITOR, 256MB DDR RAM	Desktop	IBM
27	IBM A51 TOWER W/17" CRT MONITOR, 256MB DDR RAM	Desktop	IBM
28	IBM A51 TOWER W/17" CRT MONITOR, 256MB DDR RAM	Desktop	IBM
29	IBM A51 TOWER W/17" CRT MONITOR, 256MB DDR RAM, 80GB	Desktop	IBM
30	IBM A51 TOWER W/17" CRT MONITOR, 256MB DDR RAM, 80GB	Desktop	IBM

Purchasing (continue)

31	THINKCENTRE A52, 8297-A53 W/17" CRT THINKVISION	Desktop	IBM
32	EASTGATE 466 CEL	Desktop	HP
33	HP BRIO BA600 P3500	Desktop	HP
34	HP BRIO BA600 P3500	Desktop	HP
35	HP BRIO P350	Desktop	HP
36	HP BRIO BA410 PIII-733MHZ	Desktop	HP
37	HP VECTRA VL400 DESKTOP INTEL PIII	Desktop	HP
38	TNN PENTIUM 166 CPU	Desktop	HP
39	VISION POWER P-166MMX	Desktop	HP
40	VISION POWER P-166MMX	Desktop	HP
41	VISION POWER P-166MMX	Desktop	HP
42	HP BRIO PIII-550E SYSTEM	Desktop	HP
43	HP BRIO BA600 PIII-550MHZ	Desktop	HP
44	HP BRIO BA600 PIII-600MHZ	Desktop	HP
45	HP BRIO PIII 866	Desktop	HP
46	DATAMINI FESTIVA CEL333A	Desktop	HP
47	DATAMINI FESTIVA CEL 333A	Desktop	HP

Store / Logistic Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	VISION 1-NET SYSTEM (LE)	Desktop	
2	VISION I-NET SYSTEM AMD	Desktop	HP
3	VISION I-NET SYSTEM AMD	Desktop	HP
4	HP BRIO 800MHZ	Desktop	HP
5	HP BRIO 800MHZ	Desktop	HP
6	HP BRIO 800MHZ	Desktop	HP
7	HP BRIO 800MHZ	Desktop	HP
8	HP BRIO 800MHZ	Desktop	HP
9	HP BRIO 800MHZ	Desktop	HP
10	HP VECTRA VL420	Desktop	HP

IT Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	LAPTOP - HP OMNIBOOK XE2-PIII-450MHZ	Laptop	HP
2	LAPTOP - HP OMNIBOOK XE2-PIII-450MHZ	Laptop	HP
3	LAPTOP - HP OMNIBOOK XE2	Laptop	HP
4	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
5	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
6	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
7	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
8	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP
9	LAPTOP - HP OMNIBOOK XE3-700MHZ	Laptop	HP
10	LAPTOP - HP OMNIBOOK XE3-700MHZ	Laptop	HP

IT Department (continue)

11	LAPTOP - HP OMNIBOOK XE3-700MHZ	Laptop	HP
12	LAPTOP - HP OMNIBOOK XE3-700MHZ	Laptop	HP
13	HP OMNIBOOK XE3-700MHZ	Laptop	HP
14	LAPTOP - HP OMNIBOK XEIII	Laptop	HP
15	LAPTOP - HP XEIII OMNIBOOK	Laptop	HP
16	LAPTOP - HP XEIII OMNIBOOK	Laptop	HP
17	LAPTOP - HP OMNIBOOK XT6050 SERIES	Laptop	HP
18	LAPTOP - COMPAQ EVO N1000V	Laptop	HP
19	LAPTOP - HP COMPAQ EVO N800V	Laptop	HP
20	HP COMPAQ NX9010 LAPTOP	Laptop	HP
21	HP COMPAQ NX9010 LAPTOP	Laptop	HP
22	IBM THINKPAD R50	Laptop	IBM
23	IBM THINKPAD R SERIES - LAPTOP	Laptop	IBM
24	IBM THINKPAD R SERIES - LAPTOP	Laptop	IBM
25	LAPTOP-IBM THINKPAD R-SERIES	Laptop	IBM
26	LAPTOP-IBM THINKPAD R-SERIES	Laptop	IBM
27	IBM ThinkPad R-Series	Laptop	IBM
28	IBM ThinkPad R-Series	Laptop	IBM
29	IBM ThinkPad R-Series	Laptop	IBM
30	IBM ThinkPad R-Series	Laptop	IBM
31	IBM Rack Mount Server w Oracle N Visual Studio'03	Laptop	IBM
32	IBM ThinkPad R-Series	Laptop	IBM
33	IBM THINKPAD R SERIES	Laptop	IBM
34	IBM THINKPAD R SERIES	Laptop	IBM
35	HP NC6220 NOTEBOOK PC W/ DOCKING STATION	Laptop	HP
36	HP NC 8230-15.4" DISPLAY W/ CARRYING CASE (3YRS,NBD)	Laptop	HP
37	HP COMPAQ NC6230 NOTEBOOK	Laptop	HP
38	NOTEBOOK - HP COMPAQ NC4200 NOTEBOOK PC BASE UNIT	Laptop	HP
39	IBM LENOVO THINKPAD R SERIES	Laptop	IBM

Human Resource (HR) Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP BRIO BA600 PIII-550 MHZ	Desktop	HP
2	HP BRIO BA600 PIII-550 MHZ	Desktop	HP
3	HP BRIO BA600 PIII-550 MHZ	Desktop	HP
4	HP BRIO INTEL PIII-700MHZ	Desktop	HP
5	HP BRIO BA410 PIII-733MHZ	Desktop	HP
6	HP BRIO BA410 PIII-733MHZ	Desktop	HP
7	HP BRIO 800MHZ	Desktop	HP
8	HP BRIO 800MHZ	Desktop	HP
9	HP BRIO 800MHZ	Desktop	HP
10	HP BRIO 800MHZ	Desktop	HP
11	HP EVO D510 PC	Desktop	HP
12	HP EVO D510 PC	Desktop	HP

Human Resource (HR) Department (continue)

13	HP EVO D510 PC	Desktop	HP
14	COMPAQ EVO D380 (MT)	Desktop	HP
15	HP EVO D320 MICRO TOWER	Desktop	HP
16	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
17	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
18	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
19	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
20	SNC POWERBOOK 466 CEL -PC	Desktop	HP
21	HP BRIO 800MHZ	Desktop	HP
22	OMNIBOOK XE2-PIII-500MHZ	Laptop	HP
23	LAPTOP - IBM THINKPAD R SERIES	Laptop	IBM
24	LAPTOP - HP EVO 510C WITH MOBILE EXPANSION	Laptop	HP
25	LAPTOP - THINKPAD T43, 2668-AY6	Laptop	IBM
26	LAPTOP - THINKPAD T43, 2668-AY6	Laptop	IBM
27	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	HP

Marketing Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	LAPTOP - COMPAQ EVO N1000V (37-837)	Laptop	HP
2	HP NOTEBOOK EVO N1020V	Laptop	HP
3	HP NOTEBOOK EVO N1020V, INTEL P4 2.4GHZ	Laptop	HP
4	HP NOTEBOOK EVO N1020V, INTEL P4 2.4GHZ	Laptop	HP
5	HP COMPAQ BIZ NOTEBOOK NX7000	Laptop	HP
6	NOTEBOOK-NX9420 GENERIC CONFIG	Laptop	
7	HP EVO D510 (CMT)	Desktop	HP

Finance Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	IBM Think pad 390X Notebook Computer	Laptop	IBM
2	HP Omnibook XE2 PIII-450MHz	Laptop	HP
3	Laptop-Omnibook XE2 PIII 500MHz	Laptop	HP
4	Omnibook PIII XE3	Laptop	HP
5	Omnibook XEIII	Laptop	HP
6	Compaq EVO N1000	Laptop	HP
7	Compaq Notebook EVO N410C	Laptop	HP
8	IBM Think Pad R Series	Laptop	IBM
9	HP EVO N800 V P4.18 GHz & Sony USB Floppy Drive	Laptop	HP
10	HP EVO N800 V P4.18 GHz & Sony USB Floppy Drive	Laptop	HP

Finance Department (continue)

11	Omni book 5000 Pentium 3	Laptop	HP
12	HP BRIO BA600 PIII-600MHZ	Desktop	HP
13	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
14	HP Vectra VL420 Intel Pentium 4 1.6 GHz 128 MB	Desktop	HP
15	HP BrioBA600-650Mhz	Desktop	HP
16	HP VECTRA VL420	Desktop	HP
17	HP BRIO 800MHZ	Desktop	HP
18	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
19	HP BRIO INTEL PIII-700MHZ	Desktop	HP
20	IBM LENOVO THINKCENTRE A52 W/17"CRT MONITOR	Desktop	IBM
21	HP BRIO 800MHZ	Desktop	HP
22	HP BRIO 800MHZ	Desktop	HP
23	HP COMPAQ EVO D220 MICROTOWER (W/ 15" CRT)	Desktop	HP
24	HP BRIO PIII 866	Desktop	HP
25	HP BRIO 800MHZ	Desktop	HP
26	IBM A51 TOWER W/17" CRT MONITOR	Desktop	IBM
27	IBM THINKCENTRE "A" SERIES TOWER W/17' CRT	Desktop	IBM
28	HP BRIO PII-233 COMPUTER SYSTEMS	Desktop	HP
29	IBM THINKCENTRE "A" SERIES TOWER W/17' CRT	Desktop	IBM

Management

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	COMPAQ EVO D510 CONVENTIBLE W/O MONITOR	Desktop	HP
2	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
3	COMPAQ EVO D510 CONVENTIBLE MINITOWER	Desktop	HP
4	COMPAQ EVO D510 CONVENTIBLE MINITOWER	Desktop	HP
5	COMPAQ EVO D510 CONVENTIBLE MINITOWER	Desktop	HP
6	IBM S50 W/ 17" LCD MONITOR	Desktop	IBM
7	LAPTOP - IBM THINKPAD X60	Laptop	IBM
8	IBM THINKPAD X40 NOTEBOOK	Laptop	IBM
9	IBM THINKPAD T42 NOTEBOOK	Laptop	IBM
10	FUJITSU LIFEBOOK S6120	Laptop	Fujitsu
11	IBM THINKPAD 570 PII366 NB	Laptop	IBM
12	LAPTOP - IBM THINKPAD X60	Laptop	IBM
13	LAPTOP - HP OMNIBOOK XT6200 SERIES	Laptop	HP

Technology Centre

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
2	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
3	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	

Technology Centre (continue)

4	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
5	HP OMNIBOOK PIII-XE3	Laptop	
6	IBM THINKPAD R50 SERIES	Laptop	
7	HP OMNIBK XE2 PIII-450MHZ	Laptop	
8	LAPTOP - DATAMINI PEGASUS P220 NOTEBOOK	Laptop	
9	IBM THINKPAD R SERIES	Laptop	
10	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
11	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
12	LAPTOP COMPUTER IBM THINKPAD R52	Laptop	
13	LAPTOP COMPUTER IBM THINKPAD R52	Laptop	
14	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
15	LAPTOP - HP OMNIBOOK PIII-XE3	Laptop	
16	WILLS PRO C466/32 MODEL 8400	Desktop	
17	WILLS PRO C466/32 MODEL 8400	Desktop	
18	WILLS PRO C466/32 MODEL 8400	Desktop	
19	WILLS PRO C466/32 MODEL 8400	Desktop	
20	WILLS PRO C466/32 MODEL 8400	Desktop	
21	WILLS PRO C466/32 MODEL 8400	Desktop	
22	WILLS PRO 7500/64 MODEL 4300 PIII SERIES	Desktop	
23	WILLS PRO 7500/64 MODEL 4300 PIII SERIES	Desktop	
24	HP BRIO BA410 PIII-733MHZ	Desktop	
25	HP BRIO INTEL PIII-700MHZ	Desktop	
26	HP BRIO INTEL PIII-700MHZ	Desktop	
27	HP BRIO BA410 PIII-733MHZ	Desktop	
28	COMPUTER PIII	Desktop	
29	HP COMPAQ DC 7100 CMT BASE UNIT	Desktop	
30	HP COMPAQ NC4200-12.1" DISPLAY WITH CARRY CASE	Desktop	
31	CYCLONE PII-233	Desktop	
32	SNC PIII-500 128MB & WINDOWS 98SE	Desktop	

Supply Chain

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP/COMPAQ EVO NOTEBOOK N800V	Laptop	HP
2	HP COMPAQ NC4200 NOTEBOOK PC BASE UNIT	Laptop	HP
3	IBM THINKPAD R SERIES	Laptop	IBM
4	HP COMPAQ NC6400 IDS 128M BASE UNIT (LAPTOP)	Laptop	HP
5	HP EVO D510 (CMT)	Desktop	HP
6	COMPAQ EVO D220 MICROTOWER	Desktop	HP
7	HP VENTRA VL420 DESKTOP	Desktop	HP
8	HP VECTRA VL 420	Desktop	HP
9	HP COMPAQ NC6400 IDS 128M BASE UNIT (LAPTOP)	Laptop	HP
10	HP EVO D510 (CMT)	Desktop	HP

Supply Chain (continue)

11	HP EVO D510 (CMT)	Desktop	HP
12	HP COMPAQ NC4200 NOTEBOOK PC BASE UNIT	Laptop	HP
13	HP LAPTOP NC4400-12.1" DISPLAY WITH CARRY CASE	Laptop	HP
14	HP COMPAQ NC6400 IDS 128M BASE UNIT (LAPTOP)	Laptop	HP
15	HP EVO D320 (MICRO TOWER MODEL)	Desktop	HP
16	COMPAQ EVO D220 MICROTOWER	Desktop	HP
17	HP VENTRA VL420 DESKTOP	Desktop	HP

Production Department

NO.	DESCRIPTION / MODEL	TYPE	BRAND NAME
1	HP EVO D510, P4 2GHZ, 256MB DDR RAM, 40GB HDD	Desktop	HP
2	IBM A51 SERIES	Desktop	IBM
3	HP EVO D380 (MT)	Desktop	HP
4	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
5	IBM ThinkCentre A50	Desktop	IBM
6	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
7	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
8	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
9	IBM THINKCENTRE "A" SERIES TOWER	Desktop	IBM
10	IBM THINKCENTRE A51 SERIES TOWER	Desktop	IBM
11	HP BRIO BA600 PIII-550MHZ	Desktop	HP
12	COMPAQ EVO D220 MICRO TOWER	Desktop	HP
13	COMPAQ EVO D220 MICROTOWER	Desktop	HP
14	IBM THINKCENTRE A50 SERIES TOWER W/17' CRT	Desktop	IBM
15	DESKTOP-IBM LENOVO THINKCENTRE	Desktop	IBM
16	COMPRO P90 SYSTEM	Desktop	HP
17	HP VECTRA VL420	Desktop	HP
18	IBM LENOVO THINKCENTRE	Desktop	IBM
19	IBM LENOVO THINKCENTRE	Desktop	IBM
20	IBM LENOVO THINKCENTRE	Desktop	IBM
21	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
22	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
23	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
24	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
25	IBM THINKCENTRE A SERIES W/ 15" CRT	Desktop	IBM
26	HP COMPAQ DX2000 MT	Desktop	HP
27	IBM LENOVO THINKCENTRE A52 + RAM	Desktop	IBM
28	IBM THINK CENTRE 'A' SERIES TOWER	Desktop	IBM
29	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
30	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP

Production Department (continue)

31	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
32	IBM THINKCENTRE A50 SERIES TOWER	Desktop	IBM
33	EVO 380MX MICRO TOWER FACTOR COMPUTER	Desktop	HP
34	HP BRIO PIII866	Desktop	HP
35	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
36	IBM LENOVO THINKCENTRE E-SERIES TOWER W/17 CRT	Desktop	IBM
37	IBM A51 TOWER	Desktop	IBM
38	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
39	HP COMPAQ EVO D220 MICROTOWER	Desktop	HP
40	HP BRIO BA410 PIII-733MHZ	Desktop	HP
41	HP BRIO BA600 PIII-550MHZ	Desktop	HP
42	HP PC D220 P IV-2.4Ghz	Desktop	HP
43	HP VECTRA VL420-INTEL PENTIUM 4	Desktop	HP
44	HP BRIO BA410 PIII-733MHZ	Desktop	HP

Appendix C – Survey questionnaire

Survey of Consumers Regarding Used Electronics Recycling

Name: _____(Optional)

* **Please tick only one box for each question or indicate your response in 'other'.**
(For questions 6 to 10, please choose one most important answer.)

1) Please indicate your age group.

☐ under 20 ☐ 21-30 ☐ 31-40

☐ 41-50 ☐ 51-60 ☐ above 60

2) What is your job type?

☐ Manufacturing ☐ Financial / Business Services ☐ Wholesale and Retail Trade

☐ Construction ☐ Transport and Communications Other: _____

3) Is there an environmental policy in your workplace?

☐ Yes ☐ No ☐ Not sure

4) Does the policy address electronic waste? (Answer only if question 3 indication is a 'Yes'.)

☐ Yes ☐ No ☐ Not sure

5) Your awareness about electronic waste recycling came about through…

☐ Media / Campaigns ☐ Manufacturers ☐ Workplace policy

☐ Academically ☐ Word of mouth Other: _____

6) How do you deal with unwanted electronic products?

☐ Dispose ☐ Reuse ☐ Donate

☐ Recycle ☐ Store it Other: _____

7) How does an electronic product affect your buying?

☐ Upgradable features ☐ Made from recycled materials ☐ Can be recycled

☐ Energy saving accredited ☐ Reliable Other: _____

8) You do not recycle unwanted electronics mainly because it is…

☐ Costly ☐ Time consuming ☐ Difficult to access

☐ Not aware of the avenues ☐ Not worth the effort ☐ Not appplicable - recycle all the time

9) What is your perception of recycling?

☐ Beneficial for environment ☐ Cost effective for consumers & environment ☐ Not cost effective but benefits the environment

☐ Time consuming but worth the effort ☐ A total waste of time Other: _____

10) Who should be responsible for managing electronic waste?

☐ Government ☐ Manufacturers ☐ Community

☐ Consumers ☐ Everyone ☐ Don't know

11) How much are you willing to pay to recycle an electronic product?

☐ S$1 - S$5 ☐ S$6 - S$10 ☐ S$11 - S$15

☐ S$16 - S$20 ☐ more than S$20 Other: _____

12) Do you think you are likely to be more involved in recycling electronic products in the next 5 years?

☐ Definitely yes ☐ Probably yes ☐ Don't know

☐ Probably not ☐ Definitely not

Do you have any further comments you would like to make about recycling electronic products?

_____

_____

_____

- Thank you -