GUIDE FOR ORGANIZATIONS THAT WANT TO SET UP CENTRES FOR DISASSEMBLING AND SORTING END-OF-LIFE IT EQUIPMENT

Implementation Guide

FOR INFORMATION TECHNOLOGY EQUIPMENT DISASSEMBLY AND SORTING CENTRES

Centre québécois de
développement durable

réseau cfer

Preface

This implementation guide grew out of a report on a pilot project carried out by the Réseau québécois des Centres de Formation en Entreprise et Récupération (CFERs) [Quebec network of on-the-job training and resource-recovery centres]. The purpose of this project was to test a system for collecting, transporting, reusing and recycling obsolete computers and other information technology (IT) equipment, and thereby to develop some guidelines that could help in the future implementation of such a system throughout Quebec.

This guide represents a natural outgrowth of this pilot project and was written to show organizations how to get the tools they need to set up IT equipment disassembly and sorting centres. The Réseau québécois des CFER considers it essential to pass on the know-how that it has acquired in this area to help foster the growth of organizations that do this kind of work.

Toward this end, this guide presents tools based on the approach that the CFERs have developed, in which they attempt to incorporate socially responsible business practices and sustainable development into every aspect of their operations.

The present guide is intended for all kinds of organizations—public, private, non-profit, and so on. But it should be noted that under current conditions, making a profit out of disassembling and sorting computer equipment is difficult if profitability is measured in economic terms alone. In this regard, social economy enterprises have the advantage of pursuing several other goals as well, including social, educational and environmental ones. When the results of disassembly and sorting centres run by such enterprises are measured in these terms as well, their overall benefits are far greater.

Nevertheless, this guide attempts to describe the winning conditions for a successful start-up by any organization that wants to engage in computer equipment disassembly and sorting to achieve economic, environmental and social objectives.

ACKNOWLEDGEMENTS

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Background

Current trends in information technology suggest that in coming years, more and more IT equipment will become obsolete. This trend has already become a serious concern in Canada, because disposal of such equipment is already having significant environmental impacts. A study by Enviros RIS[1] predicted that approximately 67,000 tonnes of IT equipment waste would be disposed of in Canada in 2005 alone. In recent years, the purchase price of IT equipment has decreased considerably and so has this equipment's service life. Hence the number of pieces of such equipment that will be disposed of is going to increase in future years.

In Quebec, though the negative impacts of current methods of managing IT equipment waste are well known, there is not yet any legislation regulating the disposal of this waste. It is estimated that in 1999[2], more than 300 tonnes of lead from computers was disposed of in Quebec landfill sites, not to mention significant amounts of mercury, cadmium and other heavy metals. According to Recyc-Québec (the provincial Crown corporation responsible for promoting recycling efforts), this lead from computers accounted for 15% of all the lead disposed of by Quebec municipalities. We can thus see that IT equipment waste poses a potential hazard for the environment and for human health. The heavy metals that this waste contains are highly toxic and can migrate out of landfill sites to contaminate surface and ground water, thus entering the food chain and eventually reaching human beings.

In Canada, there are currently no broadly based initiatives to process and recycle IT equipment that has reached the end of its useful life. The present guide is designed to support such efforts by helping organizations to start up IT equipment disassembly and sorting centres and to operate them effectively. Once there are more centres of this kind, it will become easier to meet the challenge of establishing a Canada-wide system for collecting, reusing and recycling obsolete IT equipment.

OBJECTIVES AND LIMITATIONS OF THIS GUIDE

This guide was written to:

- Provide an overview of the issues involved in recycling used IT equipment
- Describe the methods of collecting used IT equipment and their respective advantages and disadvantages.
- Provide a better understanding of the operations of an IT equipment disassembly and sorting centre.
- Provide a basic knowledge of IT equipment and its recyclable components.
- Provide tools to facilitate the implementation of best practices with regard to workplace health and safety.
- Identify the equipment and resources needed to set up an IT equipment disassembly and sorting centre.
- Provide an overview of the costs and potential benefits of operating such a centre.

lt should be stressed that the methods presented in this guide have proven effective in the specific context of CFERs in Quebec. Some parts of this guide may not be applicable in other contexts. Readers must realize that there are no miracle solutions for operating disassembly and sorting centres. Every organization should carefully analyze the specific circumstances in which it will have to operate and adjust its methods on the basis of this analysis.

1 ENVIROS RIS. October 2000. *Information Technology and Telecommunication Waste in Canada*.

2 RECYC-QUÉBEC. Fiche d'information août 2004 http://www.recyc-quebec.gouv.qc.ca/upload/Publications/zFiche_458.pdf

Introduction

SUSTAINABLE DEVELOPMENT

If we are ever going to achieve an integrated economy in which development proceeds with due regard for future generations and for the impact of human activities on the environment, it will be essential for us to change our ways of doing things. Our goal must not be simply a compromise among economic, environmental and social sustainability, but rather the harmonious integration of all three of these pillars of sustainable development.

Quebec's CFERs are now proposing an innovative approach that does precisely that. Ever since their inception, the CFERs have offered an example of how enterprises can be socially responsible and environmentally innovative, as well as financially successful.

In the past, to teach both entrepreneurial and environmental values to their students, the CFERs have developed recycling niches that were subsequently taken up by private industry. As part of their education and awareness efforts, the CFERs were among the first to demonstrate that a market for recovered paper and cardboard fibre could be developed in Quebec. A few years later, the CFERs carried out a paint-recovery project that showed how successfully the recycling of a particular category of material could be undertaken in co-operation with the industry that produced it. This successful experiment also marked a first step toward extended producer responsibility, a concept now being applied more and more throughout the world.

BACKGROUND ON THE CFERS

From 1975 to 1985, the Bois-Francs region of Quebec was the site of an experiment that was unique within the province. Working with the *Atelier de la culture*, 10 teachers in this region tried an original teaching approach in which over 200 young people enrolled in vocational training programs convinced the people of the region that residential waste was a valuable secondary resource. A company called Récupération Bois-Francs inc. was then founded to recover this resource from the site where it was being disposed of.

Applying what was learned in this experiment, Normand Maurice and the Victoriaville, Quebec school board established Quebec's first CFER in 1990. Since then, a total of 16 CFERs have been established. All of them operate according to the same principle developed by the original group of teachers: that undereducated youth ages 16 to 19 can become successfully integrated into society through the training they receive in a working business that targets a previously unexploited segment of the resource recovery and recycling market.

Most of the CFERs' clients are troubled youth who have attended school for at least 10 years but have not been able to complete Secondary I (grade 7). Formerly classified as "dropouts" by the statisticians, the 10% of young people who have no chance of obtaining a secondary-school diploma or a steady job find themselves shut out both socially and educationally. The CFER program provides them with courses that teach them how to communicate and how to adapt to the world of work, while also giving them on-the-job training in a CFER business. This program is approved by the Quebec ministry of education, which grants a certificate of training in business and resource recovery (*Certificat de formation en entreprise et récupération*) to the students who complete it. The vast majority of those who complete this training go on to find employment in the conventional job market.

It must be recognized, however, that when a CFER is established, training objectives must take precedence over production objectives. The main purpose of the enterprise is to provide on-the-job training that is both stimulating and worthwhile for the students concerned.

Whether any given item is useless waste or a valuable resource is really a matter of perception. As long as people think that an item cannot be put to profitable use, they will decide that it is cheaper to bury it in the landfill. For too long, this was what became of used paper, glass, plastic, metals, oil and paint. And for too long, the valuable resource that these young people represent has been allowed to go to waste as well. Society needs these manual jobs, both in the environmental sector and elsewhere.

STATISTICS ON IT EQUIPMENT WASTE

Technological advances occur so rapidly these days that IT equipment is becoming obsolete at an ever-increasing pace. As a result, the rate and quantity of IT equipment entering the waste stream bound for the landfill are increasing as well. This equipment contains a certain amount of precious metals, but it also contains substances that are toxic and hazardous for the environment if they are not managed properly.

According to a study conducted by Enviros RIS in fall 2000, it is estimated that in Canada in 1999, approximately 34,000 tonnes of IT equipment waste were disposed of, 15,600 tonnes were recycled, 24,500 tonnes were reused and 6,100 tonnes were put into storage.[3]

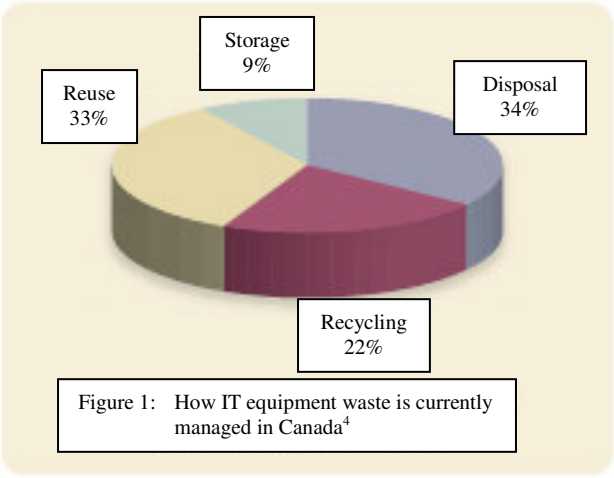
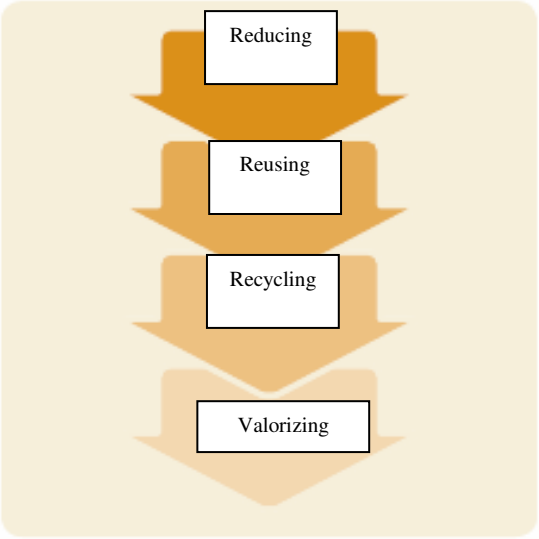


Figure 1: How IT equipment waste is currently managed in Canada[4]

The above figures can be expected to grow each year as new information technology equipment is sold on the Canadian market and more existing equipment becomes obsolete. The average computer now becomes obsolete after 3.5 years of use,[5] thus accelerating the number of computers that get thrown away. This same study predicted that in 2005, approximately 67,000 tonnes of IT equipment waste would be disposed of, 47,800 tonnes reused, 12,000 tonnes put in storage and 43,400 tonnes recycled.

THE 3RV CONCEPT[6]

To address the new concerns that arise when waste is seen as a resource, society has gradually evolved what is known as the 3RV model for prioritizing waste management activities. According to the 3RV principle, to reduce the environmental impacts of human consumption, the following activities must be carried out in the order of priority shown in the diagram below.



This order of priority defines a series of actions that should make it possible to extend the lifespan of materials, to reduce the energy consumed by the goods produced and to reduce the impacts of waste disposal.

Reducing means reducing at the source. It can involve reducing the amount of material used to manufacture or package equipment, as well as reducing the amount of equipment consumed. This latter option should be given top priority, because reducing consumption saves the most resources. Reducing can also involve eco-design. For instance, if IT equipment manufacturers know that at the end of its lifespan, they will be responsible for recovering any toxic substances that it contains, they may well find it simpler and cheaper simply to use less of these substances or to stop using them altogether.

3 ENVIROS RIS. October 2000. Information Technology and Telecommunication Waste in Canada.
4 ENVIROS RIS. October 2000. Information Technology and Telecommunication Waste in Canada.
5 RIS International Ltd. 2003. Information Technology and Telecommunication Waste in Canada - 2003 Update.
6 OLIVIER, Marc. Gestion des matières résiduelles au Québec, Saint-Lambert de Lauzon, Les productions Jacques Bernier, 1999, 311 pp.

Second in order of priority comes **reusing**, which means making a second use of a product without modifying its properties or appearance. When a product is reused, it does not undergo any transformation, so a minimum of energy is consumed (e.g., in transporting it to a new location) to let it be used again. One example of reuse of computers in Canada is a program called Computers for Schools, which collects surplus computers from business and government and donates them to schools. In order to ensure that the computers are in good condition when the schools receive them, some refurbishing and minor repairs are sometimes required. The parts needed for the refurbishing can be recovered by disassembly of other surplus computers.

Recycling consists in using secondary materials in a manufacturing process instead of virgin materials of the same kind. In Canada, the computers that get recycled are ones that are too out of date or too damaged to be reused. They may come from individuals or from businesses, or they may be computers from the Computers for Schools program that have reached the end of their useful life. In recycling of IT equipment, disassembly is a crucial step, because it allows the recovery of useful components such as memory chips, hard drives and CD drives. Before secondary raw materials can be recycled, they must be sorted into various categories, such as metals, plastics and glass. They can then be sold to businesses that can process them as required, such as metal smelters and plastics manufacturers. These businesses then resell the recycled raw materials to manufacturers who use them to produce new finished goods.

Valorizing means obtaining value from a waste material by subjecting it to a chemical transformation that radically alters its nature. One example of valorizing IT equipment waste might consist in recovering the plastics from it and burning them as fuel.

Landfilling or **incineration** without recovery should be the last resort where waste management is concerned. Both processes very often have negative impacts on both the environment and human health.

In all cases, the 3RV model attempts to modify waste-management activities so as to considerably reduce the volumes of material that go to the landfill.

Collection of IT Equipment Waste

SOURCES OF SUPPLY

One of the first steps in starting up an IT equipment disassembly and sorting centre is to determine what potential sources of used IT equipment exist in your area. Once you have done your market analysis, it is essential to conclude agreements with your centre's potential clients. To secure a supply of used IT equipment from businesses, government and other institutions, you should contact the people who manage their IT hardware and agree on a method for you to take possession of their used equipment. You can also approach municipalities and reach agreements with them on ways for you to recover used IT equipment from the residential sector.

One critical question to address is the costs of collecting and transporting the used equipment. These costs can represent nearly 40% of the total cost of recycling IT equipment,[7] so before agreeing to accept used equipment from any source, it is essential to determine who will be responsible for paying these costs. For example, businesses and institutions already incur expenses to dispose of their waste equipment. Hence it is entirely acceptable to require these organizations to pay transportation costs equivalent to what they would have paid to send their equipment to the landfill. When dealing with city and regional governments, you can negotiate agreements to have them pay at least as much as they would have paid to landfill these waste materials. These arrangements must be made at the very outset, possibly before your disassembly and sorting centre has even begun to operate, because the details of these agreements can have a serious impact on a centre's profitability.

Another important matter to verify is the availability of used IT equipment. You need to determine whether your disassembly and sorting centre's geographic location will enable it to secure a supply of such equipment that will enable the centre to operate at a profit.

The supply of equipment in your area must be both sufficiently large and fairly steady. Population density is certainly one factor that determines the quantities of equipment available and gives some indication of the methods that you will have to use to collect it. The collection methods that will work best in a rural area can be quite different from those that would work best in an urban one. The costs of collecting used IT equipment will also vary from one type of community to another. Various characteristics of these communities can also influence what kinds of equipment are available to recover and how worn out or out of date it is.

The conclusions drawn to date from the CFERs' equipment-recovery pilot project suggest that it is important to have a strong base of government and other institutions to supply your disassembly and sorting centre.

The above figure shows the proportions of IT equipment that the CFERs received for recycling from the institutional, residential and business sectors in this pilot

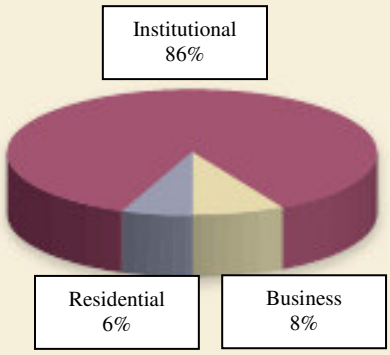


Figure 2: Proportions of IT equipment collected from three different sectors in the CFER pilot project[8]

7 According to a recycling-cost analysis carried out as part of the *CFER-3RV Ordinateurs* pilot project.
8 Centre québécois de développement durable. 2006. Projet pilote CFER 3RV Ordinateurs. Report presented to the Réseau québécois des CFER.

project. Out of a total of 365,000 kg of IT equipment received by the CFERs in one year of operation, 86% came from the institutional sector, 8% from the business sector and 6% from the residential sector. This experience clearly shows that the disassembly and sorting centres were heavily dependent on the institutional sector for the success of their operations. Consequently, one can assume that in the short term, the proximity of a strong institutional sector is a winning condition for the success of an IT equipment disassembly and sorting centre.

The volumes of each type of equipment received will also greatly influence the centre's profitability. For example, the costs involved in recycling computer CPUs, monitors and printers are all different, and the revenues that they yield differ too. Starting from the premise that the environmentally sound processing of monitors is the most costly operation at an IT equipment disassembly and sorting centre, it is important to establish a rate structure that takes the costs of processing the various kinds of equipment into account.

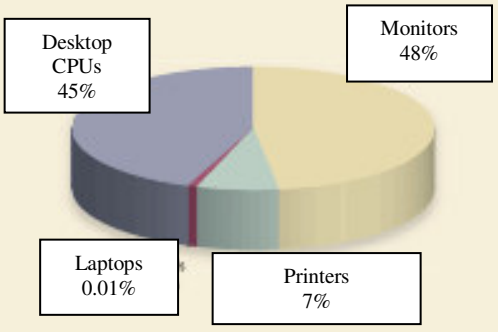


Figure 3: Proportions of each type of equipment received in the CFER pilot project[9]

In the IT equipment stream that the CFERs received in their pilot project, for example, desktop CPUs and monitors accounted for about the same proportions of the total mass, while printers accounted for a smaller proportion and laptops were practically non-existent. These figures are important for a disassembly and sorting centre, because they provide information that is essential for assessing the profitability of its operations. For example, if a centre found that monitors were going to account for twice as high a percentage of its total inbound stream as CPUs were, then it would have to develop strategies to compensate for the deficit incurred by handling such a large quantity of monitors and for the low revenues generated by the CPUs. Under such circumstances, the centre might be wise to charge a special fee per piece of equipment, so that these fees could cover the centre's total processing costs.

To sum up, the types of equipment collected and the proportions of each type play a decisive role in the profitability of IT equipment disassembly and sorting centres and in the strategies that they must employ under these varying conditions.

9 Centre québécois de développement durable. 2006. Projet pilote CFER 3RV Ordinateurs. Report submitted to the Réseau québécois des CFER.

ECONOMIC SECTORS AND GEOGRAPHIC AREAS SUPPLYING IT EQUIPMENT WASTE

To get the most out of this guide, it is important to understand the characteristics of the various economic sectors that supply the flow of equipment waste.

ECONOMIC SECTORS

Residential Sector
The residential sector includes all persons living in all types of dwellings in urban and rural areas. A small proportion of the waste from this sector may come from home-based businesses. The costs of disposing of residential waste are borne by the municipalities, which finance these costs by taxing their citizens. In the past, the residential sector did not recycle very much of its IT equipment, because there were no appropriate systems in place to collect this waste for this purpose.

Business Sector (Commercial and Industrial)
The business sector comprises the entirety of the commercial and industrial sectors and must pay its own costs for disposing of its IT equipment waste.

Institutional Sector
The institutional sector consists of the federal and provincial governments, school boards, colleges, universities and all other not-for-profit organizations. This sector too must defray the costs of disposing of its equipment waste, though school boards sometimes have special arrangements that let them pay reduced fees.

GEOGRAPHIC AREAS

Urban Areas

"Urban areas" means areas with a population of more than 5,000. Urban areas are seen as differing from rural areas in the size of the businesses and institutions located in them. In urban areas, factors that can influence the success of IT waste collection for recycling are the infrastructure available for this purpose and public receptiveness to campaigns promoting this idea.

Rural Areas

"Rural areas" means areas with a population of less than 5,000.

COLLECTION METHODS FOR EACH SECTOR

It is important to note that whatever the collection method, its convenience for users will have a direct impact on how much material still ends up in the landfill. The harder it is for users to recycle a product, the more they will be tempted to get rid of it by the easiest method, which often means letting it go to the landfill.

RESIDENTIAL SECTOR

Regularly Scheduled Pick-Up

In regularly scheduled pickup, the collection service provider travels door-to-door and picks up used equipment at people's homes. This method has proven very effective, because it lets people get rid of their used equipment with very little effort. In fact, regularly scheduled pick-up is probably the collection method that results in the best participation by the residential sector.

It is estimated that when this form of pick-up is used, participation can be up to eight times higher than when people have to drop off their used equipment at a recycling depot.

Call-In Pick-Up
In the call-in pick-up method, residents of a municipality who have used computer equipment to dispose of simply call in to the collection service and ask for a pick-up. The service then comes and gets the equipment. Residents can receive this service year-round; they do not have to worry about waiting for a special pick-up day to dispose of their used equipment.

Special-Day Pick-Up

Many jurisdictions schedule special days when they will pick up used IT equipment along with other special categories of waste, such as bulky objects or hazardous materials. Because these special pick-up days usually occur only once or twice per year (in spring and fall, for example), residents have to hold on to their used equipment until the next such day. Some people may just want to get rid of their equipment as quickly as possible and may therefore find it easier simply to put it out with their garbage instead.

Drop-Off at Indoor Depots

Resource centres, eco-centres and other establishments may provide indoor spaces where used IT equipment can be dropped off and temporarily stored. Indoor depots of this kind are often open only during the business hours of the host establishments and require the co-operation of people who work there. Some indoor depots accept used equipment all year round, while others do so only on special occasions—for example, when a school runs a used-equipment drop-off event.

This collection method has the advantage of ensuring that the used equipment is handled properly. But when people have equipment that they want to recycle, they have to drop it off at the depot themselves. This means that they have to be physically able to get to the depot and that they must have some means of transporting their used equipment there as well. The size and weight of the equipment can create various obstacles to getting it to the depot. For example, people may perceive that small devices such as modems are not worth the trouble it would take to drop them off. Experiments with indoor depots at eco-centres have shown that when people live more than 15 minutes away, their participation in the drop-off program is very limited. Thus, the geographic location chosen for an indoor depot can have a decisive effect on its ability to meet its collection objectives.

Drop-Off at Outdoor Depots

This collection method has characteristics similar to those of indoor depot drop-off, with the same problems of access to the depot and of transporting equipment to it. But there are some differences.

When a depot is located outdoors, people may be able to drop off equipment at any time of day and any time of year. Outdoor spaces are easier to obtain than indoor ones. The establishment that owns the site expends little effort and does not have to supply any labour to operate the depot. On the downside, however, because the used equipment is handled only by the people who are dropping it off, rather than by depot workers, the risk of breakage is higher.

Drop-Off at Computer Retail Outlets

In this collection method, a computer store or chain of such stores invites consumers to drop off their used IT equipment to be recycled. In terms of participation, this drop-off method has some advantages over the two others just described. First of all, many people who might be coming into computer stores to buy new equipment already own equipment that is out of date or that they will not be using anymore once they buy new, higher-performance models. Being able to donate their old equipment at the same retail outlet where they buy their new equipment is highly convenient: it lets them make one trip instead of two. Also, they already know where the retailer is located, so they do not have to do any research to find out where to drop off their used items.

Another advantage of this method is that it cuts the cost of promoting drop-off programs, because retailers can advertise them at the same time as the products they have for sale. In addition, by promoting these programs, retailers enhance their image as businesses that care about their impact on the environment. Retailers do generally have to absorb the costs of handling and storing the used equipment, but can substantially reduce them by setting up outdoor depots at their store locations.

The effectiveness of all of the collection methods discussed in this section can be enhanced if the municipality adopts a by-law that prohibits disposing of IT equipment in landfills.

Collection Method	Advantages	Disadvantages	Effectiveness
Residential pick-up	• Can be combined with existing pick-up services (outsized items, hazardous materials, etc.) • Requires very little effort by consumers • Existing pick-up service can quickly train employees to handle used IT equipment • Service can be promoted through the service provider's existing communication methods • Pick-ups can be made throughout the year • Cost per unit weight may go down as volume goes up • Better participation by people who would have no way to transport used equipment to a collection depot	• Equipment may get broken or stolen if it is left at curbside for pick-up • Transportation costs are high • Transportation costs are borne by the program, rather than by the consumer	High
Ongoing drop-off program at indoor depot	• Reduces risk that equipment will get broken, because it is handled by employees who know how to do the job properly • Equipment protected from weather and theft • Program can be promoted through the establishment's existing communication methods • Employees can be quickly trained in how to handle IT equipment, do not need training repeated as they would if equipment drop-offs were scheduled only as special events • Equipment can be dropped off throughout the year • Can be combined with existing drop-off programs at eco-centres, charities, etc.	• Requires an employee on-site to handle the equipment • Drop-offs can be made only during host establishment's business hours • People must make a trip to get rid of their used equipment • Small possibility of equipment breakage reducing chances of re-use • Requires indoor space to store dropped off equipment • Depot at fixed location, attracts only people who live relatively close to it • Difficulty in finding suitable available locations	Moderate
Ongoing drop-off program at outdoor depot	• People can make drop-offs 24 hours per day, all year round • Requires only a small outdoor space and can be set up at many different locations, which might increase the number of suitable sites available • Does not require an employee on-site to handle the equipment • Drop-offs can be made throughout the year • Participants become familiar with the site • Can be combined with existing drop-off programs at eco-centres, charities, etc. • Collection may be easier when the carrier comes to get the equipment to be taken to the processing centre (CFER)	• Moderate possibility of equipment breakage reducing chances of re-use • Possibility of equipment theft if drop-offs are made by individuals themselves • Equipment may be exposed to harsh weather • People must make a trip to get rid of their used equipment • Depot at fixed location, attracts only people who live relatively close to it	Moderate

Collection Method	Advantages	Disadvantages	Effectiveness
Drop-off at computer retailer	• Convenient for consumers • Helps bring customers into the retailer's stores • Can facilitate return to manufacturer, through the transport system already in place • Promotes producer responsibility • Provides retailers with benefits associated with being environmentally responsible businesses • Consumers often already familiar with drop-off location • Program can be easily promoted through retailers' usual advertising vehicles • Drop-offs can be made throughout the year • Reduces risk that equipment will get broken, because it is handled by employees who know how to do the job properly • Equipment protected from weather and theft • Opportunity to share the costs with the retailer	• Requires storage space • Requires one of the retailer's employees to handle the equipment • Possible additional costs for the retailer • Drop-offs can be made only during retailer's business hours • People must make a trip to get rid of their used equipment • Difficulty in obtaining corporate approval to participate in the program	Moderate
Special collection drive	• Low costs, because special collection drives are often organized by volunteers • Large quantity of equipment collected in a short time • Excellent means of raising awareness • Possibility of getting sponsors for the event • Can be combined with existing collection drives	• Hard to predict how many pieces of equipment will be collected and what resources will be needed both to receive them and to recycle them • Event's success heavily dependent on how effectively it is publicized • Participation may be reduced if other events are being held at the same time • Requires a lot of planning and preparation • Managing volunteers and participants can be a complex undertaking	Uncertain

INSTITUTIONAL AND BUSINESS SECTORS

Government agencies, other institutions and businesses may use their own means of transportation to send their used IT equipment to disassembly and sorting centres, or they may pay to have it taken there by a third party. Some institutions and large businesses have their own in-house organizations that manage their IT equipment and these organizations may have their own transportation systems that can deliver their used equipment to such centres at lower cost. Smaller businesses that do not have their own transport resources may either have the disassembly and sorting centre pick up their equipment (if it offers this service) or pay a private carrier to drop the equipment off.

PROMOTING IT EQUIPMENT RECYCLING PROGRAMS

For recycling programs to be effective, potential participants must know that they exist and must be able to access them easily. The level of participation by the residential, institutional and business sectors depends heavily on how familiar they are with the collection methods available and the locations where they are being offered. Promotional efforts play a decisive role in the success of any collection system.

In some U.S. municipalities, a number of pilot projects for recycling IT equipment have been carried out, so the public is more aware of the recycling programs available to them. In these municipalities, the use of the same collection methods continuously over the years has made it easier for people to get into the habit of recycling their used IT equipment.

The methods used to promote an IT equipment recycling program must of course be tailored to its target audience. The promotional methods that yield the best results may vary according to whether this audience is urban or rural or to whether it consists of consumers, businesses or municipalities. Methods that can be used to promote IT equipment recycling programs include:

- Holding press conferences to launch collection drives
- Mailing out flyers and brochures
- Advertising in local newspapers
- Advertising on radio and television
- Placing ads on municipal utility bills, paycheque stubs, etc.
- Conducting promotion campaigns by telephone
- Conducting promotion campaigns via Web sites and e-mail
- Using logos and slogans

The CFERs' experience in Quebec confirms the need for proper publicity whenever a new collection system is being launched. According to the CFERs, following an advertising campaign, a given sector's participation may increase by as much as 400%.

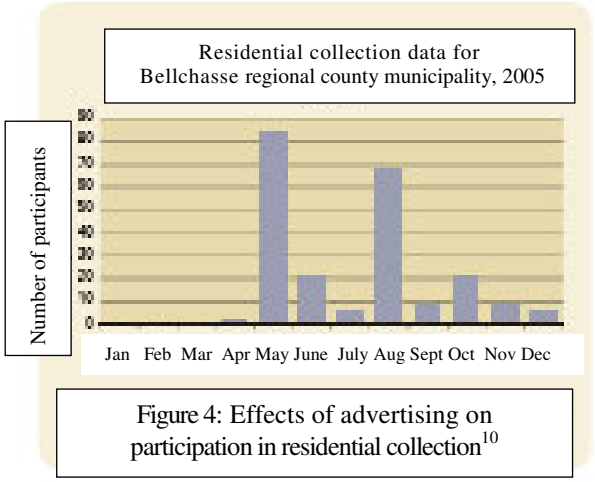


Figure 4: Effects of advertising on participation in residential collection[10]

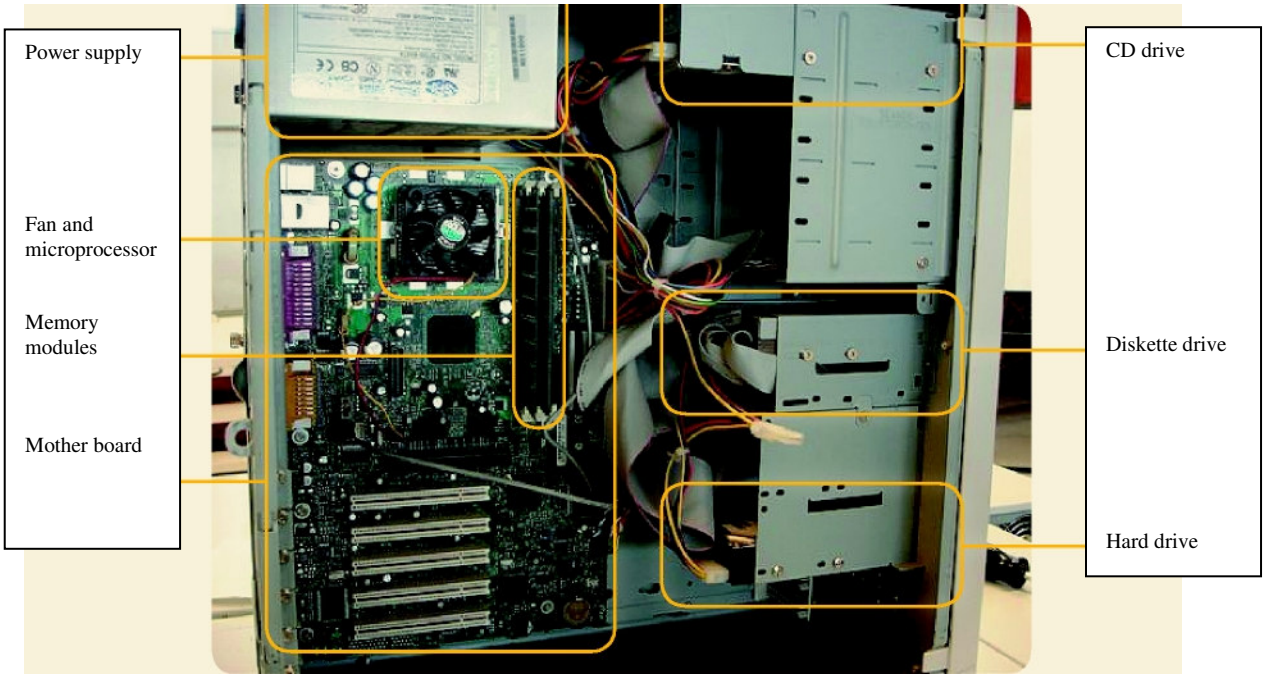
The graph above shows the effects of an advertising campaign conducted in conjunction with the CFERs' pilot project. In this example, the campaign was conducted at the end of April 2005 and a sharp increase in public participation can be seen in the months that followed. Before the campaign, participation was almost zero. Right after the campaign, participation jumped dramatically, but it then decreased over time. This pattern points to the need to maintain ongoing communication with the public in order to keep their participation high.

10 Centre québécois de développement durable. 2006. Projet pilote CFER 3RV Ordinateurs. Report submitted to the Réseau québécois des CFER.

Components of Desktop Computers and Peripheral Equipment

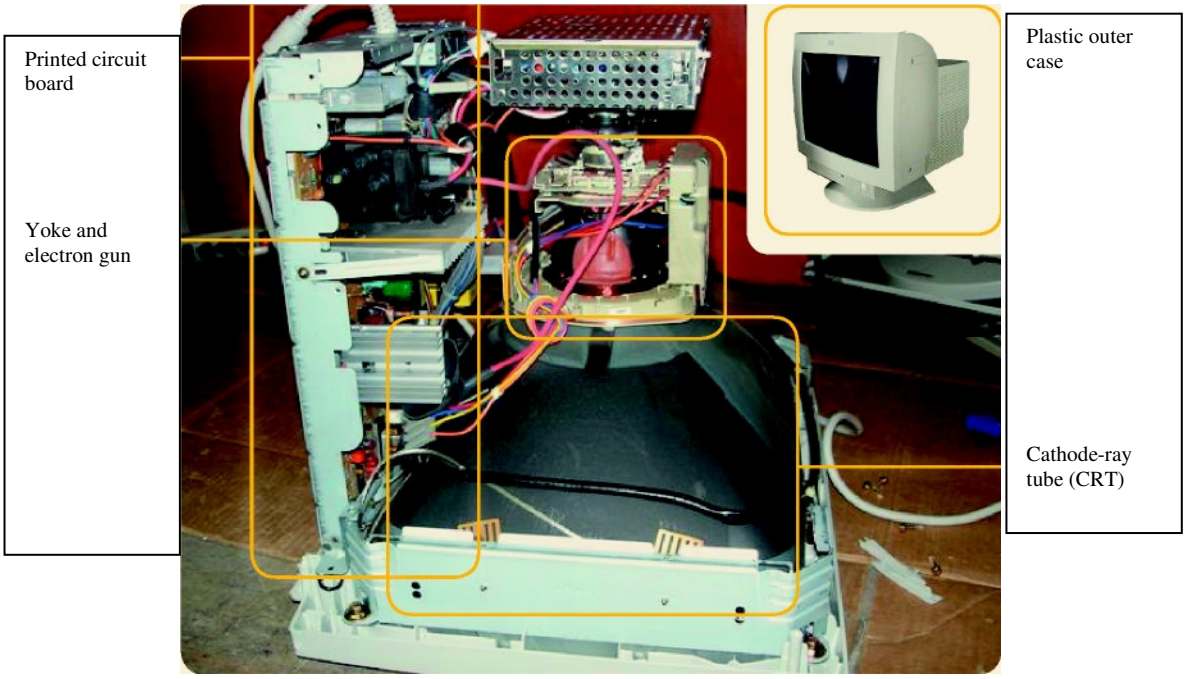
DESCRIPTION

The IT equipment waste stream covered by this guide consists mainly of the central processing units (CPUs) of desktop computers and the monitors that go with them. A smaller proportion of the mass of equipment collected will consist of portable computers and computer peripherals: printers, keyboards, scanners, modems, routers, and so on. In coming years, sales of peripherals are expected to increase, so these items will account for a growing proportion of the total volume of used equipment collected.



CPU

The CPU comprises most of the computer's internal operating components. It includes the mother board, various adapter boards (video card, network card, etc.), microprocessor, power supply, hard drive, diskette drive, CD drive, fan and wiring.



MONITOR

A computer monitor consists of a case made of plastic (ABS, polycarbonate, etc.), a cathode-ray tube (CRT), a yoke, a printed circuit board and wiring. The CRT consists of leaded glass and an electron gun.

HARD DRIVE

The hard drive consists of a cover, a metal enclosure, a data disk and a printed circuit board with electronic components. The data disk is made of a plated aluminum alloy.

POWER SUPPLY

The power supply consists of a heat sink, a fan, connection interfaces, cables and connectors, and a printed circuit board containing capacitors and a transformer.

DISKETTE DRIVE

The diskette drive consists of two parts: a metal case and a printed circuit board with electronic components.

METAL CASE

The case comprises the outer envelope of the computer and the various structures that support its internal components. The case consists almost entirely of ferrous metals.

MONITOR

The monitor consists of a case made of plastic (ABS, polycarbonate, etc.), a cathode-ray tube (CRT), a yoke, a circuit board and wiring. The CRT consists of the funnel glass, the panel glass, lead and an electron gun.

KEYBOARD

The keyboard consists of a plastic case, plastic keys, a printed circuit and wiring.

PRINTERS

Printers consist of a plastic case, ink cartridges, moving metal parts, a printed circuit board and wiring.

MATERIALS COMPOSITION OF DESKTOP COMPUTERS AND MONITORS

A typical desktop computer CPU and monitor are composed of the materials listed in the pie chart opposite. "Precious metals" includes actual precious metals such as gold and silver, plus other metals, such as nickel, manganese, cobalt, tin and chromium, that are present in small amounts. "Plastics" composition is 57% ABS resin, 36% polyphenylene oxide (PPO), 5% high-impact polystyrene and 2% polycarbonate.[11]

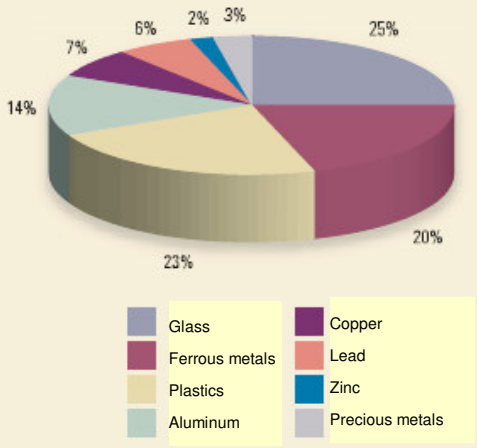


Figure 5: Typical composition of a desktop computer and monitor

(Source: Electronics Industry Environmental Roadmap, Microelectronics and Computer Technology Corporation, 1996)

11 Plastic from Consumer Electronics Recycling Report 1999, American Plastics Council.

The current infrastructure for recycling IT equipment consists of a combination of primary and secondary recyclers and secondary raw materials buyers (such as metal smelters and plastics manufacturers). Usually, primary recyclers (disassembly and sorting centres) refurbish equipment for resale when possible. They disassemble the remaining components and sort them into various categories, such as printed circuit boards, cathode-ray tubes, plastic cases, and cables and wiring, then sell them to secondary recyclers or to smelters for further processing. In refurbishing and disassembling the equipment that they collect, primary recyclers rely mainly on manual labour.

Secondary recyclers process the metals, plastics and glass in IT equipment waste to recover the raw materials that it contains. These recyclers generally use automated equipment that requires minimal human intervention for disassembly. Secondary recyclers are unfortunately extremely dependent on the flow of recyclable materials: the automated equipment that these recyclers use is so expensive that to amortize their costs, they must have a large, continuous supply of these materials.

Computer components can also be processed in smelters, in order to recover the precious metals that they contain. The pyrometallurgical processes used in smelters involve combining and melting metals to separate their component elements, such as lead and copper.

Cathode-ray tubes (CRTs) require special processing, because they can contain from 0.7 to 2.7 kg of lead, depending on the size of the screen and how long ago it was manufactured. Screens that cannot be refurbished can be recycled to manufacture new ones or used as fluxing agents and/or secondary raw materials by secondary casting lead smelters.

The plastics in computers contain two types of resins: thermoplastic and thermosetting. Thermosetting resins, such as the ABS in monitor cases, cannot be remelted and must be converted into granules before they can be used to manufacture new products. Thermoplastics, such as the PVC in the insulation on electrical wires, can be remelted and hence are of greater interest for recycling. However, sorting the various plastics is a very time-consuming operation, which has hampered the development of effective systems for recycling electronic plastics.

IT Equipment
Disassembly and Sorting Centre Operations

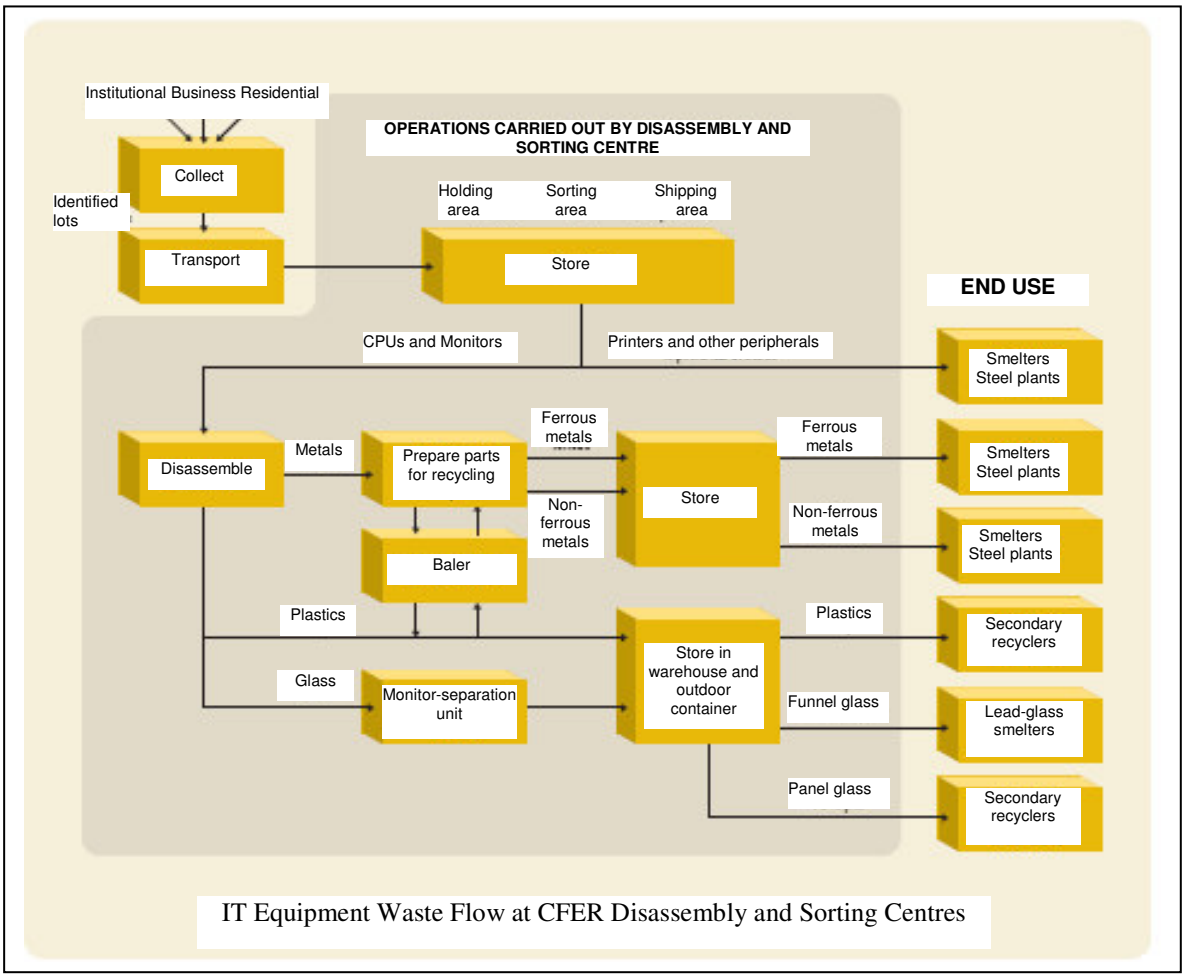
MANAGING THE IT EQUIPMENT WASTE STREAM AT DISASSEMBLY AND SORTING CENTRES

The role of an IT equipment waste disassembly and sorting centre is a) to collect used IT equipment so that it does not go into the landfill, and b) to carry out other operations so that the materials in this equipment can be recycled in an optimal fashion. Because the IT equipment waste stream contains so many different kinds of items, a manual sorting and separation process is essential if maximum value is to be derived from their components.

In the CFERs' pilot project, to ensure that the equipment that they processed would be recycled in an environmentally responsible manner, the Réseau québécois des CFER had their primary recycler supply a list of the secondary recyclers that it would be using in Canada and the United States.

In future, the Réseau québécois des CFER will continue to encourage recyclers to adhere to environmentally sound practices and standards and to apply new knowledge to attempt to recover the maximum amount of resources throughout the equipment life cycle.

The following diagram shows the flow of IT equipment waste in the process developed and used by the CFERs.



IT Equipment Waste Flow at CFER Disassembly and Sorting Centres

FLOOR PLAN FOR A DISASSEMBLY AND SORTING CENTRE

The following diagram shows a typical floor plan for a disassembly and sorting centre. This arrangement of work areas was developed by the CFERs; it was chosen after several years of operation and definitely represents the most effective layout for their particular situation. Other layouts might prove equally effective for other organizations or other kinds of IT equipment.

The infrastructure of a disassembly and sorting centre is divided into three main areas: the disassembly and sorting area, the storage area and the receiving/shipping area. A more detailed explanation of these areas is provided in the section describing the disassembly and sorting operations.

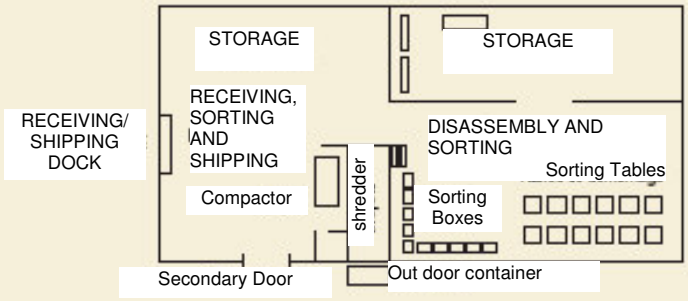


Figure 6: Typical floor plan of a CFER disassembly and sorting centre

WORK ASSIGNMENTS

To carry out the disassembly and sorting operations as effectively as possible, the CFERs created three different work assignments. The Receiving and Warehousing Clerk receives the used equipment and places it in the appropriate storage areas. The Disassembly Technician disassembles the various types of equipment received. The Parts Clerk sorts and processes the disassembled parts. The following lists provide more details on the tasks performed by each of these three types of workers.

Receiving and Warehousing Clerk

- Receives the goods
- Unloads the goods
- Unpacks the goods
- Sorts and stores the goods
- Places the goods in the appropriate storage areas
- Arranges the pallets in the storage areas
- Transports goods inside the centre
- Operates the forklift and the pallet trucks
- Secures the used IT equipment onto the pallets
- Transports boxes of equipment to the receiving/shipping dock
- Loads the truck

Parts Clerk

- Gathers the parts
- Sorts and categorizes the parts
- Packs and weighs the various parts
- Identifies and enters the weights of the boxes in the database
- Bales the empty boxes
- Informs the disassembly technicians of any errors in categorizing the parts
- Maintains his or her work area

The CFERs' experience has shown that with a team of 10 disassembly technicians, one receiving and warehousing clerk, one parts clerk and one supervisor, a centre can disassemble and sort an average of 80 desktop CPUs per hour.

Disassembly Technician

- Prepares the work area
- Finds out what used equipment has to be disassembled
- Brings this equipment to the work table
- Selects the appropriate tools
- Disassembles this equipment, using the appropriate tools
- Removes all of the internal components from the equipment
- Recycles the electrical and data cables from the used equipment
- Cuts the cable connectors
- Determines which components are to be recycled or reused
- Classifies the components to be recycled or reused
- Maintains his or her work area

Manuals may be written and given to these workers to help them understand their assigned tasks and carry them out effectively. These manuals should include descriptions of these tasks and the tools used to perform them, helpful hints and "tricks of the trade" for performing them, and so on. It is also essential to provide new employees with training and to coach them during the first few weeks that they are on the job. Some special tasks may also require task-specific training.

Supervisor

The supervisor's job is to oversee the work of the team and to plan and monitor production, shipping and receiving. A good supervisor must be able to assess employees' performance, ensure that workplace health and safety standards are maintained, and ensure that the work done is of consistently high quality. The supervisor must therefore have strong leadership, communication and problem-solving skills. He or she must be able to monitor the employees' work and give them constant feedback to help them continuously improve their work. The supervisor must be able to identify opportunities for improvement, motivate the employees to work hard and help to create a healthy, friendly work environment.

DETAILED DESCRIPTIONS OF DISASSEMBLY AND SORTING OPERATIONS

RECEIVING, SORTING AND SHIPPING OPERATIONS

In general, the storage area is the part of the centre that requires the most space; it should be at least three times as large as the disassembly and sorting area. The storage area plays a critical role, because the recycling firms that buy the equipment disassembled and sorted by the centres tend to come pick it up in large volumes at widely spaced intervals. Hence, it is important to have enough space to store this equipment until a recycling firm comes to get it. The storage area must also be designed to have some flexibility in its capacity. Used IT equipment does not always come in at a steady pace throughout the year. If a large volume arrives all at once, you need enough room to store it until you can disassemble it later on. Thus your storage area also acts as a reserve buffer, letting you keep your disassembly and sorting operations going even when the volume of incoming material is low.

Storage area

One basic principle is that the design and layout of your storage areas should be a model of effective space management. Shelving should be the same height as the pallets of equipment to be stored, and the IT equipment should be categorized in a way that makes it easy to locate and handle. Though you should put your space to maximum use, you must also ensure that your employees can operate your materials-handling equipment safely and freely.

Sorted IT equipment shelved by category

Ideally, your storage area should have several access doors, so that you can both receive and ship equipment easily. If you have a loading/unloading dock designed for tractor-trailers, that will make it much easier to handle used IT equipment coming in or going out on such vehicles. It is also essential to have a secondary access door suitable for light trucks and other small vehicles that cannot use a loading/unloading dock.

Operationally, the incoming used equipment arrives by the various collection methods described earlier in this guide. Generally, this equipment comes either taped to pallets deposited on the receiving dock or in Gaylord cardboard boxes. As soon as this equipment arrives, one or two employees must sort it by type (CPUs, monitors, printers, etc.) and place it on new pallets. It is therefore important to provide about 80 square feet of space for this sorting operation but to locate it so as not to interfere with other materials-handling operations. Once all of the used IT equipment has been sorted, it must be placed in the storage area. Each piece of equipment from each batch should be labelled with a bar code that identifies both the municipality and the sector (residential, institutional or business) from which it came.

An optical scanner is then used to read this information from the bar codes into the database. The quantities of equipment are converted in the database into units of mass, using average masses that have been predetermined for each type of equipment. In this way, you can have some idea of the mass of equipment collected, by sector and municipality of origin. This information lets you monitor the IT equipment waste flow and compile statistics and perform analyses on the equipment collected, disassembled and sorted.

DISASSEMBLY OPERATIONS

The disassembly and sorting area must be laid out so that these operations can be performed as efficiently as possible. As Figure 6 shows, the boxes containing the equipment to be disassembled are arranged around the edge of this area, while the disassembly tables are arranged in two rows running down its centre, with their backs to an aisle 1 m wide that runs between them. As the technicians disassemble the various components (aluminum extrusions, cables, microprocessors, etc.), they sort them into compartments at the backs of their tables. Another worker, known as the picker, then moves down the centre aisle, picking up these sorted components from the backs of these compartments and placing them in sorted bins on a cart. Once the picker has made a complete pass down the entire length of the tables, he or she returns to the starting point, removes the sorted parts from the bins and places them in the appropriate boxes, which are weighed before being shipped.

Disassembly tables laid out so that a worker can pick up the components from the back and sort them

In order to carry out the various disassembly and sorting tasks, certain kinds of equipment are required, and they must be purchased before the centre can begin operations. The main kinds of equipment needed are work tables; storage shelves; small tools such as pliers, screwdrivers, scrapers and Allen wrenches; wheeled bins; an electronic scale; and a glass-separating unit. The materials-handling operations will also require various kinds of equipment, such as a forklift, a metal/plastic compactor, warehouse shelf trucks, a storage trailer and a tape dispenser for securing equipment for shipping. Table 1 provides a summary of the kinds of equipment required and their estimated cost as of 2006.

Table 1: Equipment required to operate an IT equipment disassembly and sorting centre

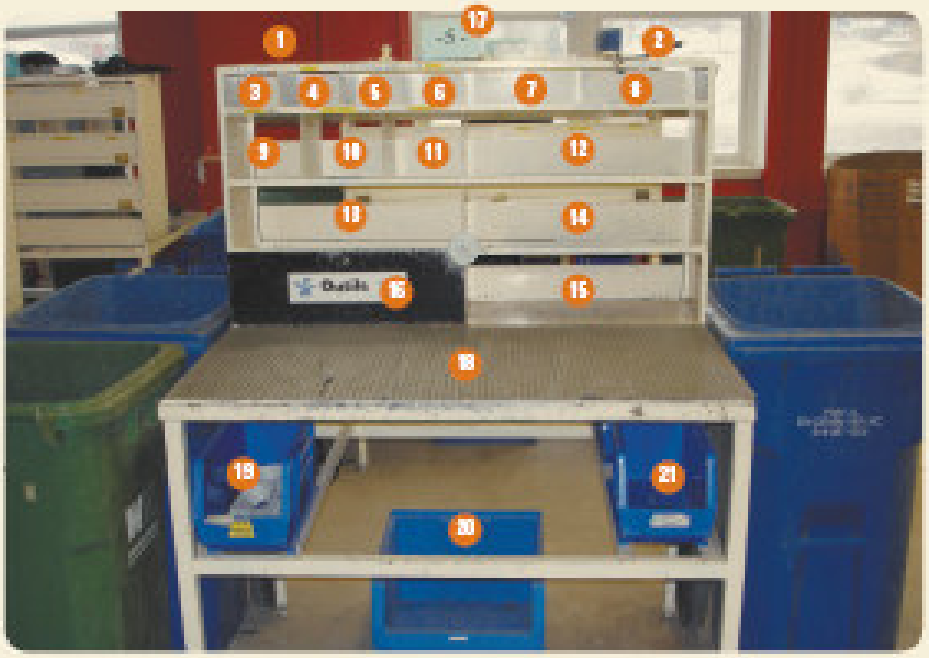
Equipment	Cost ($)
Forklift	25,000.00
Work tables	15,000.00
Glass-separating unit	75,000.00
Metal/plastic compactor	15,000.00
Containers	10,000.00
Storage trailer	2,500.00
Electronic scale	2,500.00
Pallet trucks	2,000.00
Shelving	5,000.00
Storage bins	1,500.00
Electric screwdriver	1,200.00
Wheeled bins	1,000.00
Warehouse shelf trucks	800.00
Storage boards	400.00
Software and laptops	8,000.00
Other items	1,500.00
TOTAL	166,400.00

The used equipment to be disassembled comes from the sorted inventory in the storage area. Of all the different kinds of equipment received, only CPUs and monitors are brought to the disassembly tables. (In the case of printers, the cartridges are removed and the printers are then sent directly to the metal recycler.) The receiving and warehousing clerk moves the pallets of CPUs and monitors next to the disassembly tables, so that the technicians don't have to leave their tables to go get more equipment to disassemble. The receiving and warehousing clerk thus ensures that the technicians always have a fresh supply of equipment to disassemble.

The disassembly technicians work independently of one another. In the past, the CFERs experimented with various kinds of disassembly lines, where one technician disassembled part of a unit, then passed it on to the next technician, who disassembled another part, and so on. But experience has shown that it is more efficient for each technician to completely disassemble entire units at his or her own table. That way, one technician does not have to wait for another to finish part of the job, and the faster technicians can work more quickly without being hampered by the slower ones.

The technicians' tables have been designed to let them work more efficiently and can be adjusted for optimal ergonomics. Each table has compartments into which the technicians sort the various components as they disassemble them. At the back of these compartments are panels that open onto the centre aisle, so that the parts-picker can walk down the aisle behind the tables, pick up the sorted parts and place them in sorted bins. If technicians make sorting errors, the picker must let them know. In this way, the quality of the flow of materials that are going to be shipped to the recycler can be improved, which has a direct impact on the price that the centre receives for these materials.

LAYOUT OF A DISASSEMBLY TABLE



1. Yokes from monitors
2. Metal strips
3. Ceramic-gold, ceramic, and plastic microprocessors
4. Memory modules
5. Aluminum extrusions
6. Video cards
7. Pentium II 350 + microprocessors
8. Cable connectors
9. Network cards
10. CD-ROM drives
11. Sound cards
12. Mixed aluminum
13. Aluminum
14. Daughter and expansion boards
15. Power supplies
16. Tool box
17. Table identification
18. Disassembly surface
19. IDE cables, hard disks, audio cables
20. Mother boards, video cards
21. Cables

At the disassembly table, the technician opens up each CPU, disassembles each component and sorts it into one of the compartments at the back of the table, according to the categories that the recycling firm is interested in buying. In the CFERs' experience, a good technician should be able to disassemble eight CPUs or seven monitors per hour.

To begin disassembling a CPU, the technician removes the outer metal case and exposes the internal components. If some pieces of plastic remain attached to the metal case, it is important for the technician to separate them, so that the two types of materials can be sent into the right recycling streams.

Once the case has been removed, the technician can take out the following internal components.

Disassembling a CPU

POWER SUPPLY

Several coloured wires run from the power supply to various other parts of the computer. To remove the power supply, the technician must disconnect all of these wires and remove the small number of screws that secure the power supply to the computer. The technician must cut the white connectors with scissors and cut the bundle of wires in order to recycle them separately. The housing is not disassembled; it is sold to the recycling firm intact.

HARD DRIVE

To disassemble the hard drive, the technician unscrews the six to eight small screws that hold the small aluminum cover in place, then removes it. The technician also unscrews and removes the circuit board mounted on the other side of the drive. The technician sorts this board into the same compartment as the daughter and expansion boards. The cover goes into the "Aluminum" compartment, and the rest of the hard drive goes into the "Mixed Aluminum" compartment. Before the hard drive is sent to the recycler, holes are drilled in it so that no one can ever recover any data that it might still contain.

DAUGHTER AND EXPANSION BOARDS

Daughter and expansion boards are small circuit boards that are inserted into a larger board in the computer, known as the mother board. There are generally several daughter and/or expansion boards on a mother board. They include video cards, network cards, sound cards and other types of boards. Each one has at least one edge connector with gold-coloured contacts.

MOTHER BOARD

The mother board is the largest circuit board in the computer. All of the other components of the computer are connected to it. Besides the daughter and expansion boards, there are three types of parts—memory modules, microprocessors and batteries—that the technician must remove from the mother board and sort into separate compartments. The mother board then goes into a compartment set aside for mother boards.

ALUMINUM EXTRUSIONS

The main extruded-aluminum parts in a computer are the heat sinks. The most common heat sink is found on top of the microprocessor. Sometimes, this heat sink is covered by a fan, and the technician has to remove the fan before removing the heat sink.

MICROPROCESSOR

A desktop computer usually has only one microprocessor and it is plugged into the mother board. The microprocessor is a small part, typically measuring 2 inches square and ½ inch thick. The microprocessor is sometimes covered by a heat sink and a fan, both of which must be removed before the microprocessor can be removed.

CABLES

There are two kinds of cables in a computer: flat ribbon cables and the small coloured wires coming out of the power supply. All of these cables are recycled for their copper content. The technician must, however, remove all of the connectors from these cables before sorting them. The black plastic connectors are saved and sorted into the "Connectors" compartment.

Winning Conditions

- ❑ **Know how to sort the various components into the right categories (good sorting has a direct impact on the price received for the components sold).**
- ❑ **Develop fast, effective, safe methods for removing the various types of components from the computer (use appropriate tools, take care not to break the components, etc.).**

CONNECTORS

The kind of connectors most commonly recycled are the black connectors attached to the ribbon cables. There are also other kinds of connectors, attached to certain cables on monitors, printers and other pieces of equipment.

FANS

There may be a small fan over the microprocessor. When the technician is removing this fan, it is important not to cut the connectors off of its wires, because that would make the fan unusable.

BATTERIES

The batteries present on the mother board must be removed and sent to a battery recycler, because they contain cadmium or lithium.

Disassembling a monitor

The process for disassembling a monitor begins the same as for disassembling a CPU: the technician removes the outer case (which is plastic, in this instance) to expose the internal components. The cases are compacted into bales and stored until they can be shipped to the plastics recycler. Once the case is off, the technician must cut all of the wires inside in order to remove the components (monitor board, metal components, monitor wire, etc.).

Removing the yoke

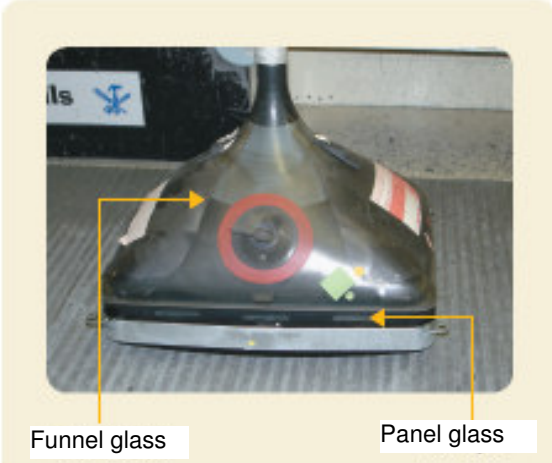
To remove the yoke, the technician first undoes a screw that secures it to the end of the cathode-ray tube. The technician then removes the yoke, which is sent to the recycler, who recovers the copper that it contains.

After removing the yoke, the technician removes the rest of the components, until all that is left is the cathode-ray tube.

Once the other components that have resale value have been removed, each tube is processed in a unit specially designed to meet the strictest occupational health and safety requirements.

The reason for such strict precautions is that cathode-ray tubes contain lead and therefore require special processing. The glass on the front of the tube, known as the panel glass, contains lead integrated into the glass matrix. This lead does not pose any problems for the environment, because it is trapped inert in the glass matrix. But the other part of the tube—the funnel glass—contains soluble lead oxide. This compound can leach out of the glass and contaminate the environment. In order to recycle cathode-ray tubes properly, it is therefore essential to separate the funnel glass from the panel glass.

To do this, the operator of the glass-separation unit first uses a suction-cup device to place the tube inside the cutting area. The operator then uses a laser beam to determine the height of the cut, and the cutting element separates the two sections inside a closed capsule that makes the operation safe and effective.



Cathode-ray tube

A two-position conveyor belt is then used to carry the funnel glass out of the building and place it directly in a storage container, in a section set aside for funnel glass only. The same conveyor is used to transport the inert panel glass into another dedicated section of this same container.

Glass-separating unit

STORING AND SHIPPING

The various components to be sent to the recycler are weighed, and their weights are recorded in a database. In order to identify the contents of each box, the weight of each category of components is then written on the outside. The metal cases from the CPUs and the plastic cases from the monitors are compressed in a compactor to reduce the volume of material before it is shipped (one pallet of compacted material corresponds to five Gaylord boxes). Once all of the processed materials have been boxed, they are returned to the shipping area to await pick-up by the recycler.

Receiving and shipping clerk at work

PROTECTING PREVIOUS OWNERS' DATA

Because the computers received at a disassembly and sorting centre may still contain confidential information, it is important to render this information unusable by third parties before shipping any of this equipment to a recycler. For this reason, holes must be drilled in all hard drives that will be going out for recycling, so that none of the information that they might contain can be retrieved. If the equipment is destined to be reused, then it is important to put a system in place to track this equipment inside the centre, as well as when it leaves it. Any hardware that may contain data must be erased with special software.

MAINTAINING A DATABASE

A database is an indispensable tool for managing an IT equipment disassembly and sorting centre effectively. A database lets you maintain production statistics, manage your inventory better, determine the characteristics of your incoming stream of used equipment and develop profiles of your various clients. A database is also indispensable for properly tracking the equipment to be recycled, for maintaining quality control and for being able to give destruction guarantees to clients who require them.

For example, the Réseau québécois des CFER has developed a database in order to identify pieces of IT equipment according to their origin and thereby analyze the performance of the various collection methods. The implementation of a bar-coding system simplifies the task of identifying and tracking the equipment collected. The database thus enables the CFER centres to compile collection results according to various user-specified criteria. For example, the database lets users estimate the quantities of equipment collected from a specified sector over a specified period in a specified municipality. By comparing the results thus obtained, users can also compare how well certain collection methods perform in a given sector or a given community. Similarly, the database can also be used to determine what impact a promotional campaign aimed at a given sector has had on that sector's participation in the centre's IT equipment recycling program.

It may be worthwhile to ask the designer of your database to implement it in such a way that you will be able to make simple modifications without the help of a programmer. In this way, you can adjust the structure of your database to meet the evolving needs of your disassembly and sorting centre.

The Market for Recyclable IT Equipment Components

The resale market for materials recovered from used IT equipment is divided into three segments: metals, plastics and glass. Disassembly and sorting centres can sell their recovered metal components to recyclers and scrap merchants, who resell them to metal smelters who process them into separate products (copper, aluminum, etc.) that they sell to industry. The market for recovered plastic components is just starting to develop. So far, these components are being accepted by recyclers but have very limited commercial value. The situation for plastics is changing in Quebec, however, because ever since the Réseau québécois des CFER implemented their pilot project, a recycler has been paying to collect the plastic components from the equipment disassembled and sorted by these centres, thus defraying part of their costs while keeping these components out of the landfill. This is an encouraging development, because in recent years, computer manufacturers have been using more and more plastics in their products.

This section describes the categories of materials that IT equipment disassembly and sorting centres generate and sell to recyclers in Quebec. These categories have been based on the prices that can be obtained for each type of recycled component, and they are fairly similar from one disassembly and sorting centre to another.

To date, the four main categories of disassembled and sorted IT equipment components generated by these centres have been as follows:

- Ferrous metals
- Non-ferrous metals
- Plastics
- Glass

FERROUS AND NON-FERROUS METALS

The centres separate ferrous metals such as steel from the other categories of components and store them in outdoor containers, from which they are picked up by local recyclers.

The metal-containing components in which recyclers are interested are sorted into the sub-categories shown in Table 2.

Table 2: Sub-categories of disassembled components

Materials	
Stainless steel	Pentium microprocessors
Daughter and expansion boards	Power supplies
Mixed aluminum	286, 386, & 486 microprocessors
Mother boards	Regular wire
Hard drives and diskette drives	Plastic microprocessors
Connectors	Miscellaneous boards
Aluminum extrusions	Transformers
#1 copper wire	Mother boards
Metal CD ROM drives	Copper yokes

Table 11: Sub-categories into which disassembled components are sorted


stainless steel


monitor boards


connectors


aluminum


miscellaneous boards


copper


mixed aluminum


mother boards


monitor wires


aluminum extrusions


expansion boards


microprocessors (plastic, gold, and ceramic)


power supplies


cables

These components are weighed and sorted into their respective sub-categories in clearly identified bins. The total mass of each sub-category of component sent to the recycler can thus be determined.

FERROUS METALS

Once the components containing ferrous metals have been shipped to the recycler, the recycler takes them to a sorting and conditioning centre. There a variety of equipment, including powerful magnets, shredders and analytical instruments, is used to sort the metals and remove the impurities. The ferrous metals in some components may be plated with other metals or contain various alloys, so it is important for the recycler to sort them properly before shipping them to smelters.

Steel smelters melt down ferrous metal scrap in oxygen converters, electric-arc furnaces and, to a lesser extent, blast furnaces. Oxygen converters can accept a maximum of 30% recycled metals in their feed, whereas electric-arc furnaces can accept up to 100%.

NON-FERROUS METALS

Non-ferrous scrap metals such as copper and aluminum are picked up by the recycler, who takes them to the various smelters that have the ability to process them. The methods that these smelters use to process these metals are similar to those just described for ferrous metals.

The CFERs ship their circuit boards and certain metals mixed with plastics and other materials to the Noranda Horne smelter in Rouyn-Noranda, Quebec. There they are shredded into pieces measuring less than 4 inches, and then mixed with the concentrate in the smelter's fusion reactor.

The carbon content of the plastic materials contributes to the copper reduction reaction and provides additional heat to the heat bath. All of the metals are smelted; most of them combine with the copper and are cast into copper anodes. Other metals, such as beryllium, are left in the slag. Once the copper is extracted from the slag, it is inert and can be sent to the slag heap.

The combustion of the plastics takes place at very high temperatures, so the process emits practically no dioxins or furans. The concentrations of these pollutants are monitored and scarcely reach the detectable threshold.

The copper anodes produced by the smelter are then shipped to the CCR Refinery in Montreal, where an electrolytic process is used to remove the impurities. Thus, at the same time as the copper is purified, metals such as gold, silver, selenium, tellurium, lead and palladium are recovered.

PLASTICS

The recycling of plastics is still in its infancy, but the growing interest in this non-renewable material is accelerating the development of this market. The CFERs' experience shows that plastics can now be sold to Canadian recyclers. (These recyclers require the plastic to be compacted in bales, so if your organization wants to recycle the plastics from used IT equipment, it will have to buy a compactor.) The recyclers then sell the plastic into international markets as a secondary raw material.

There are other possible outlets, such as the United States, where certain companies, such as MBA Polymers, specialize in sorting and recycling plastic resins. Identifying and separating the various types of resins is in fact the major problem in recycling plastics. The ideal would be to be able to separate each type of resin so that the plastic could be resold as a secondary raw material with no impurities. Also, the additives in plastics make them even harder to separate, because the additives may be incompatible with the fabrication of a new product.

12 H.-Y. Kang, J.M. Schoenung. *Resources, Conservation and Recycling* 45 (2005) 368-400.

There are currently three possible approaches to reusing plastics: chemical, mechanical and thermal.[12] The chemical approach consists in using plastics in smelting processes, such as the copper reduction process in the Noranda reactor. The mechanical approach involves separating the plastics with mechanical systems, which may include flotation ponds, triboelectric separators, analytical instruments and other technologies. The separated plastics can then be granulated for purposes of resale.

Figure 7: Granulation of recycled plastics

Lastly, the thermal approach involves using the plastics as an energy source. Plastics have a very high heating value and can serve as fuel for blast furnaces such as those used in the cement industry. It should be noted, however, that if plastics are not burned under the right conditions, they can release toxic substances into the atmosphere.

Because plastics are derived from petroleum, fluctuations in the value of petroleum products can strongly affect the profitability of plastics-recycling operations.

GLASS

There are two possible methods for recycling the glass from computer monitors: glass-to-glass recycling and glass-to-lead recycling. In glass-to-glass recycling, companies that manufacture cathode-ray tubes reuse the glass from old tubes to manufacture new ones. For this purpose, recyclers such as Envirocycle Inc. in the United States require the panel glass to be separated from the funnel glass, so that the glass manufacturer can carefully control the amounts of lead in the glass produced.

The other possible method is glass-to-lead recycling. In this method, the glass is sent to lead smelters, which use it as part of the feed for their process and recover the lead that the glass contains. At present, there are some Canadian smelters that do glass-to-lead recycling.

The CFERs have designed a unit that separates the funnel glass in the cathode-ray tubes, which contains leachable lead, from the panel glass, which contains lead in inert form in its matrix. The funnel glass is stored in a bin provided for this purpose so that it can be shipped to a lead smelter once a recycling agreement has been reached. Methods of reusing the inert panel glass are currently under study.

Workplace Health and Safety

If used personal computers are landfilled or incinerated, the toxic substances that they contain can pose hazards for human health and the environment. But even when computers are reused or recycled, some of the processes involved can pose problems—for example, melting solder to remove electronic components, or recovering metals by means of certain treatments, or shredding, burning, or melting plastics. All of the resulting risks of exposure can be reduced through appropriate work practices, proper combustion controls and the use of devices to control atmospheric emissions. When it comes to workplace health and safety, the most important thing is to know the potential risks of every operation and to take steps to reduce and control them.

HEALTH AND SAFETY PRECAUTIONS FOR DISASSEMBLING IT EQUIPMENT[13]

Workplaces whose main activity consists in dismantling used IT equipment to salvage reusable parts and/or raw materials can range in size from very small centres to fairly large facilities. Their disassembly operations can range from highly manual to highly automated. The level of danger for employees and for the environment at these workplaces also varies greatly, depending on the particular characteristics of each site. For instance, some manual disassembly centres pose few risks for their employees or the environment, whereas others that melt lead solder, or break cathode-ray tubes, or use shredding machines give rise to a wider range of potentially serious hazards.

When IT equipment is disassembled manually, using only hand tools (with no heating or shredding, for example), the risk for employees and the environment is fairly low. But whatever the type of facility, an effective system must be put in place to identify and manage the hazardous components that are removed from the used computers during disassembly. The employer must make sure that the employees have been properly trained in handling materials and equipment, as well as in matters regarding human exposure, emissions control, and safety and emergency procedures.

Regular inspections must be conducted by the competent authorities to ensure compliance with health, safety and environmental standards. The facility's managers must also conduct their own regular audits and/or inspections to ensure their compliance with environmental protection requirements.

Another important part of workplace health and safety in an IT equipment disassembly and sorting centre is to observe the appropriate precautions when handling and disassembling certain specific types of components. The following paragraphs give a non-exhaustive description of the precautions to be followed in disassembling some of these components.

PRINTED CIRCUIT BOARDS AND THEIR COMPONENTS

In a used computer, the printed circuit boards are especially valuable, because they may contain marketable chips that can be sold for reuse, as well as valuable metals that can be recovered in a smelter. If components are recovered through destructive methods such as shredding, cutting, or heating, they can release dust and fumes that are harmful to workers' health. Hence it is advisable to use non-destructive, manual methods whenever possible. If other methods have to be used to extract the desired components, then it is strongly recommended that this work be done under fume hoods.

13 OECD. February 2003. ENV/EPOC/WGWPR(2001)3/FINAL. Technical Guidance for the Environmentally Sound Management of Specific Waste Streams: Used and Scrap Personal Computers.

COIN CELL BATTERIES

The mother board on a personal computer contains a small battery that provides electrical power to maintain certain settings such as the date and the time. Lithium cells are by far the most common type of battery used for this purpose. They are about the size of a small coin and are also called coin cells. The coin cell should be removed from the mother board before it is shredded. Once coin cells have been removed, they must not be stored in large quantities without being physically separated from one another to prevent uncontrolled electrical discharges.

BATTERIES FROM LAPTOP AND NOTEBOOK COMPUTERS

Batteries used in portable (notebook/laptop) computers include rechargeable nickel cadmium (Ni-Cd), nickel metal hydride (NiMeH) and lithium ion batteries. Lead acid batteries are also sometimes used. All of these batteries should be removed by hand during the disassembling process, then sorted by type. They should then all be managed so as to avoid inadvertent external short circuits and current flows. Large inventories of batteries should be avoided and any batteries that cannot be reused should be sent to metal-reclamation facilities. If lithium ion batteries are opened or broken, workers should handle them cautiously, because lithium hydroxide is somewhat corrosive.

PLASTIC COMPONENTS

When hard plastic components containing brominated flame retardants are shredded, workers can be exposed to dust containing these chemicals. Hence workers in shredding areas should be protected through adaptations in shredder design, air flow controls, personal protective devices, or a combination of these measures.

CATHODE-RAY TUBES

In a personal computer system, it is the CRT that contains by far the most substances of concern. An older polychrome CRT can contain some 2 to 3 kg of lead, while a new one typically contains no more than 1 kg. The lead is encapsulated in the glass and cannot be released unless the glass is broken. However, the glass must be broken into relatively small pieces before significant levels of lead would be available for release into the environment.

Workers in charge of the mechanical separation of the glass must be protected against inhalation of the dust released when the tube is broken, because this dust may contain lead or barium oxide. The CRT glass is cleaned and the phosphor coatings are removed. The phosphor coatings on CRT glass can present an inhalation hazard if handled in a dry state. Wet processes are often used to remove the phosphors.

HARD DRIVES

When holes have to be drilled in hard drives to render them unusable, it is recommended that a vacuum be used to capture the fumes released by the drilling, because these fumes may contain metals that are harmful to human health.

[14] TREMBLAY, Johanne. 2003. Rapport d'étude environnementale. Occupational health and safety report prepared for the Bellechasse CFER.

As part of the CFERs' recycling project, a workplace health and safety study was conducted at the Bellechasse CFER[14] to verify whether the various aspects of the disassembly and sorting operations might have an impact on the health of the students and instructors who worked there. While showing that this work environment was entirely safe, this study also provided a better understanding of the risks associated with disassembling and sorting used IT equipment and thus enabled these centres to implement certain practices that improved working conditions.

Among all the operations examined in this study, the one that received the most attention was the one in which the glass from the monitors is crushed. Monitors contain a certain amount of lead, so it is essential to ensure that they are processed under conditions that do not pose any health risks for the people in the building.

In the CFERs, two criteria were used to determine which contaminants to look for: their toxicity and the likelihood of finding them, given the composition of the various components concerned. The contaminants identified as most likely to harm the health of the people working at these centres were as follows:

- beryllium
- lead
- cadmium
- nickel
- chromium
- copper
- iron

FINDINGS OF THE STUDY

The manual disassembly operations generate practically no contaminants that workers might absorb by breathing.

The risk of workers' absorbing contaminants comes instead from indirect contamination (e.g., workers could ingest contaminants on their hands if they do not wash them properly before eating).

Though these risks of contamination are low, here are a few recommendations for controlling them.

- Store protective equipment where it is safe from contaminants.
- Pay particular attention to operations that could allow contaminants to migrate.
- Place the monitor-crushing operation in a confined location under negative pressure.
- Vacuum the premises to avoid raising dust.
- Comply with the Workplace Hazardous Materials Information System (WHMIS) with respect to the various materials used:
    - Material safety data sheets
    - Product labelling
    - Employee training
- Wear disposable outer work wear, or clean reusable outer work wear regularly by washing it separately.
- Provide sinks, soap and paper towels right in the work areas, in sufficient number for the number of occupants.
- Ensure that the employees have taken workplace health and safety training.
- Inform the personnel and the students (or employees) of the personal hygiene precautions to be observed to avoid absorbing contaminants indirectly.
- Do not eat, drink, or smoke in the workplace.
- Wash your hands before eating snacks or meals.
- Do not bite your fingernails and clean them frequently with a nail brush.

Special attention should also be paid to work tasks that might cause musculoskeletal injuries. Workstations can be designed ergonomically to help prevent such injuries. Tasks that are performed frequently should be designed so as not to require any unstable movements on the part of employees, nor any repetitive movements that could lead to chronic pain or other such conditions. The wearing of protective equipment such as safety goggles and safety boots must be mandatory.

For more information on workplace health and safety issues in IT equipment waste processing facilities, see the Environment Canada report entitled *Screening Level Human Health and Ecological Risk Assessment for Generic E-Waste Processing Facility* and the OECD document entitled *Technical Guidance for the Environmentally Sound Management of Specific Waste Streams: Used and Scrap Personal Computers*. Also, for any new facility, it is recommended that an assessment be done by an industrial hygiene professional.

Protecting workers' health and safety represents the bare minimum requirement that disassembly and sorting centres must satisfy with regard to working conditions. But the overall success of such centres depends on many other aspects of working conditions as well, such as motivation, pay levels, relations among employees, supervision, and so on. Hence it is important to make sure your centre has a team of competent supervisors.

Disassembly and sorting centres are a kind of organization that is very likely to have a high rate of employee turnover. But because employees become efficient and productive only as they acquire more experience over time, it is very much in these centres' interest to find incentives that will help them retain their workers for a long time.

Consequently, in addition to providing a safe and healthy work environment, centre managers should look for innovative ways to motivate their staff and make their work more pleasant. Here are a few examples of ways to do this.

FOSTERING PRODUCTIVITY

If your particular employees respond well to competitive incentives, one good way to stimulate productivity can be to run a friendly contest among your various work teams to see which one can do the best work. The winning team receives a bonus. This approach can be used to foster team spirit, or to develop good work habits, or to achieve any other kind of improvements that you might want to target.

PROVIDING VARIETY

Having to perform the same task all the time can be very demoralizing for your workers. Putting a task-rotation system in place is a good way to keep them interested in their jobs and to help them acquire new skills. In fact, a task-rotation system represents a major asset for your organization, because it lets you adapt easily to all kinds of unforeseen circumstances. When employees leave, their jobs can be quickly filled internally by employees who already have the required skills and experience. Moreover, by enabling your employees to develop new skills, task rotation also helps them to understand the connections among your various operations and to come up with innovative ideas and solutions for improving them.

MAKING THE WORKPLACE STIMULATING

Two ways that you can make your organization stand out from other employers paying comparable wages are to create a warm, friendly work environment and to offer attractive conditions not common in other workplaces. For example, you can emphasize group activities that foster team spirit among your employees, enhance their sense of belonging, stimulate their creativity, and encourage openness and involvement in the organization. You can also design work and rest areas to meet workers' needs and requests. For example, placing a pool table or a computer in the employee lounge might be one way to make your workers feel good about their workplace. Letting them design this room and decide how it should be equipped is another way to show that you as their employer will listen to their concerns. Once again, a willingness to listen and respond to employees' concerns is a major asset for the smooth operation of any organization.

Having a formal labour agreement can provide employees with the kind of security that they want and demonstrate the employer's openness and concern for their well-being.

To sum up, there many ways to enhance working conditions in an IT equipment disassembly and sorting centre so as to contribute to the overall growth and success of the operation.

Economic Analysis

Before your organization decides to start up an IT equipment disassembly and sorting centre, it is essential to develop a business plan in order to verify whether certain conditions for the success of such an operation will be present. The conditions to verify include the sources of supply of used IT equipment; the costs of collecting, transporting, disassembling, sorting and processing it; the revenues generated by the sales of the equipment and components you recover; and the advertising and promotion that your program will require. This section provides an overview of the costs and revenues that you should analyze before deciding whether to open an IT equipment disassembly and sorting centre.

COSTS OF OPERATING AN IT EQUIPMENT DISASSEMBLY AND SORTING CENTRE

This section discusses the various costs involved in operating an IT equipment disassembly and sorting centre. The figure below shows the estimated percentage breakdown of these costs.

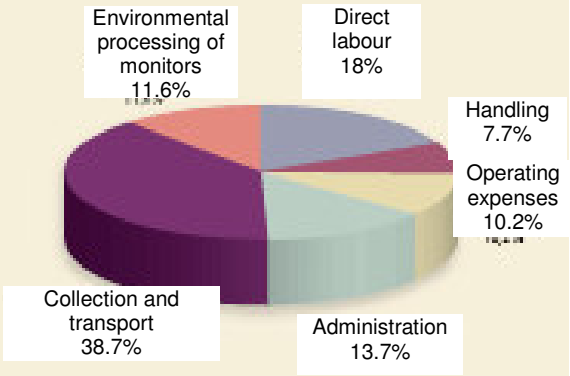


Figure 8: Breakdown of costs for collecting, disassembling, and sorting used IT equipment[15]

- Handling costs = Receiving, handling, cost of materials-handling equipment
- Operating expenses = Depreciation, maintenance, building, fixed costs, etc.
- Collection and transport costs = Collecting and transporting used IT equipment
- Costs for environmental processing of monitors = Processing the glass from the cathode-ray tubes
- Administration costs = Managers, supervisors, bookkeeping and accounting, etc.

ADMINISTRATION COSTS

In general, you can assume that administration costs will equal about 15% of your centre's gross sales. Examples of the administration costs that you must estimate include rent, fixed expenses, maintenance, telecommunications, advertising and promotion, office supplies and professional fees. These costs include a portion of the salaries for the centre managers and supervisors.

USED IT EQUIPMENT COLLECTION COSTS

Your centre's costs for collecting used IT equipment will depend on the agreements that it reaches with the various sectors that can supply such equipment. Estimating collection costs can be a very complex task, because the details of how such collection is done can vary so much from one geographic area to another. In fact, collection costs are affected by many different variables; examples include the collection method (door-to-door pickup, indoor drop-off, outdoor drop-off, drop-off at retail outlets, etc.), the distances over which equipment has to be transported to the centre, the price of gasoline and the volume of equipment to be collected. Also, the various agreements concluded between the centre, the municipality and the transport companies can involve various collection costs. In some cases, the centre picks up the equipment and charges a fee for this service; in other cases, the client assumes all responsibility for getting the equipment to the centre. Thus the estimated collection costs for any prospective centre will depend on the specific collection arrangements for that particular project.

15 Cost analysis conducted as part of the *CFER-3RV Ordinateurs* pilot project.

DIRECT LABOUR COSTS

Direct labour costs for a centre include the wages of the clerks and technicians, which we have estimated at $10 per hour and $15 per hour for the purposes of our economic analysis. For example, according to the average production pace observed at the CFERs, a centre can process about eight computer CPUs per worker per hour. Some faster students may dismantle 10 CPUs per hour, while others may manage only four. Part of the difference obviously depends on the skills of the individuals concerned, but part also depends on the models of computers being disassembled, some of which take much longer to disassemble than others. However, a team of 10 disassembly technicians and one supervisor should easily be able to disassemble 50 CPUs every 60 minutes.

COSTS FOR ENVIRONMENTALLY SOUND PROCESSING OF MONITORS

In general, IT equipment disassembly and sorting operations generate net revenues except when it comes to processing monitors.

In this particular case, the disassembly and sorting costs are estimated from a knowledge of what it costs to process cathode-ray tubes in an environmentally sound fashion. These costs include the costs of collecting, transporting and processing the glass; operating the unit that separates the panel glass from the funnel glass; and purchasing a special container for storing these two types of glass separately. Indeed, the purpose of segregating the two streams of glass is to reduce the mass to be processed and thus reduce the processing costs.

OPERATING EXPENSES

Operating expenses include depreciation on equipment, maintenance costs, rent for the premises in which the centre is housed, heating and electricity expenses, and so on.

START-UP COSTS

The costs of the activities involved in starting up an IT equipment disassembly and sorting centre are additional to the costs of operating it once it is up and running. These start-up activities that involve additional costs may include developing the business plan, fitting out the premises in which the centre will be housed, moving into these premises, etc.

The table below is a repeat of Table 1 from earlier in this guide. This table lists the estimated costs, as of 2006, of the various pieces of equipment needed to start up a used IT equipment disassembly and sorting centre.

Table 1: Equipment needed to start up a used IT equipment disassembly and sorting centre

Equipment	Cost ($)
Forklift	25,000.00
Work tables	15,000.00
Glass-separating unit	75,000.00
Metal/plastic compactor	15,000.00
Containers	10,000.00
Storage trailer	2,500.00
Electronic scale	2,500.00
Pallet trucks	2,000.00
Shelving	5,000.00
Storage bins	1,500.00
Electric screwdriver	1,200.00
Wheeled bins	1,000.00
Warehouse shelf trucks	800.00
Storage boards	400.00
Software and laptops	8,000.00
Other items	1,500.00
TOTAL	166,400.00

Note that if your organization already owns some of this equipment, your costs for starting up a disassembly and sorting centre may be lower.

As in any other kind of recycling operation, an IT equipment disassembly and sorting centre's access to the market and the prices that it gets for its products will depend on the quality and quantity of the products that it has to offer. Hence if you open such a centre, you should not hesitate to sort the disassembled components into a large number of carefully defined subcategories. You will receive the best prices for components such as cables, printed circuit boards, power supplies, semi-precious metals and base metals. You will receive less for plastics, because the value of mixed plastic resins is lower. As far as the glass from computer monitors is concerned, as of this writing, you will still have pay to get it processed.

The table to the right shows the market prices (as of 2006) for the various parts and materials recovered at IT equipment disassembly and sorting centres. The prices shown here are those that a salvage dealer will pay for minimum volumes, including the transportation costs for recovering the equipment. It should be noted that the required volumes of material necessitate adequate storage areas and appropriate packing, handling and loading equipment. However, in some cases salvage dealers will come make a pick-up at your centre, if they feel that the value of the materials that you are offering is sufficient.

Table 3: Selling prices of disassembled components (April 2006)

Material	Price/pound ($)
Stainless steel	0.40
Daughter and expansion boards	1.55
Mixed aluminum	0.60
Mother boards	1.25
Aluminum + some non-metallic material	0.18
Connectors	0.70
Aluminum extrusions	0.70
#1 copper wire	1.30
Metal CD ROM drives	0.08
Ceramic microprocessors	13.00
Power supplies	0.12
Ceramic-gold microprocessors	33.00
Regular wire	0.40
Plastic microprocessors	5.00
Miscellaneous boards	0.12
Transformers	0.25
Monitor boards	0.10
Copper yokes (from monitors)	0.25

Revenues from the recycling of used computers depend greatly on the materials of which they are composed and the fluctuating market prices for these materials. Sales of portable computers are currently growing, which means that the composition of the stream of recyclable IT equipment waste will change in coming years. This trend will have a definite effect on the costs of disassembling computers and on the revenues derived from selling recycled components. The following tables show the revenues typically generated from disassembling and sorting computer monitors and CPUs.

Table 4: Average revenues per monitor (April 2006)

Component	Price/pound ($)	Price/unit ($)
Monitor boards	0.10	0.28
Monitor wire	1.30	0.36
Yokes	0.25	0.40
Plastic	0.05	0.25
Cathode-ray tubes	---	
Total per monitor 14" or 15" (25.4 lbs)		1.29
17" (36.6 lbs)		1.81

Table 5: Average revenues per CPU (April 2006)

Component	Price/pound ($)	Price/unit ($)
Mother boards	1.25	1.38
Daughter/expansion boards	1.55	1.09
Ceramic microprocessors	13.00	0.78
Ceramic-gold microprocessors	33.00	1.98
Plastic microprocessors	5.00	0.20
Power supplies	0.12	0.38
Aluminum extrusions	0.70	0.21
Mixed aluminum	0.18	0.33
Connectors	0.70	0.11
Cables	0.40	0.16
Iron	0.02	0.26
Total per CPU with ceramic-gold (old) microprocessor		6.15
Total per CPU with ceramic microprocessor		4.95
Total per CPU with plastic (recent) microprocessor		4.37

It is noteworthy that the changes that manufacturers have made in the composition of their computers in recent years have resulted in a 30% decrease in the revenues derived from disassembling and sorting CPUs.

With the introduction of environmentally sound processing of computer monitors, the costs of disassembling and sorting computers will exceed the revenues generated by selling the materials recovered from them. To overcome this problem, a compensation system will have to be put in place to defray the rise in processing costs. In the not-too-distant future, Canadian provinces will be instituting systems for turning in and processing used IT equipment. To prepare for this new paradigm, new IT equipment disassembly and sorting centres will have to be established in most parts of Canada.

Recommendations

CONDITIONS FOR THE SUCCESS OF A USED IT EQUIPMENT DISASSEMBLY AND SORTING CENTRE

The Réseau québécois des CFER considers the following steps to be essential for the successful establishment of a used IT equipment disassembly and sorting centre.

- Perform a market analysis and develop a business plan to verify whether the essential conditions for establishing a disassembly and sorting centre are present.
- Make arrangements to ensure that a sufficient, steady supply of used IT equipment will be available to make the centre profitable and to sustain its operations on a regular basis.
- Make sure that your centre will have enough floor space to store the equipment that it receives, to disassemble this equipment, and to prepare and ship out the disassembled components.
- Acquire the tools that will be needed for the centre's start-up and for its ongoing production operations.
- Provide a stimulating workplace so as to maximize retention of employees.
- Provide an attractive workplace that goes beyond simply meeting health and safety standards.
- Organize the work so as to encourage efficiency and productivity.
- Conclude agreements with a reliable, financially stable recycler, or a reliable resale market, so as to ensure the profitability of your operations.

If you are a Quebec-based organization that wants to start up a CFER, the Réseau québécois des CFER can supply some of your used IT equipment, help you to develop your markets, provide you with technical support for your start-up and get you better prices for your recycled materials.

Conclusion

The growing volumes of information technology equipment waste are making it essential for us to behave proactively to protect the integrity of our environment and future generations. In this regard, the recycling of IT equipment waste represents a sizeable challenge, but one that Canadians seriously intend to meet.

Agencies such as Quebec's CFERs combine experience in resource recovery and recycling with a mandate to help their students achieve social and vocational integration. This combination lets these agencies operate in sectors not usually accessible to private enterprise. It also enables them to develop expertise in these sectors by leveraging the imagination and talents of all of the teachers, trainers and students involved.

These agencies have thus begun to play an indispensable role in the recovery and recycling of used IT equipment. They have done so because of their ability to carry out these activities at a low production cost while contributing to the development of the individuals concerned. In contrast, few private firms have become involved in this field to date, because of the low profitability of disassembly and sorting operations. The mixed composition of IT equipment waste makes a manual separation process essential if maximum value is to be obtained for the disassembled components. Moreover, from an environmental standpoint, separating the material streams allows the recovered resources to be used more efficiently. The teaching/training method that the CFERs promote makes it possible to apply such an approach and to increase the percentage of end-of-process materials that are recycled and reused.

In the past, the CFERs, seeking to instil both entrepreneurial and environmental values in their students, have successfully developed recycling market niches that were subsequently taken up by the private sector. With the primary goals of educating and of promoting awareness, the CFERs were among the first to demonstrate that the paper and cardboard fibre recovery market could be developed in Quebec. A few years later, the CFERs established the residential paint recovery market, thereby demonstrating just how feasible it was to recycle a product in co-operation with the industry that manufactures it.

Ever since their inception, the CFERs have offered an outstanding example of socially responsible, environmentally innovative, financially successful enterprises. Their experience is now encouraging them to support similar initiatives by other organizations, so that one day, information and communication technology equipment waste can be successfully recycled throughout Canada.

Abbreviations

ABS	Acrylonitrile Butadiene Styrene
CCME	Canadian Council of Ministers of the Environment
CFER	Centre de Formation en Entreprise et Récupération [centre for on-the-job training and resource recovery]
CO_2	Carbon dioxide
CRT	Cathode-Ray Tube
CSST	Commission de la santé et de la sécurité au travail [Quebec occupational health and safety board]
EC	European Community
EEEW	Electrical and Electronic Equipment Waste
EPA	Environmental Protection Agency (U.S.)
ICT	Information and Communication Technologies
MÉQ	Ministère de l'Éducation du Québec [Quebec ministry of education]
MRC	Municipalité régionale de comté [regional county municipality]
OECD	Organization for Economic Cooperation and Development
OHS	Occupational Health and Safety
OPEQ	Ordinateurs pour les écoles du Québec [Quebec Computers for Schools program]
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PVC	Polyvinyl Chloride
RCMP	Royal Canadian Mounted Police
TBBPA	Tetrabromobisphenol-A

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