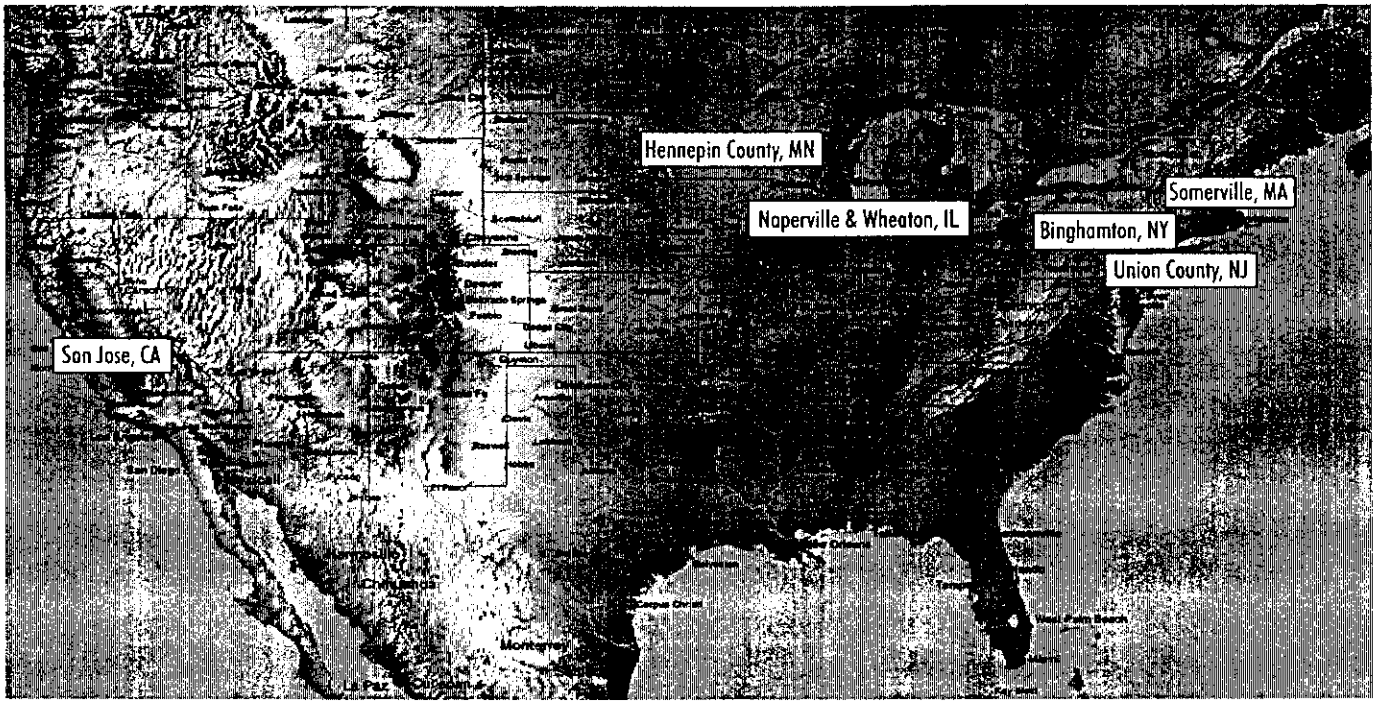
United States Environmental Protection Agency, Region 1

Common Sense Initiative
Computer and Electronic Sector

EPA-901-R-98-003
April 1999



Analysis of Five Community Consumer/Residential Collections

End-Of-Life Electronic and Electrical Equipment

ANALYSIS OF FIVE COMMUNITY CONSUMER/ RESIDENTIAL COLLECTIONS OF END-OF-LIFE ELECTRONIC AND ELECTRICAL EQUIPMENT

ACKNOWLEDGMENTS

Analysis of Five Consumer/Community Residential Collections of End-of-life Electronic and Electrical Equipment was prepared for the U.S. Environmental Protection Agency (EPA) by Ecobalance, Inc., Bethesda, MD. Ecobalance is an international environmental consulting firm that specializes in Life Cycle Management.

This report was drafted by Ecobalance, Inc. and written by Brian Glazebrook with the assistance of Remi Coulon.

This project was managed by Christine Beling, U.S. Environmental Protection Agency Region I (EPA – New England) and directed by a workgroup formed under EPA's Common Sense Initiative which included: Thomas Bartel, Unisys Corporation; Tony Hainault, Minnesota Office of Environmental Assistance; Patricia Dillon, Tufts University – The Gordon Institute; David Isaacs, Electronic Industries Alliance; Rick Reibstein, Massachusetts OTA; John Alter, U.S. EPA; Mike Winka, New Jersey Department of Environmental Protection; Gregory Cobbs, Rutgers University.

This report was peer reviewed by several members of the workgroup as well as Mark Mahoney, EPA – New England; Cheryl Lofrano-Zaske, Hennepin County Department of Public Works; Joe Carpenter, New Jersey Department of Environmental Protection; Frank Peluso, New Jersey Department of Environmental Protection.

Please note that while the above individuals contributed to and reviewed the report, they do not necessarily endorse all of its analysis or conclusions.

CONTENTS

TABLES

FIGURES

1. EXECUTIVE SUMMARY

The goal of this study was to produce a written report that aggregates and analyzes existing data from five Electronic Product Recovery and Recycling (EPR2) programs in order to:

- Identify a common format for data collection for materials and cost;
- Evaluate and aggregate existing collection and demanufacturing materials and cost data sets;
- Identify common opportunities and barriers for different collection and transportation models;
- Define the advantages and disadvantages of different collection and transportation models;
- Identify commodities that are most viable economically (positive revenue) for collection and demanufacturing;
- Identify successful motivators and strategies for marketing collection events;
- Identify key issues and motivators for various groups that have or may participate in electronic equipment collection including consumers, local government officials, small businesses, recyclers, demanufacturers, shippers, etc.;
- Identify data gaps and infrastructure needs to increase residential participation; and
- Analyze what motivates the public to participate in collection events

The collection programs that were studied consisted of two Common Sense Initiative (CSI) sponsored programs (San Jose, CA and Somerville, MA/Binghamton, NY), as well as programs in Union County, NJ; Hennepin County, MN; and Naperville/Wheaton, IL. These collection programs represented a range of different collection models – from one-day collection events to permanent collection depots – and subsequently a range of costs and revenues.

The costs and revenues for each of these collection programs were gathered in order to calculate the net costs. The following table indicates the available data. Since only two of the programs included the upfront promotional costs, which were quite high, these costs were not included in the calculation. On the revenue end, all of the programs had some revenue from scrap, but only Somerville, Union County, and San Jose received revenue from the resale of equipment.

Table 1: Available Cost and Revenue Data

Collection Agency	***Publicity***	***Operating***	***Transport***	***Demanufacturing***	***Disposal***
Binghamton/ Somerville	X		X	X	
Naperville/ Wheaton			X	X	X
Union County	X	X	X	X	X
Hennepin County		X	X	X	X
San Jose			X	X	X

The costs and volumes associated with these programs are outlined in the following table. The table shows that the cost per pound of material collected varies from less than $0.10 per pound to $0.50 per pound. The range of values reflects not only the different collection and management models, but also the different sets of data that were available for each program.

Table 2: Collection Program Summary Table

Program	***Period***	***Net Cost****	***Pounds Collected***	***Cost Per Pound***
Somerville	Fall 1996 Spring 1997	$3,299 $1,091	7,448 13,723	$0.44 $0.08
Binghamton	Fall 1996 Spring 1997	$444 $1,863	2,372 9,031	$0.19 $0.21
San Jose	Oct. 1997	$4,373	61,600	$0.29
Union Co. *Cranford* *Westfield* *Clark* *Kenilworth* *Linden* *New Providence* *Rahway* *Summit*	Oct. 96 to Mar. 98	$5,858 $13 $234 $2,003 $1,075 $15,155 $767 $8,843 $11,957	42,886 120 2,240 10,640 6,680 87,060 5,180 26,560 51,500	$0.14 $0.10 $0.10 $0.19 $0.16 $0.17 $0.15 $0.33 $0.23
Hennepin Co.	Average 1995-1997	$278,000	552,000	$0.50
Naperville	Fall 1996 Fall 1997	$8,000 $8,000	24,267 60,000	$0.33 $0.13
Wheaton	Spring 1998	$8,000	22,414	$0.36

* See Appendix C for an explanation of how this value was calculated.

While these differences in net costs among programs would seem to imply that some programs were more successful than others, the differences in how the data was collected and provided for each programs makes such a cursory assessment impossible. However, while making a comparison between these programs is not possible based on a comparison of the net costs, it was still possible to use this cost data to make some limited assessment of the economics and dynamics of these collection programs:

- The net costs of the programs were driven by the demanufacturing costs; the operational costs for many of the case studies were either not accounted for or very small. However, since a number of these collection programs were pilots, this may not be the case for programs operating over longer periods.

- In terms of pounds of material collected per resident, the curbside collection programs appeared to be more efficient than the other collection models, while the one-day collection events appeared to the least efficient. More and better collection data is necessary to confirm this.

- In contrast to the previous point, the number of items collected per dollar of collection program cost was higher for the curbside events than the other collection models. This was evidently due to the high transportation costs associated with collection. For the one-day collection events, the cost per item collected was lower than the other collection models. However, the one-day collection events that were studied did not incur any operating costs, which would likely narrow the differences between the two collection models.

- A weighted average of all of the collection programs indicates that over 75% of the equipment that was collected fell into five categories: 36% of the items were televisions, 16% consisted of audio and stereo equipment, 11% were monitors, 8% were computers and CPUs, and 6% were VCRs. The remaining equipment consisted of keyboards (5%), printers (4%), telephones (3%), peripherals (1%), microwaves (1%), and miscellaneous other equipment (9%).

- The residential EEE waste collected by these programs was generally outdated and in poor condition. Consequently, the material was expensive to manage and little valuable scrap was extracted from this equipment. Of the equipment that was collected, computers and CPUs provided most of material that generated revenue for the programs.

- Items that contained CRTs (e.g., televisions and monitors) predominated in the five collection programs. Since the cost to manage these materials is quite high, the large number of CRTs had a substantial impact on the net cost values.

- Promotion and planning of the events were essential to the effectiveness of the collection programs. This was made evident by the lack of turnout for the first week of the San Jose pilot, for which there was little prior publicity. Additionally, the first Binghamton collection event was affected by a number of factors, including a local football game that was being held at the same time.

- The public is interested in EPR2 programs. This is evident from the fact that the amount of equipment that was collected increased over time for all the programs that had more than one collection. In addition, the CSI-sponsored events (Somerville, Binghamton-One day drop off model and San Jose-retail collection model) will be continuing due to the positive public reception in their communities.

In addition to the specific conclusions from the analysis of these collection models, some general comments may be drawn on the basis of the assembled information provided by these case studies. Since these general comments are based on qualitative information, additional data and research into these areas would be beneficial.

- Most demanufacturers focus exclusively on commercial EEE waste. According to the Hennepin County program coordinators, the low quality of the residential equipment keeps many demanufacturers from getting involved in a residential collection program. A collection program for both residential and small business waste may generate more interest from demanufacturers simply because the quality of EEE waste may be better.

- Total transportation, demanufacturing, and disposal costs may overwhelm all other program costs. These costs relate to the variety of material collected, local labor market, the distance required to transport materials to a demanufacturing facility, the distance to end markets and the disposal costs of unmarketable materials.

- The loading of heavy metals in the municipal solid waste stream was a fundamental driver for the two collection programs (Union County and Hennepin County) where most of the residential solid waste stream is incinerated. Both counties believe that removal of EEE waste from the waste stream may play an important role in reducing the heavy metal burdens in the fly and bottom ash, which can result in an indirect economic benefit for the community by lowering ash disposal fees.

- The ultimate disposition of demanufactured materials should be evaluated to determine if these venues (e.g., glass to glass recycling, smelting, overseas disposition for CRTs) meet the objectives of the program.

- The advantages and barriers to different collection models are such that determining the best collection method depends on the motivations of the collection agency. The following table summarizes these factors for the different collection models. The definition of each model is provided in Section 5.3.2.4 of the report.

Table 3: Summary of Advantages and Barriers to Collection Models

Collection Model	***Barriers***	***Advantages***
Drop-off Events	• Ineffective or insufficient publicity can result in low participation • Conflicts with other events may affect participation • Resident's unfamiliarity with drop-off events can affect participation	• Low up-front costs • Short time-frame but high collection amount
Regional Approach	• Potential unequal distribution of costs among communities	• Economies of scale over single community drop-off event model • Planning of the events is shared • Larger base of residents to participate
Permanent Collection Depot	• Not effective for every community size • Need for staff may increase operational costs	• Year-round collection of equipment • Convenient for most residents • Economies of scale are possible
Curbside Collection	• Potential of theft of equipment for parts, and then abandonment • Operational costs can be higher than other models	• Easy for residents used to curbside collection • Residents without transportation can more easily participate
Point of Purchase (Retail) Collection	• Retailer's active participation is essential • Retailer may not be able to collect the data on participation • Logistical issues	• Low up-front and operational costs for the collection agency • Promotion of the program by retailers ensures high visibility
Combined/ Coordinated Collection Methods	• The economies of scale are uncertain. • Requires large population to be viable	• The gaps created by one model can be filled by another model • Year-round collection • Good if inhabitants are spread over a large area

- The experiences from other recycling programs indicate that these EEE residential waste collection programs are in their infancy and have the potential to evolve and eventually become more cost effective. As these programs expand and markets for the recovered materials grow, the net cost per pound collected can be expected to decrease. The potential economies of scale from the expansion of these programs and the creation of demanufacturing businesses will also help to reduce costs. However, based on the quality and varied nature of the collected materials, it seems likely that the costs of these programs will remain relatively high compared to other traditional solid waste disposal methods.

Overall, these case studies provided insight into the costs associated with the operation of an EEE waste collection program. Additional research into the effects of economies of scale and the development of secondary markets would be useful to get a better understanding of how the economics of these programs will change over time.

2. INTRODUCTION

2.1 PROJECT BACKGROUND / THE COMMON SENSE INITIATIVE

The Common Sense Initiative (CSI) is an innovative approach to environmental protection and pollution prevention developed by the U.S. EPA. The Common Sense Initiative addresses environmental management by industrial sector rather than environmental media (air, water, land). EPA selected six industries to serve as CSI pilots: automobile manufacturing, computers and electronics, iron and steel, metal finishing, petroleum refining, and printing. Six sector subcommittees, each consisting of representatives from industry, environmental justice organizations, labor organizations, environmental organizations, the U.S. EPA, and state and local governments address environmental issues facing these industries.

The Common Sense Initiative (CSI) Computers and Electronics Sector has been discussing, researching, and evaluating pilots focusing on consumer and community Electronic Product Recovery and Recycling (EPR2) collections of End-of-Life Electronics and Electrical (EEE) waste from the municipal solid waste stream. To date, CSI has supported several efforts to collect and analyze data on EEE waste recovery and processing, including the Somerville/Binghamton pilot and the San Jose pilot.[1] The collection pilots test various collection models: residential collection; ongoing drop-off at retail establishments; one-day drop-off programs versus curbside collection; and small business programs. The three collection pilots were independently sponsored and implemented, with CSI providing support for data collection and analysis. CSI was also instrumental in the Electronic Product Recovery and Recycling (EPR2) roundtable, which works on end-of-life issues for electronics.

2.2 PROJECT SCOPE

The goal of the project was to produce a written report that aggregates and analyzes existing data from the CSI-sponsored pilots as well as from other EEE waste collection programs in Union County, Hennepin County, and Naperville/Wheaton into a summary report. No new collection data was generated for this report, which:

- Identifies a common format for data collection for materials and cost;
- Evaluates and aggregates existing collection and demanufacturing materials, and cost data sets;
- Identifies common opportunities and barriers across different collection and transportation models;
- Defines the advantages and disadvantages of different collection and transportation models;
- Identifies commodities that are most viable economically (positive revenue) for collection and demanufacturing;
- Identifies successful motivators and strategies for marketing collection events;
- Identifies key issues and motivators for various groups that have or may participate in electronic equipment collection including consumers, local government officials, small businesses, recyclers, demanufacturers, shippers, etc.;
- Identifies data gaps and infrastructure needs to increase residential participation; and
- Analyzes what motivates the public to participate in collection events.

---

[1] A collection pilot in the San Francisco area was also sponsored by CSI, and summary information is provided in Section 8.

3. SUMMARY OF COLLECTION PROGRAMS

The collection programs included in this report represent different geographic locations, collection methods, and data sets (see the map and table below). Since some of the programs were pilots, much of the data regarding operational and other costs were not available. Therefore, the differences in the amount of data available for each program make direct comparisons between the programs difficult. The following summaries include discussions of the design of the collection program, the participation rate, estimated cost and revenue, and any important comments relative to the program's operation.

Table 4: Collection Models Used by Collection Program

Collection Agency	*Drop-off Event*	*Permanent Depot*	*Curbside*	*Point-of-Purchase (Retail)*
Binghamton/ Somerville	♦			
Naperville/ Wheaton	♦			
Union County	♦			
Cranford	♦			
Westfield	♦			
Clark		♦		
Kenilworth		♦		
Linden			♦	
Rahway			♦	
Westfield			♦	
Summit		♦	♦	
Hennepin County	♦	♦	♦	
San Jose				♦

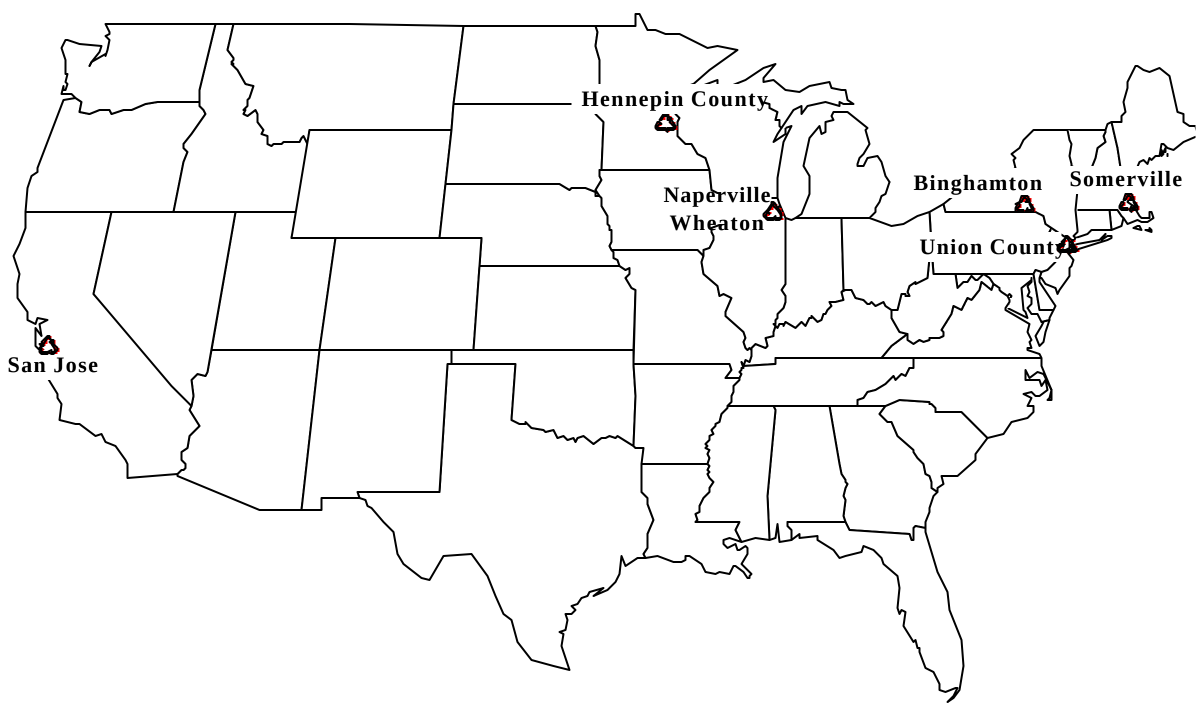


Figure 1: Location Map for Collection Programs

3.1 BINGHAMTON, NEW YORK/SOMERVILLE, MASSACHUSETTS

Collection Method:	One-day drop-off events
Number of Collections:	Two events in each city
Collection Dates:	Fall 1996, Spring 1997
Demanufacturer:	Envirocycle, Inc.

Motivation Behind Collection:

Under the Common Sense Initiative, the U.S. EPA sponsored a pilot residential EEE waste recycling and demanufacturing program in Binghamton, NY and Somerville, MA. The goals of the project were to:

- Characterize the types and volumes of EEE waste in the municipal solid waste stream;
- Assess the viability of collecting, demanufacturing, and recycling these materials; and
- Gauge the consumers' willingness to offset the cost of such a program[2]

Binghamton was initially chosen to participate in the project because of its existing relationship with the demanufacturer (Envirocycle, Inc.) and its proximity to their demanufacturing plant in Hallstead, PA. Somerville was included as the second community for the pilot study because of its demographic similarity to Binghamton, and its existing recycling program and its household hazardous waste (HHW) drop-off program.

Demographics:

Although Binghamton has historically been a blue-collar community, its population of white-collar workers is growing. It is the largest community in Broome County, which is located near the northeast corner of Pennsylvania. Somerville has a mixture of blue- and white-collar workers, although the white-collar population has been rising due to a shrinking manufacturing sector. It is located just outside of Boston. The following demographics are available for the two communities:[3]

Table 5: Binghamton/Somerville Demographics

Municipality	***Population***	***Households***	***Median Income***
Binghamton	53,000	25,000	$29,169
Somerville	72,280	30,000	$44,866

Event Promotion:

The participation rate for recycling programs in the two communities is about 48% in Binghamton and 15% in Somerville[4], which reflects the general public's awareness and interest in recycling. A number of

[2] Unless noted, all information was gathered from *Residential Collection of Household End-of-Life Electrical and Electronic Equipment: Pilot Collection Project*, Common Sense Initiative – Computer and Electronics Sector, U.S. Environmental Protection Agency, Region I, EPA-901-R-98-002, February 1998.

[3] *Census of Population and Housing, 1990*. Bureau of the Census, Washington: The Bureau, 1992.

[4] Participation rates for HHW collection programs generally range from one to three percent, and can be as high as 10 percent. *Household Hazardous Waste Mangement: A Manual for One-Day Community Collection Programs*. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency. EPA-530-R-92-026. Washington. August 1993.

methods were used to promote the specific EEE waste collection event. An informational flyer was sent to every household in both cities and also was made available to residents in retail stores and public buildings. The flyer outlined the collection program, listed the items that would be accepted by the municipality, and gave directions to the collection site. In addition, members of the local chambers of commerce who had an interest in electronic and electrical appliances (i.e., repair shops, electronics retailers) were contacted and notified of the program. The events also were promoted on the community calendar listings on local radio and TV stations, and in press releases. Finally, a press conference, attended by local government officials, was organized in both cities to promote the events. These promotional events required expenditures for the printing of the direct mailing, the labels for the mailing, and the postage. The costs of each of these expenses are listed below.

Table 6: Promotional Expenses for Binghamton and Somerville Pilots

Municipality	***Direct Mail Costs***	***Printing Costs***	***Labels***	***Postage (both locations)***
Binghamton	$1,380	$4,387	$1,242	$9,707
Somerville	$1,439	$4,359	$384	

Resident Participation:

Both communities saw an increase in participation during the second event: about a 30% increase for Somerville and a 170% increase for Binghamton in the number of cars that dropped off equipment. The following table indicates the number of households that participated in the events, and the percentage of total households that this number represents (participation rate). These numbers do not reflect the participation of the residents of Broome County, who were also allowed to participate in the Binghamton events.

Table 7: Participation Rates for Binghamton and Somerville Pilots

	No. of Households		***Participation Rate***		
Municipality	***1996***	***1997***	***1996***	***1997***	***Net Increase***
Binghamton	47	128	0.2%	0.5%	172%
Somerville	193	250	0.6%	0.8%	30%

Considering the rather high participation rate for general recycling programs in Binghamton, the participation numbers for their first event is interesting. This modest turnout is believed to be due to circumstances that were beyond the control of the organizers, notably the poor weather (snow), construction outside the drop-off facility, and the high school football championship being held that day. The attendance may have also been affected by the implementation of a user fee. All of these deterrents were not in evidence during the second collection event. Since only 10 of the 128 cars that dropped off equipment in the second event had participated in the first event, it is reasonable to assume that these elements did have some impact on participation.

Collection:

The pilot was modeled after a typical one-day collection event for household hazardous waste held on a Saturday morning/afternoon. Both communities have experience in managing a recycling program and a HHW drop-off program.

The collection took place at existing municipal facilities – in Somerville at the public works facility, and in Binghamton at the Broome County Transit Garage, so there was no property cost associated with the collection. Additionally, the volunteer workers minimized any labor costs associated with collection.

No limitations were applied to the types of EEE waste that would be accepted. One of the goals of the program was to determine the types of equipment that could be collected during a municipal collection program, and the demanufacturer agreed to accept anything that came in. This equipment consisted of the following.

Table 8: Items Collected During Binghamton and Somerville Pilots

	Computers	***Monitors***	***Keyboards***	***Printers***	***TVs***	***VCRs***	***Microwaves***	***Stereos***
Binghamton								
Fall 1996	7	8	7	2	23	4	3	30
Spring 1997	19	33	26	9	52	23	12	111
Somerville								
Fall 1996	21	17	18	12	54	27	12	134
Spring 1997	72	52	44	40	61	46	12	96

In addition, the collection events also took in a number of telephones, household electrical appliances, and air conditioners. The following table shows the total weight of equipment that was collected for each collection event.

Table 9: Pounds of Equipment Collected During Binghamton and Somerville Events

	Fall 1996	***Spring 1997***
Binghamton	2,372 lbs	9,031 lbs
Somerville	7,448 lbs	13,729 lbs

During the collection events, participants were surveyed to determine their willingness to pay for the ability to drop-off EEE waste. They were given a range of values to choose from: $1 to $5; $5 to $10; and over $10. A majority of the respondents (>80% in both communities) indicated they would pay between a $1 and $5 fee for the drop-off program. In fact, during the first Binghamton event, a $2 user fee was charged of those people dropping off equipment. The fee was abandoned during the second event, in part because the city believed that it contributed to the low turnout in the first event.

Transportation:

All transportation costs associated with a drop-off event are those for transporting EEE waste to the demanufacturer. Due to the distance between Somerville and the Envirocycle facility (312 miles), transportation costs for the Somerville pilot were more than 6 times those for the Binghamton pilot.

Table 10: Binghamton and Somerville Transportation Costs

Municipality	***Transport Costs per 53' Truckload***
Binghamton	$96

Somerville	$646

Demanufacturing:

Envirocycle, a large firm with experience in EEE waste recycling, was the contractor for the demanufacturing. They provided in-kind services for the pilot project, including free transport to and from the collection site, and free demanufacturing of the material. Even though the municipalities were not charged for the demanufacturing, Envirocycle provided data on their total costs to assist with the analysis of the project. These costs are based on a labor rate of $26.50 per hour, which include all of their overhead and wages:

Table 11: Binghamton and Somerville Demanfacturing Costs

Municipality	***Fall 1996***		***Spring 1997***	
	Hours	***Total Cost***	***Hours***	***Total Cost***
Binghamton	31.5	$835	111	$2,942
Somerville	118.3	$3,135	85	$2,253

Revenue:

The resale of electronics and electrical appliances occurred only during the second Somerville collection event, where Envirocycle collected about $962 from the sale of working equipment. All the rest of the equipment was disassembled and the valuable material sold for scrap, except for the wood which was landfilled. The revenue from scrap per event can be broken down as shown.

Table 12: Binghamton and Somerville Gross Revenues

Municipality	***Fall 1996***	***Spring 1997***
Binghamton	$487	$1,175
Somerville	$481	$845

Envirocycle's total yield from the sale of scrap from the four events came to $2,889 most of which derived from the sale of metal, plastic and CRTs. The materials that were extracted for revenue include the following.

- Metal 26%
- Scrap Plastic 13%
- CRTs 12%
- Carcass 12%
- Clean Plastic 8%
- Radiators 4%
- Motors 4%
- Wire 3%
- Copper 2%
- Aluminum 1%
- Fans 1%
- Yokes 1%
- Disc Drives 1%
- Refine Boards 1%
- Capacitors <1%

The percentages represent the weight percentage of material extracted for the total of all four collection events. Data on which materials contributed most to the net revenue is not available.

Net Cost:

The costs for the four collection events are derived from the costs of promotion and the demanufacturing costs. The net costs, taking into consideration the revenue, are as shown.

Table 13: Binghamton/Somerville Net Costs

Municipality	***Fall 1996***	***Spring 1997***
Binghamton	$444	$1,863
Somerville	$3,299	$1,091

For Binghamton, these costs translate to $0.19/pound collected for the first event and $0.21/pound collected for the second event. For Somerville, the costs equate to $0.44/pound collected for the first event and $0.08/pound collected for the second event. These values do not include the promotional costs, which would substantially increase the cost per pound collected.

Project Comments:

The participating municipalities considered both collection programs to be successful because the participation rates increased from one collection event to the next while the cost per pound collected decreased. The positive public attitude toward these collections has motivated both communities to continue the collection programs. Somerville had an additional collection event in the spring of 1998 and Binghamton is planning another event for 1999.

A number of conclusions came from these two pilot events:

- The demanufacturing rate (lbs of equipment dismantled per hour) increased between the first and second collection events. According to Envirocycle, this was largely due to increased efficiency on the part of their staff members. For the Somerville collection pilot, the increased demanufacturing rate was also influenced by a growth in the amount of computer equipment that was collected, since computer equipment is generally easier to dismantle than some of the older EEE waste that was collected.
- The timing of the event is key to guaranteeing adequate participation. The low turnout at the first Binghamton event was due in part to adverse weather conditions and a local high school football game that was going on at the same time.
- The transport distance to the demanufacturer had a noticeable impact on the net costs of the program, thus indicating that the presence of a local demanufacturer can be important.
- The implementation of a user fee during the first Binghamton event may have affected the public turnout; however, other mitigating factors make it difficult to confirm this assumption. In fact when surveyed, residents of both Binghamton and Somerville indicated their willingness to subsidize the collection program with a minimal user fee.

3.2. SAN JOSE, CALIFORNIA

Collection Method:	Point of Purchase (Retail) Drop-off
Number of Collections:	Three participating retailers
Collection Dates:	The period from October 1 to November 2, 1997
Demanufacturer:	Berman's Diversified Industries

Motivation Behind Collection:

A Common Sense Initiative sponsored data collection for a computer-equipment collection program conducted in San Jose, CA, in October of 1997. The goals of this pilot project were to:

- Determine the feasibility of a point of purchase (consumer retail store) collection scheme for EOL computer equipment;
- Identify potential barriers, regulatory and other, which might inhibit a collection/recycling program of this nature; and
- Determine the economics of collecting consumer equipment via this approach[5].

Demographics:

San Jose is located in Santa Clara County, about 56 miles south of San Francisco. The population of Santa Clara County is over 1.6 million (1995); San Jose covers 174 square miles, with an estimated (1994) population of over 873,000 residents. San Jose is described as the capital of Silicon Valley, making it a good focus community for the pilot study. The community is a mix of white-collar and blue-collar residents; the median household income is approximately $50,000.

Event Promotion:

Extensive publicity was planned for the pilot program, including: countywide mailing of a missing children/computer collection "marriage card"; billboard messages; public service announcements; press releases; and electronic equipment retail store flyers, posters and advertisements. Much of this publicity never took place because of timing and scheduling conflicts. The only publicity that actually occurred before the event was a bulletin published on the U. S. Environmental Recycling Hotline (1800 Cleanup) website, which was just coming on-line at the time. This lack of advance publicity appeared to have a significant impact on the program since no equipment was collected during the first week of the pilot.

To remedy this lack of participation, EPA held a press event on October 9 to promote the collection program; television and newspaper coverage of the event helped increase the pilot's visibility. This event was followed by distribution of flyers promoting the drop-off program with the San Jose City employees' paychecks. An email notice was also distributed to Santa Clara County employees.

---

[5] All information was gathered from *San Jose Computer Collection and Recycling Pilot: Draft*, Common Sense Initiative – Computer and Electronics Sector, US Environmental Protection Agency, Region IX, February 1998, pp. 1.

The participating stores also ran some publicity for the event. One of the stores ran a newspaper advertisement for the event; the other two stores publicized the pilot via ads stuffed in customers' bags.

Resident Participation:

Residents and small businesses dropped off equipment at the three participating stores; however, no data was collected on the participation of the two consumer groups. A one-page questionnaire was developed for the collection program to determine the demographics of the participants. However, no statistical data on participation is available since not all of the participating stores decided to use the questionnaire and not all of the participants chose to fill it out.

Resident participation seemed to be affected by the aggressiveness of the participating stores. Only one store actively promoted the pilot program, making the drop off of equipment easy for consumers. This store also collected most of the equipment during the pilot program.

Collection:

The program consisted of a 5-week drop-off program that was organized with the participation of three local electronic and computer retailers distributed throughout the city. The stores were charged with collecting the equipment, surveying the residents to determine a participation rate, and stockpiling the equipment until the demanufacturer came to collect it each week

The retailers themselves covered the operational costs. These costs included the labor for collecting the equipment from residents' cars, the construction of displays, and any storage space allocated to the EEE waste. No information on each individual store's cost for the program is available. No fees were charged by the stores to the municipality or of the participants to cover their costs.

The items collected were limited to computer-related EEE waste – e.g., monitors, keyboards, printers, and computers. The number of items collected was tallied in terms of the number of pallets collected per store. Each pallet consisted of an estimated 64 cubic feet of equipment, leading to a total of 4,220 cubic feet of equipment collected during the pilot. The following table shows the number of pallets that were collected per store, per week.

Table 14: Pallets Collected During San Jose Pilot

	Week 2	***Week 3***	***Week 4***	***Week 5***
Store 1	4	2	2	4
Store 2	1	1	1	3
Store 3	13	10	11	14
Totals	18	13	14	21

In all, 61,600 lbs of equipment was collected over the five-week program. The equipment collected consisted of the following items:

Table 15: Items Collected During San Jose Pilot

	Computers	***Monitors***	***Keyboards***	***Printers***	***Peripherals***	***Laptops***	***Misc. Parts***

Total All Stores	972	937	341	413	66	27	63

More detail on the number of items collected per store is not available.

Transportation:

The transportation distance to the manufacturer depended on the location of the store. Stores 1 and 2 were about 15 miles from the demanufacturer, whereas Store 3 was only 10 miles away. The equipment was picked up from the stores once a week over the five-week period, although Store 3 required two additional pickups per week. A total of 20 trips were made over the duration of the project.

The total cost of transport for the pilot collection project amounted to $480. Transportation was calculated to include the costs of standard loading and unloading time. The large loads and small entryways for the participating stores were determined to require excessive labor, the cost of which was estimated to have the potential to increase total transportation costs by up to 60%.

Demanufacturing:

Berman's Diversified Industries, a San Jose-based recovery/resale/recycle service provider, conducted the demanufacturing. The firm dismantled all of the computer equipment that had no resale value. Overall costs for sorting and dismantling was given as $7,500.

Monitors predominated in terms of the weight of material collected - 30,000 lbs or 49% of the total weight collected. Berman's did not itself demanufacture the monitors, but rather shipped them overseas for demanufacturing. The monitors were exported at a net cost of $0.05 per pound, which yielded a total cost of approximately $1,500 for the 30,000 lbs of monitors. This gave a total demanufacturing cost for the pilot program of around $9,000.

It is interesting to note that the cost of demanufacturing CRTs overseas is estimated to be only 1/10th of the equivalent costs in the San Jose area. Had the CRTs been demanufactured in the area, the cost would have increased tenfold, to around $15,000. This would have led to a total cost of $23,000 for the demanufacturing component of the program. It should be noted that the numbers for demanufacturing CRTs around San Jose are based on Berman's estimates of local costs, and are not necessarily equivalent to demanufacturing costs elsewhere in the United States.

Revenue:

Resale of working equipment accounted for 40% of the total revenue, most of which came from the sale of black and white monitors. These black and white monitors represented only 10% of all the monitors that were collected. No working computers were successfully sold because of the age of the equipment.

The remainder of the revenue came from the extracted scrap. The breakdown of material recovered from the collected equipment is as follows, shown as percent composition by weight and by revenue yield for the entire collection period.

Printed circuit boards and high-grade breakage (hard drives, motors and mixed metal parts) comprised the majority of the revenue from scrap, which was supplemented by the sale of mixed

Table 16: Distribution of Commodities by Weight and Value

Commodity	***Weight***	***Revenue***
CRTs	49%	-
Steel	20%	-
Scrap Plastic	13%	-
High Grade "Breakage"	10%	48%
Mixed Metals	3%	6%
Plastic	3%	-
Circuit Boards	3%	42%
Wire	1%	4%

metals and wire. Aside from CRTs, most of the material recovered from the disassembled equipment was steel and plastic; this material produced no revenue since it had little market value. The total revenue for the five-week pilot totaled $5,120.

Net Cost:

The net cost of the five-week pilot project was $4,373. This is equivalent to a cost of $0.07 per pound of material collected. The management of the CRTs had a large impact on the net cost of the program. As explained previously, the shipment of the CRTs overseas resulted in costs that were substantially lower than they would have been had the demanufacturing occurred in the San Jose area. In a scenario where the monitors are recycled locally, the net cost would be more than four times greater–$17,990. This is equivalent to a cost of $0.29 per pound of material collected. Note that the retailers' costs were not included but were donated as in-kind services.

Project Comments:

The extensive publicity that resulted from the EPA press conference appears to have affected participation since the collection went from zero pallets of equipment the first week to 18 pallets the second week. Despite the perception of some of the participants that the stores were profiting from the collection program, the program coordinators indicated that the overall attitude of the participants seemed to be positive. This perceived positive attitude has motivated one of the participating chains to continue the program at a number of its other stores.

During the pilot program, some barriers to EOL computer equipment collection were identified:

- The slow start in promotion of the event led the consultant assessing the project to conclude that "marketing efforts should be established at least six months in advance and should be monitored regularly before and throughout the collection event." This conclusion is based on the fact that the program relied on volunteer groups to promote the program, many of whom in the end did not provide the promised service.
- In California, special approvals and permits must be granted before CRT glass can be handled or shipped. Special permits are also required for CRT glass recyclers, which has the effect of limiting the number of firms that recover this material. The end result is a high cost for demanufacturing of CRTs. Considering that almost half of the equipment (by weight) consisted of computer monitors, these monitors were shipped overseas to avoid excess costs.
- Contrary to the results from the Binghamton/Somerville pilot, a survey designed for this program indicated that most participants (over 60%) would <u>not</u> pay a fee to drop off electronics.

3.3 HENNEPIN COUNTY, MINNESOTA

Collection Method:	Permanent Drop-off One-day Drop-off Events Mobile Collection Events Curbside Collection Retail Collection[6]
Number of Collections:	Permanent facilities and drop-off events (ongoing)
Collection Dates:	1997
Demanufacturer:	Hennepin County

Motivation Behind Collection:

Hennepin County, MN, began recycling EEE waste in 1992, with the goal of eliminating the metal content, specifically mercury, lead, and cadmium, from the county's municipal solid waste (MSW) stream. Most of this waste is managed as waste-to-energy or refuse-derived fuel. The county uses both front-end removal of materials and back-end facility control equipment to manage heavy metals in MSW.

The residents had an accepting attitude toward environmental programs before the EEE waste recovery program began since Hennepin County was already managing a number of other similar programs, e.g., collection and recycling of used tires and HHW.[7]

Demographics:

Hennepin County, which consists of some 45 communities, is located in the eastern portion of Minnesota. The median household income for the entire county is $35,659. The county (population: over 1 million) includes metropolitan Minneapolis, consists of around 439,000 households. One-third of the county's population resides in Minneapolis.[8]

Event Promotion:

Since Hennepin County manages a number of different recycling programs, publicity for EEE waste collection is covered by newspaper advertisements and flyers that are produced for the collection of all "problem materials" (i.e., HHW, tires, batteries, and EEE waste).[9] Some advertisements highlight the EEE waste collection component of the program. Brochures and radio advertisements are used as well.

---

6 A regional retail collection pilot that focused on the collection of CRTs was held in the summer of 1998. Data on this collection was not available at the time of publication.

7 The budget for the EOL electronics collection program in Hennepin County is 1/10th of the budget for the HHW collection program.

8 Census of Population and Housing

9 Unless noted, all information was gathered from personal communication with Cheryl Lofrano-Zaske, Principal Planning Analyst/Problem Materials Program, Hennepin County Environmental Management Division, April 13, 1998.

The county sponsors most of the publicity, although the cities may advertise to their residents as well. There is also word-of-mouth publicity for the program.

Resident Participation:

The equipment is collected with other HHW and problem materials and is not recorded separately. For this reason, no data is available as to resident participation in the EEE waste collection program. The county estimates that participation in the HHW program may be around 15%.

Collection:

The county operates two drop-off sites: one at Brooklyn Park in the north and the other in Bloomington in the south. While residents are invited to drop-off materials year-round at the permanent facilities, collection events are also held throughout the county. EEE waste is also collected through city cleanup days, and facility and curbside collection in the city of Minneapolis (initiated in November 1997). Participation in the collection program is limited to households and residents.

Hennepin County has permanent facilities that accept HHW, recyclables, brush, auto waste, white goods, and EEE waste. Fees are charged for the white goods ($10 to $30) and tires ($1), but not for EEE waste. One site also takes in MSW from county residents for a fee. The cost of all facility operations that can be allocated to the collection of EEE waste has not been determined.

For mobile events, the county covers all of the setup, organizational, and transportation costs. For city events, the county covers the labor to collect and transport the equipment.

In its promotion of the EEE waste collection program, the County indicates what types of materials will be accepted. The program targets materials with CRTs, but also is used to manage the inflow of camcorders, stereos, radios, computers, tape players, VCRs, and telephones. Rechargeable and cordless appliances that contain batteries are also accepted and disassembled by PPL (the county's contractor), and then disposed of via the battery recycling program.

The bulk of the material collected in 1997 came from the permanent facility (62%), with about 26% from the city/county collection events, and 12% from the curbside collection in Minneapolis. Since the curbside program has been going on for only a few months, and participation has been higher than expected, it is expected that the curbside collection percentage will increase in the coming year.

The following table lists the number of items and tons collected for the years 1995 to 1997. The county collects a wide range of equipment; the miscellaneous/other category encompasses equipment such as answering machines, typewriters, and dust busters. The county estimates that approximately 800 tons of material will be collected in 1998.

Table 17: Items Collected During Hennepin County Program

	Computer / CPUs	*Monitors*	*Keyboards*	*Printers*	*TVs*	*VCRs*	*Audio / Stereo*	*Telephone*	*Copiers*	*Misc. Other*	*Tons*
1997	1,331	1,734	899	554	7,376	1,184	2,813	514	4	1,686	366
1996	661	1,156	517	261	5,115	617	1,898	357	43	1,249	262
1995	67	673	254	189	4,428	407	1,932	340	81	1,388	200

Transportation:

Hennepin County generally covers the transfer of the collected equipment to the demanufacturer. The county pays PPL to staff and transport the equipment from most city events.

Demanufacturing:

The county contracts with a local train-to-work not-for-profit organization (PPL) to provide labor and space for the disassembly of the collected material. The county is responsible for management of the disassembled components from the demanufacturing process. PPL's fee accounts for the bulk of the county's demanufacturing costs for the program.

The main motivation behind the initiation of the EEE collection program was the elimination of heavy metals from the waste stream, which led to the choice of target materials – CRTs, CPUs, PWBs, batteries, mercury relays, and PCBs. Plastics and wood are managed by the county's Solid Waste Management System. All of the extracted scrap metals are recycled.

The demanufacturing process is labor intensive and the yield can be affected by the lower productivity of workers who are new to the program. Yield can also be affected by the quality of the material that is taken in since most is old and of little value (old TVs, electronics). Virtually all circuit boards collected are low-grade. Furthermore, there are costs associated with management and disposal of the heterogeneous materials stream.

The county has estimated that the cost of demanufacturing approaches about $20 per item collected. That includes any overhead, transportation, labor, and hazardous/non-hazardous material disposal associated with collection and disassembly. This cost is paid directly from the county's solid waste management fees.

Revenue:

No revenue is received from resale of working electronics and electrical equipment – any material that is in working condition is offered to residents free of charge at the collection facilities. In 1997, roughly 350 units (of the 18,100 units collected) were placed on a re-use shelf and taken by residents. The county estimates that the average age of materials is over 20 years old and thus there is little reuse opportunity.

Minimal revenue comes from the sale of the scrap material that is extracted (copper wire and other metals) – around $25,000 in 1997. For 1996, the revenue was a bit less at $20,000 while for 1995 the amount was even smaller, around $10,000. The revenue per commodity ranges from between $0.01 and $0.50 per pound. The county has found that the market for most of the commodities that are extracted is not strong enough to generate sufficient income from the material collected.

The county pays about $10 per CRT (at an average weight of 30 pounds) to dispose of them via a secondary lead smelter. Over 50% of the units collected contain a CRT. There are also costs associated with disposal of other materials including plastics, wood, and other waste (PCBs, mercury switches, and batteries). The overall program operates as a cost center.

Net Cost:

The gross cost for the EEE waste collection program in 1997 was $350,000. For the previous two years, the costs were very similar: $350,000 in 1996 and $190,000 in 1995. Based on these costs, the following table outlines the net cost and net cost per pound of equipment collected for all three years.

Table 18: Hennepin County Net Cost

Hennepin County Year	***Net Cost***	***Net Cost per Pound of Material Collected***
1997	$325,000	$0.48
1996	$320,000	$0.67
1995	$180,000	$0.48

This is estimated, since not all of the material that is collected in a year is demanufactured and/or disposed of in that same year. Over 90% of this cost is attributed to demanufacturing – labor and transportation to PPL's facilities, labor for demanufacturing, and the transportation of CRTs to the secondary smelter and disposal.

Project Comments:

According to Hennepin County, the collection program has been effective in reducing the equipment containing heavy metal that enters the municipal solid waste stream. Since the inflow of equipment has increased annually, the community attitude toward recycling seems to be positive. However, there are a couple of concerns that affect the program's operation:

- In the development of Hennepin County's program, the decision was made to collect only material from the residential sources through the collection program, targeting electronics containing a CRT. Within the state of Minnesota, CRTs have been identified as the number one remaining source of lead in MSW and there is an existing infrastructure to handle electronics, i.e., computers, generated from commercial sources. In developing the infrastructure for demanufacturing and the end markets for the recovered materials, both economic and environmental considerations are evaluated. Material is managed in accordance with the state's waste management hierarchy as listed in Minnesota Statute 115A.02: reduction and reuse, recycling, resources recovery, and landfilling. The county also verifies and reviews end sites for final management
- The design of the demanufacturing scheme means that the operation of the program is greatly influenced by disruptions in the outflow of demanufactured material. The demanufacturer has limited storage capacity for the collected materials, so a shutdown at the secondary lead smelter or any other end market for materials may lead to additional storage and handling costs.
- In 1997, 9,000 CRTs were collected. It cost the county about $10 to dispose of each CRT; almost one third of the County's budget is allocated to CRT disposal. The county has evaluated CRT disposal options including glass-to-glass recycling, primary smelting, and overseas export. They

determined that secondary lead smelting recovers most of the lead from the CRTs (estimated by the smelter at over 99%) and is the most cost-effective option for a mid-western operation at this time.

3.4 UNION COUNTY, NEW JERSEY

Collection Method:	Curbside Permanent Drop-off One-day Drop-off Events
Number of Collections:	Seven Countywide Events and ongoing city programs
Collection Dates:	October 1996 to September 1997 (ongoing)
Demanufacturer:	Electronics Processing Associates, Inc.

Motivation Behind Collection:

In May of 1995, the Union County Utilities Authority (UCUA) and the New Jersey Department of Environmental Protection (NJDEP) began planning the implementation of an EEE waste collection program. The move was intended specifically to reduce the flows of lead, cadmium, mercury, and other heavy metals entering the Union County Resource Recovery Facility (UCRRF), therefore improving the quality of its air emissions and ash residue.[10] Union County began by signing an agreement with Electronics Processing Associates, Inc. (EPA, Inc.) of Lowell, MA, to demanufacture the collected equipment. One requirement of the contract was that EPA, Inc. set up a facility in Union County.[11] In October 1996, NJDEP issued a Research Development and Demonstration approval to EPA, Inc. to operate their facility under a Universal Waste Exemption.

Demographics:

Union County has a population of around 500,000, with an estimated 180,000 households. The median family income is approximately $49,000. Each participating municipality in the county was invited to develop its own collection standards, based on its labor, transportation, and storage capacities, as well as its experience with waste collection. Six communities signed contracts with the county to participate and develop a collection system. Four other communities also signed contracts to participate in regional collection programs, two of which have since held collection events:

Table 19: Union County Demographics

Municipality	*Population*	*Households*	*Median Income*
Cranford	22,633	8,407	$60,659
Westfield	28,870	10,588	$77,022
Scotch Plains	21,160	8,407	$64,920
Mountainside	6,657	2,454	$80,639
Clark	14,629	5,638	$54,521
Kenilworth	7,574	2,449	$45,774
Linden	36,701	11,877	$42,634
New Providence	11,399	4,312	$70,618

[10] Unless noted, all Union County information was gathered from the *Union County Demanufacturing Program - Semi-Annual Report*, Union County Utilities Authority, October 1, 1997-March 31, 1998.

[11] EPA, Inc. has consolidated its activities in New Hampshire. Union County is currently collecting proposals to manage the demanufacturing locally.

Rahway	25,327	9,844	$46,962
Summit	19,757	5,997	$83,876

Event Promotion:

The program was initially promoted via flyers distributed to 120,000 households in the county. Countywide events were also promoted through newspaper advertisements in the five county newspapers. A presentation was made to the Rutgers University Demanufacturing Partnership Program and the Rutgers University Eco-Policy Center Solid Waste Workshop for Mercer County to promote the program. The flyers cost $0.105 a piece, plus an additional $2,000 for printing costs, resulting in a net cost of $14,600. Most of these flyers (and their cost) went toward the countywide events. The additional newspaper advertisements cost around $1,800 per event (with four events), for a total cost of $7,200. The estimated net cost for publicity was $21,800.

Resident Participation:

The participation rate for all programs was estimated to be about 5% of the County's households.[12] No specific information is available about the participation of specific municipal programs, or the County programs versus the municipal programs.

Collection:

Due to variances in municipal resources and experience, each municipality developed its own collection scheme. The municipalities followed the curbside recycling program experience in NJ, by piggybacking on the current infrastructure for bottle and can recycling in the state. The county found it necessary to also provide countywide collection for residents and businesses that were interested in participating only if no personal transportation or processing costs were incurred. As of the end March 31, 1998, the county has held seven such events.

The agreement between Union County and the demanufacturer provides that participating municipalities receive free processing of their EEE waste, and are paid $50 per ton for their collection. Residents, government agencies, schools, and small businesses were invited to participate. Large businesses can participate by working directly with EPA, Inc.

Among the ten municipalities participating in the program, Clark, Kenilworth, and Summit have permanent collection depots where residents can drop off materials. The collected material is delivered to EPA, Inc. once a month. Summit supplements this facility with a curbside collection program that is tied in with its bulk waste (by appointment) collection. Linden and Rahway also operate curbside collection programs. Rahway's curbside program operates as part of its bulky item and recyclable collection scheme, and the costs for the EEE waste collection cannot be disassociated from the other program costs.

Four other communities (Westfield, Scotch Plains, Mountainside, and Cranford) agreed to participate in the program under a "regional approach." (They alternately host a quarterly collection event solely for their residents, with labor and transport covered by the host municipality.) Through March 31, 1998, one regional collection event has been held in Cranford and another was held in Westfield.

[12] Personal communication with the New Jersey Department of Environmental Protection.

Union County focuses on collecting items that were determined to have some environmental impact, namely monitors, TVs, computers, VCRs, keyboards, telephones, copiers, audio/stereo equipment, printers, peripherals, and microwaves. The following table lists the items collected in each location:

Table 20: Items Collected During Union County Pilot

	Computers	*Monitors*	*Keyboards*	*Telephones*	*TVs*	*VCRs*	*Microwaves*	*Audio/ Stereo*
County	258	273	268	136	157	103	38	261
Cranford	2	2	2	0	0	0	0	0
Westfield	24	20	19	1	4	0	1	2
Clark	22	149	22	18	67	16	21	41
Kenilworth	7	48	0	8	55	12	9	36
Linden	138	176	48	67	931	97	145	429
New Providence	3	10	0	2	44	0	4	6
Rahway	33	44	27	76	198	17	24	81
Summit	243	317	115	68	462	39	46	224
Totals	730	1,039	501	376	1,918	284	288	1,080

Transportation:

In the following table, the transportation costs given for the curbside programs include the cost of collecting the material and delivering it to EPA, Inc. The two regional collection events in Cranford and Westfield generated no information on transportation costs.

Table 21: Union County Transportation Distances and Costs

Program	***Trips Made***	***Transport Costs***
Clark	6	$389
New Providence	1	$360
Kenilworth	3	$233
Linden	15	$4,620
Rahway	62	$6,200
Summit	40	$5,622
Union County	7	$1,437

Transportation costs for Rahway and Linden, which have curbside collection programs, is high relative to the other municipalities. This is due to the frequency of equipment collection and the additional need to transport the equipment to EPA, Inc.

Demanufacturing:

Demanufacturing is managed by EPA, Inc., which opened a new location in Union County after winning a competitive bid between eight demanufacturing companies in the US. After selecting EPA, Inc., the county completed an environmental survey of six original equipment manufacturers (OEMs) and a number of demanufacturers to rank the importance and relevance of eliminating EEE waste from the waste stream. Of "high" environmental benefit were monitors and TVs (due to the CRT). Of medium impact were computers (CPUs), VCRs, keyboards, telephones, copiers, audio/stereo equipment, and microwaves. Of "low"' benefit were printers and peripherals. The focus of the collection was to remove most of these high-impact items from the waste stream.

EPA, Inc. charged a set cost per type of equipment collected. The price per unit reflects the demanufacturing and disposal costs. The charges are provided in the following table.

Table 22: Demanufacturing Charges per Item Collected

	Price Per Unit
Computers/CPUs	$1.00
Monitors	$5.75
Large TVs	$9.50
Small TVs	$7.00
Printers	$2.00
VCRs	$2.00
Keyboards	$0.75
Telephones	$2.00
Peripherals	$0.75
Copiers	$5.00
Audio/Stereo	$2.50
Microwaves	$2.00

While they generate revenue from most of the material that they extract, EPA, Inc. must pay about $0.10 per pound for disassembly of the CRTs.. With 28,000 lbs collected every 4 months, it costs the company $8,400 for one year of CRT disposal. In addition, the cost of disposing of the solid waste that was generated came to about $200 per week, for a total cost of over $10,000 per year. This disposal cost was not included in the cost data; however, since it was not possible to determine what percent of this waste was derived from the residential demanufacturing program.

Revenue:

Many of the items collected in Union County are technologically obsolete or broken beyond repair, so EPA, Inc. is only able to sell about $40 worth of equipment (VCRs, TVs, consumer electronics) a week, providing roughly $2,000 per year in revenue from the resale of used electronics and electrical equipment. This does not, however, include any resale value from working computers (about 1% of input), since they are shipped to EPA's other facilities. Data on the income from this equipment is not available.

The bulk of the income comes from the sale of recovered scrap. Scrap metal, wire, and components yield EPA around $0.06 per pound of scrap sold. The outflow of scrap is estimated to be about 7,000 lbs per month, resulting in about $5,000 per year in revenue. Additionally, circuit boards net about

$0.85 per pound, so with about 1 pound of circuit board per computer, the annual revenue from this source equals about $458. The net revenue from all sources comes to around $3,358 for the first year of the program.

Net Cost:

The net cost for each program is outlined in the table below. The initial infrastructure costs of the program make the net cost for the time period look higher than they currently are because initial costs flatten out as the program matures and the tonnage of collected material increases.

Table 23: Union County Net Cost

Municipality	***Net Cost***	***Net Cost per Pound Collected***
Clark	$2,003	$0.19
Cranford	$13	$0.10
Westfield	$234	$0.10
Kenilworth	$1,075	$0.16
Linden	$15,155	$0.17
New Providence	$767	$0.15
Rahway	$8,843	$0.33
Summit	$11,957	$0.23
UCUA Countywide	$5,858	$0.14

Project Comments:

The Union County program was funded via a grant from the NJDEP and a $120,000 grant, over two years, from U.S. EPA Region II. Participation appears to be consistent, and the attitude of the public is generally positive.

A tracking system to determine the source of incoming material has not been fully coordinated, since loads arrived infrequently and in low volumes at the beginning of the program. For the first few months, there was not enough volume to justify tracking and billing on a monthly basis.

After 18 months, testing of the incinerator stack and ash has indicated that the EEE program has been effective in diverting materials containing heavy metals from the MSW waste stream since concentration levels are lower than the baseline values. This conclusion is supported by the information provided in Table 39, which shows the calculated concentration of heavy metals in MSW, based on metals in the ash residue and air emissions. However, the specific contribution of the demanufacturing program to these reductions has not been calculated.

3.5 NAPERVILLE AND WHEATON, ILLINOIS

Collection Method:	One-day Drop-off Event
Number of Collections:	Three events
Collection Dates:	October 1996, 1997 (Naperville), and April 1998 (Wheaton)
Demanufacturer:	The Electronic Recovery Specialist, Inc.

Motivation Behind Collection:

Naperville and Wheaton organized their EEE waste collection events with the cooperation of a local demanufacturer, The Electronic Recovery Specialist, Inc. (ERS). The goals of these events were to:

- Reduce the amount of material that the municipality sends to the landfill;
- Safely dispose of the potentially hazardous materials; and
- Promote the collection of EEE waste on a municipal level[13]

The demanufacturer got involved with the intention of increasing interest in residential collection events, which would ultimately result in a greater volume of EEE waste for them to demanufacture. With the completion of their first event in October 1996, Naperville followed with another event in October 1997. Wheaton then followed suit by working with ERS to conduct a drop-off collection event in April 1998.

Demographics:

Naperville, IL, is a western suburb of Chicago and one of the fastest growing cities in the state. The town is largely white collar. The neighboring suburb of Wheaton is similar in profile to Naperville. Both towns are active in waste management, with collection programs for HHW, tires, books, and recyclable materials. In fact, Naperville was the first city in Illinois to implement a HHW collection scheme.

Table 24: Naperville/Wheaton Demographics

Municipality	*Population*	*Households*	*Median Income*
Naperville	85,000	32,000	$60,000
Wheaton	50,000	18,000	$52,000

Event Promotion:

Promotion in Naperville began six weeks before the first event and consisted of the placement of door hangers by meter readers at all single-family homes in the city. The door hangers outlined the date, time, and location of the program as well as what items would be accepted. Since ERS cannot demanufacture equipment that is 110V or 220V, people were asked not to bring household electrical equipment and appliances. This was combined with publicity in the local Chamber of Commerce newsletter a couple of

[13] Unless noted, all Naperville background information was gathered via personal communication with Marta Keane, the City of Naperville and all Wheaton background information was gathered via personal communication with Kay McKeen, DuPage County, Illinois.

weeks before the event. The city produced the door hangers in-house at "no net cost" to the municipality.

The second Naperville event was publicized using notices and flyers sent to every library, chamber of commerce, municipality, township office, and park district within the county. There was also good coverage by some of the local papers promoting the event. The city also sent flyers home with school children that attended the public and private schools serving the Naperville area. These flyers were also produced in-house.

For the Wheaton event, publicity consisted of an advertisement in the city newsletter during the months of March and April. Notices were also sent to the local churches, where they were placed on church bulletin boards. Additionally, there was comprehensive newspaper coverage of the event, resulting from the strong competition between newspapers in the community. All of this publicity came at no net cost to the municipality.

Resident Participation:

Over 250 households (measured by the number of cars) dropped off material during the first event, 185 of which were from Naperville. For the second event, there were 670 cars measured, but the household participation is uncertain since there were a number of businesses, schools, and organizations that dropped off equipment as well. Overall, the total number of cars increased by almost 170% from the first to the second event.

At the Wheaton event, 906 cars were counted but the city estimated the actual participation to be more than 1000 households since a number of residents parked on the streets, or delivered their EEE waste on foot. The high attendance is due in part to the fact that the event combined EEE waste collection with a book and tire collection.

Collection:

All three events were Saturday drop-off collections held on municipal property. Volunteers handled some of the greeting and unloading of the incoming cars, although a large number of ERS employees were present to sort, unload, and stack the material.

The events targeted electronic equipment – e.g., computers, TVs, VCRs, microwaves, and stereos – since the demanufacturer did not have the ability to work with electrical equipment (110 or 220 V items). The items listed in the table were collected at the events, 1996 and 1997 held in Naperville, and 1998 in Wheaton:[14]

Table 25: Items Collected During Napervill/Wheaton Pilots

	Computers	***Monitors***	***Keyboards***	***Printers***	***TVs***	***VCRs***	***Microwaves***	***Stereos***
Naperville								
1996	367	152	160	113	111	54	28	286
1997	305	290	65	130	292	236	40	120
Wheaton								

[14] Naperville data provided in City of Naperville Memorandum dated October 10, 1996 and Memorandum dated November 21, 1997. Wheaton data provided via personal communication with Bob Bell, The Electronic Recovery Specialist, Inc.

1998	99	226	0	102	102	109	33	115

Telephones, copiers, and miscellaneous other items were also collected.

In terms of weight, 24,267 lbs were collected in Naperville in 1996, around 60,000 lbs in Naperville in 1997, and 22,414 lbs in Wheaton in 1998.

Although the demanufacturer, ERS did not charge the municipalities for their labor, the company's cost per event was given at around $8,000. A portion of these costs derive from the labor for the event (e.g., sorting, stacking of the equipment) and the rental of the truck.

Transportation:

The total transportation distance from Naperville/Wheaton to the ERS facility in Niles, IL, is about 30 miles. Because both a 53-ft and a 23-ft truck were being used to transport the equipment, multiple trips were required at each event. The cost of these trips makes up the portion of the $8,000 event cost not due to labor. After the Wheaton event, Tire Grinders Transporters, Inc., a company that was participating in Wheaton's tire collection program, voluntarily hauled one-half of a 53-ft truck's worth of material to ERS. Their transportation costs are not included in the estimate.

Demanufacturing:[15]

ERS explained what they could and could not take to the volunteers and participants, in order to limit the collection of useless material. They do not have the capacity to demanufacture many electrical appliances (i.e., those that run on 110 to 220V).) Most of the electrical equipment that was collected was thrown away during the event.

The equipment was broken down into wiring, circuit boards, and high-grade breakage. The monitors and televisions were disassembled and the CRTs recycled. The process used to disassemble and recycle the CRTs was considered proprietary. It is unclear what type of recycling occurred and if it was domestic or international. The demanufacturer did not provide the exact type and percentage yield of commodities from these events.

Revenue:

No exact data was provided on the revenue from any of the demanufacturing; however, ERS estimated that their total income from the material comes to around $6,000 per event. ERS indicated, however, that for each event an additional $6,000 was spent in disposing of unusable material. This disposal cost includes the extra cost of the sorting, storage, and shipment of broken electronics to re-training programs throughout the U.S. and to overseas markets.

Net Cost:

The demanufacturer carried the net cost for all of the events, which they estimated to be around $8,000 per event. The net cost per pound decreased more than 60% between the two Naperville events.

---

[15] Demanufacturing, revenue and cost data gathered via personal communication with Bob Bell, The Electronic Recovery Specialist Inc.

Table 26: Naperville/Wheaton Net Cost

Municipality	***Net Cost***	***Net Cost per Pound Collected***
Naperville 1996	$8,000	$0.33
Naperville 1997	$8,000	$0.13
Wheaton 1998	$8,000	$0.36

Project Comments:

According to the municipalities, the collection programs were successful because they had a large turnout for each event. The coordinator in Naperville indicated that despite the high yields for the two events, only a periodic collection would be the most cost-effective choice for her community. In her opinion, additional collection events would probably not lead to substantially greater amounts of equipment collected.

The demanufacturer explained that these events could have broken even with better collection support during the events. ERS employees covered most of the labor for sorting and loading, a cost that could have been offset by more coordinated volunteer help. All the same, they have been working with other municipalities to continue expansion of these collection events in the area.

ERS also noted that an essential element in coordinating the event is the existence of an "exit plan," meaning a client for the demanufactured material or equipment. This was especially relevant to ERS since they had limited storage space, and ended up shipping some of the collected material to re-training programs.

3.6 SUMMARY DATA FOR THE PILOT PROJECTS

The range of data gathered from these five collection programs makes it impossible to develop a linear relationship between collection method, costs, and equipment yield. This is due to the different collection models used in the programs, the variety of the equipment collected, the management of the equipment that was collected, and the ultimate disposal of the equipment. The following table shows what cost data was available for each collection program.

Table 27: Available Cost and Revenue Data

Collection Agency	*Publicity*	*Operating*	*Transport*	*Demanufacturing*	*Disposal*
Binghamton/ Somerville	X		X	X	
Naperville/ Wheaton			X	X	X
Union County	X	X	X	X	X
Hennepin County		X	X	X	X
San Jose			X	X	X

The summary tables in this section provide data for all available data sets (aside from upfront costs), with the caveat that the values are not directly comparable.

Some data regarding the cost of pre-program publicity was available. However, this information was only available for Union County and Binghamton/Somerville. The impact of the large up-front outlay for publicity was enough that including these values in the summary table would skew the values for these two programs. Therefore the available data on upfront costs was not taken into account.

It should also be noted that the cost associated with the Hennepin County program is an aggregate of all costs paid by the county – labor for some collection, demanufacturing, staff salaries, transport, disposal, supplies, overhead, etc. Due to the design of the program and the selection of vendors, many of the costs could not be divided into specific categories such as collection type or total transportation cost.

Finally, for curbside collection programs that coincide with other collection programs (bulk items, HHW, appliances), no attempt was made to allocate costs to the EEE waste collection. The costs that are presented include some of the costs associated with the collection of both the EEE waste and other items. However, these costs are assumed to be small in comparison to the cost of transporting the EEE waste to the demanufacturer.

Table 28: Binghamton/Somerville and San Jose Summary Cost Data

	Binghamton / Somerville				San Jose
Location	Somerville	Somerville	Binghamton	Binghamton	San Jose
Event Date	Fall 1996	Spring 1997	Fall 1996	Spring 1997	October 1997
total revenue	$481	$1,807	$487	$1,175	$5,100
total cost[a]	$3,781	$2,898	$931	$3,038	$23,110
net income (cost)	($3,299)	($1,091)	($444)	($1,863)	($18,010)
total inflow (lbs)	7,448	13,723	2,372	9,031	61,600
total cost/lb	$0.51	$0.21	$0.39	$0.34	$0.38
revenue/lb	$0.06	$0.13	$0.21	$0.13	$0.08

Note: Total cost per pound is equal to the total cost divided by the pounds collected, ***not*** the net cost divided by the pounds collected.

a: Binghamton and Somerville total cost values consist only of the cost of transporting the EEE waste to the demanufacturer and the cost of the demanufacturing labor. The San Jose costs include the cost of transporting the EEE waste to the demanufacturer, the cost of the demanufacturing, and the disposal costs associated with disposing the CRTs.

Table 29: Union County Summary Cost Data

Union County

Location	Union Co.	Cranford	Westfield	Clark	Kenilworth
Event Date	October 1, 1996 to March 31, 1998				
total revenue	$456	$2	$34	$77	$46
total cost[b]	$6,314	$15	$268	$2,080	$1,122
net income (cost)	($5,858)	($13)	($234)	($2,003)	($1,075)
total inflow (lbs)	42,886	120	2,240	10,640	6,680
total cost/lb	$0.15	$0.13	$0.12	$0.20	$0.17
revenue/lb	$0.01	$0.02	$0.02	$0.01	$0.01

Note: Total cost per pound is equal to the total cost divided by the pounds collected, ***not*** the net cost divided by the pounds collected.

b: The Union County total cost values include the cost of transportation to the demanufacturer and the cost of demanufacturing the EEE waste and disposing of the unsold scrap and CRTs.

Table 30: Union County Summary Cost Data (cont.)

Union County (cont.)

Location	Linden	New Providence	Rahway	Summit
Event Date	October 1, 1996 to March 31, 1998			
total revenue	$592	$34	$184	$454
total cost[b]	$15,747	$801	$9,027	$12,412
net income (cost)	($15,155)	($767)	($8,843)	($11,957)
total inflow (lbs)	87,060	5,180	26,560	51,500
total cost/lb	$0.18	$0.15	$0.34	$0.24
revenue/lb	$0.01	$0.01	$0.01	$0.01

Note: Total cost per pound is equal to the total cost divided by the pounds collected, ***not*** the net cost divided by the pounds collected.

b: The Union County total cost values include the cost of transportation to the demanufacturer and the cost of demanufacturing the EEE waste and disposing of the unsold scrap and CRTs. The curbside collection program in Linden also includes some small operating expenses, which could not be separated from the transportation costs.

Table 31: Hennepin County Summary Cost Data

Hennepin County

Location	Hennepin Co.		
Event Date	1995	1996	1997
total revenue	$10,000	$20,000	$25,000
total cost[c]	$190,000	$350,000	$350,000
net income (cost)	($180,000)	($330,000)	($325,000)
total inflow (lbs)	400,000	524,000	732,000
total cost/lb	$0.48	$0.67	$0.48
revenue/lb	$0.03	$0.04	$0.03

Note: Total cost per pound is equal to the total cost divided by the pounds collected, ***not*** the net cost divided by the pounds collected.

c: The Hennepin County total cost values include the operating costs, costs of transportation to the demanufacturer, demanufacturing costs, and disposal costs for the unsold scrap and CRTs.

Table 32: Naperville/Wheaton Summary Cost Data

Naperville/Wheaton

Location	Naperville	Naperville	Wheaton
Event Date	Fall 1996	Fall 1997	Spring 1998
total revenue	$6,000	$6,000	$6,000
total cost[d]	$14,000	$14,000	$14,000
net income (cost)	($8,000)	($8,000)	($8,000)
total inflow (lbs)	24,267	60,000	22,414
total cost/lb	$0.58	$0.23	$0.62
revenue/lb	$0.25	$0.10	$0.27

Note: Total cost per pound is equal to the total cost divided by the pounds collected, ***not*** the net cost divided by the pounds collected.

d: The Naperville and Wheaton total cost values include the costs of transportation to the demanufacturer, demanufacturing costs, and disposal costs for the unsold scrap.

4. ECONOMIC ANALYSIS OF PILOT PROJECTS

This section provides a more detailed analysis of the collection programs, which covers the following items:

- Net economics;
- Analysis of cost;
- Analysis of revenue; and
- Collection efficiency.

4.1 NET ECONOMICS

The net economics of an EEE waste collection program is defined by the sum of the revenue and costs associated with the program. The experience shown by the previous five collection examples is that collection programs generally run at a *net cost*. Note that this is a purely economic statement. Some of the programs and pilots have other objectives that have not been translated into cost.

In looking at the net economics, it is helpful to understand what costs and revenue sources are contributing to this value. The following graphic indicates the economic interactions between the important stakeholders in these collection programs.

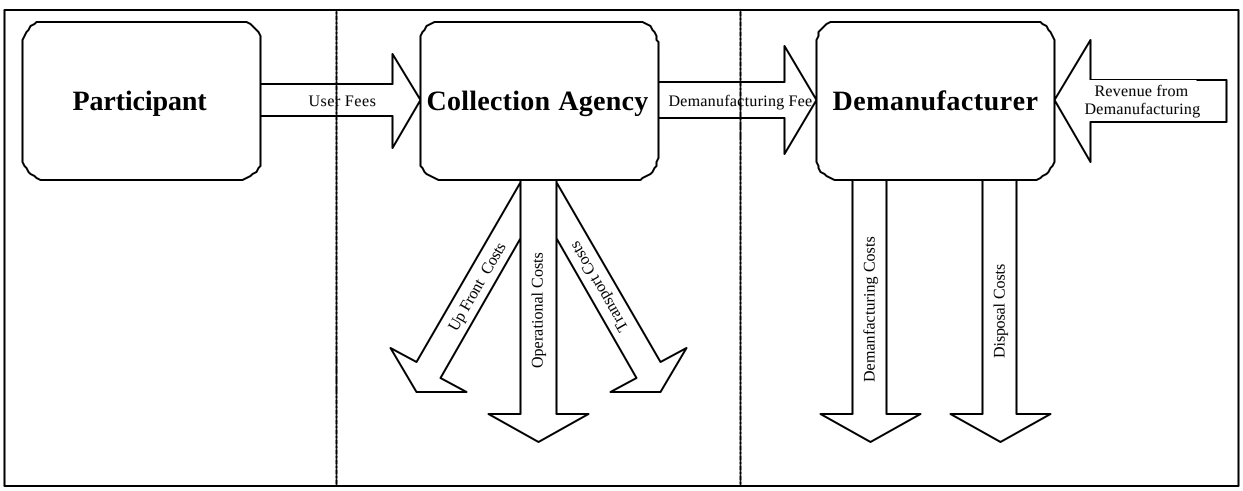


Figure 2: Economic Interaction Between Stakeholders

Each of these stakeholders has its own specific cost and revenue structure, and not every one will bear the same economic burden. However, it is important to note that the net cost of the five collection models for this report includes the sum of all of the *available* cost and revenue data; not all of the following cost and revenue data was available for every program:

Cost = demanufacturing + transport + operating + publicity + disposal costs

Revenue = revenue from scrap + revenue from resale + *revenue from fees or services*

While the data that was gathered for these programs was useful in determining the total cost of a program, it is not as helpful in assessing the economic role that each individual stakeholder has in the total economics. Each stakeholder's economic role is expanded upon in the discussion in Section 5.

4.2 COST ANALYSIS

Looking at the program summary tables in Section 3 indicates that even for similar collection models and geographic locations, costs were not consistent or predictable. Specifically, this irregularity is due to differences in data collection methods. The short-term nature of many of these pilot programs resulted in services provided "in-kind" or "in-house." The end result is that the demanufacturing costs had the most significant impact on the apparent cost of the programs. In fact, almost all of the available cost data is related to demanufacturing.

4.2.1 Demanufacturing Versus Disposal

The two charts below indicate the net cost per pound recycled for each of these programs in comparison to the average disposal fees per pound (either for landfilling or incineration). The charts show how widely the costs for recycling vary, both between and within communities. This is likely due to both the limited amounts of data that are available for each model, and the fact that, with the exception of Hennepin County, none of the programs have been running a long time.

The charts are organized by collection model, with the first chart presenting one-day drop-off events and the second chart presenting the other collection methods. Each data set has two separate columns – the net cost per pound for recycling and the disposal costs per pound. The recycling cost column incorporates the cost data for demanufacturing the collected equipment and disposal of any scrap that was not sold, and any income from scrap and resale. Hennepin County is not included in the graphs so as not be misleading, since their demanufacturing costs cannot be dissociated from their collection and transport cost. The disposal costs column represents the tipping fees or incinerator fees for each locality. Collection and transport were not included since collection costs for MSW were not available.

In examining these charts, it is obvious that the recycling programs are more costly than disposal of the material via incineration or landfilling, and this difference appears to be independent of the type of collection program. It should be noted that these charts do not incorporate any non-quantified costs, such as the costs associated with disposing of incinerator ash containing heavy metals, which may increase the disposal cost per pound.

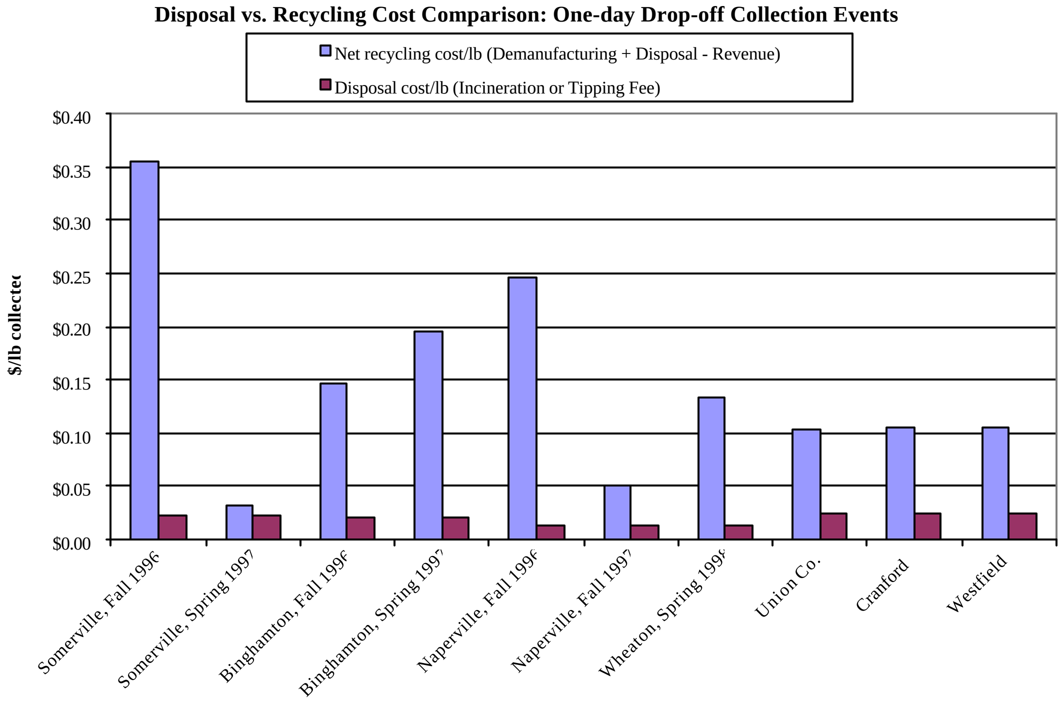


Figure 3: Disposal vs. Recycling Cost Comparison: One-day Drop-off Collection Events

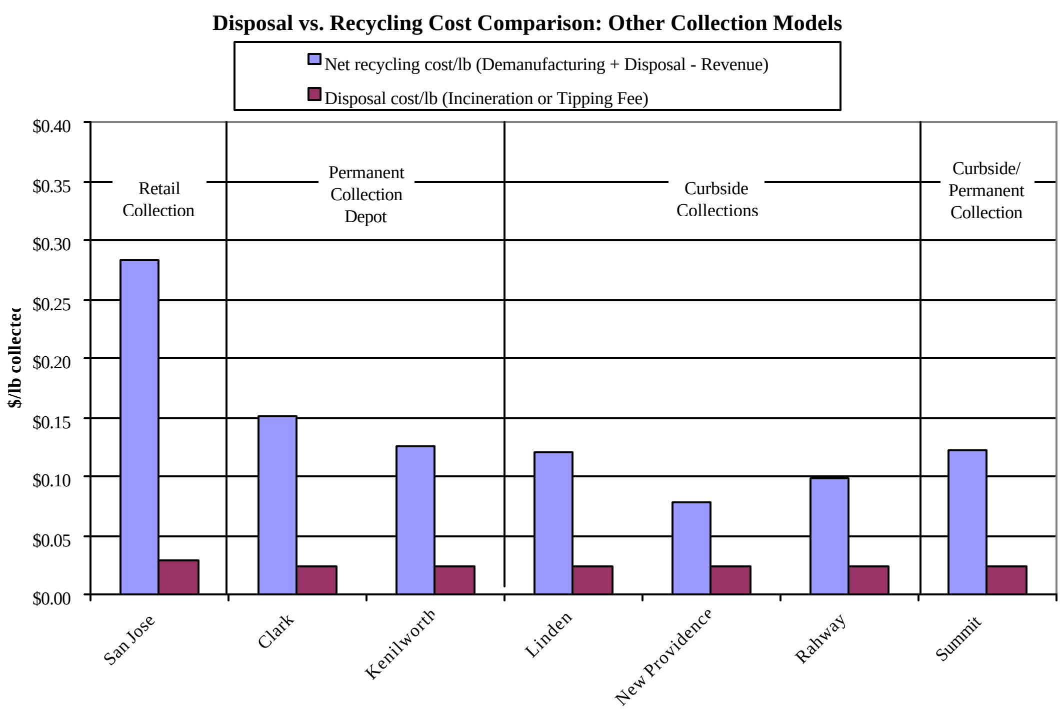


Figure 4: Disposal vs. Recycling Cost Comparison: Other Collection Models

4.2.2 CRT Recycling

The commodity that predominated in most of the five collection programs is the CRT (see the following chart). Televisions, monitors, and some other electronic equipment (e.g., oscilloscopes) all contain CRTs. It is obvious then that a demanufacturing program can be greatly affected by what is done with this material. There are a number of options that were used by these five collection programs – domestic glass recycling, smelting, and export – that have varying costs.

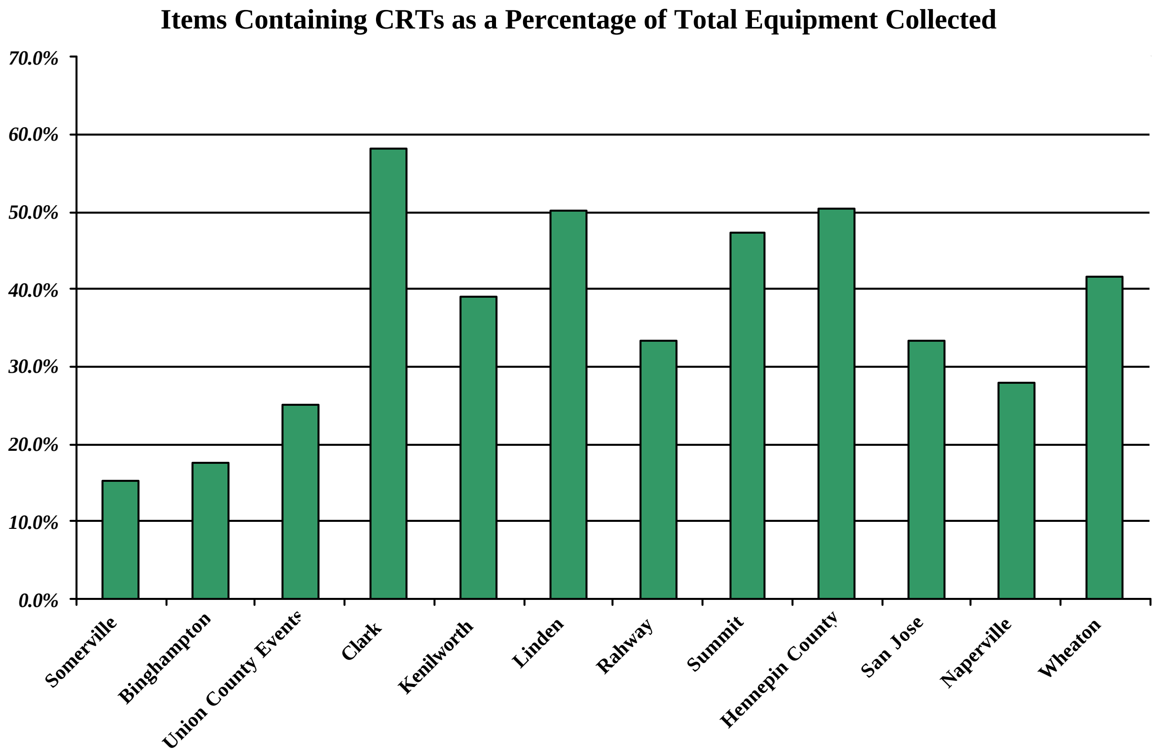


Figure 5: Items Containing CRTs as a Percentage of Total Equipment Collected

One optimum demanufacturing option, at least in terms of the net economics, may be the recycling of the CRT into glass. Demanufacturers who recycled CRTs received some revenue for the glass that they generated. However, it is difficult to determine just *how much* revenue they received per CRT since glass recyclers consider their process to be proprietary. The complexity of this option is also technically related to the multiple formulations of CRT glass (over 200 chemical formulations), and the demand by manufacturers for product specifications of the secondary material. In addition, federal and state regulations regarding CRTs are complex, which may also increase the cost of the recycling process and ultimately limits the number of companies that can do the recycling. For the collection agency, the lack of a local demanufacturer to provide this service could result in high transportation costs that outweigh the revenue generated from the recycled material.

Smelters were also used as a disposal option for the CRTs. A smelter uses the silica in the CRT glass as flux in its operations and recovers some of the lead. Most smelters are located in remote locations, which can make transportation costs high relative to the value of the material. Further, since secondary smelters have moderate feedstock needs, the outflow of CRTs from the collection program sent to a smelter can become dependent on the smelter's demand. Such is the situation for Hennepin County, where the demanufacturing program is affected when the smelter shuts down (the county is affected by the shutdown of any end market, not just the smelter). The county then has to store the CRTs it collects.

A third option for CRT disposal is export to developing nations. The cost for demanufacturing may be much lower in other countries than it is in the United States - as much as ten times lower, as indicated in the San Jose study. There is an open debate as to what actually constitutes demanufacturing and/or disposal in an overseas market. While this overseas disposal option does reduce the costs to a demanufacturer, there are issues to consider before exporting the material. Worker health and safety laws, and hazardous waste disposal laws overseas may be less stringent than in the U.S. and may contribute to cost savings when CRTs are shipped abroad for management, disposal, or recycling. The demanufacturing of CRTs therefore may lead to health problems for overseas workers.[16] Because of the hazardous nature of some of the materials in CRT glass (lead and cadmium) and the less stringent environmental standards in developing countries, the shipment of these materials overseas may in fact just be a displacement of pollution.

The disposal of CRTs is consistently a cost for the collection agency. While a demanufacturer may generate some revenue from the sale of the CRT glass that they generate, the revenue does not fully offset costs that the demanufacturer will transfer to the collection agency for the transport and disposal of the material.

4.3 REVENUE ANALYSIS

The revenue for these programs was derived either from resale of the collected material or sale of the demanufactured scrap. Most of the programs received a notable amount of revenue; however, the amounts were not sufficient to offset the collection agency's costs for collection and demanufacturing. The following section analyzes in more detail some of the revenue streams from these programs.

4.3.1 Resale

The following table lists the collection programs that received revenue from the resale of equipment. Revenue/pound collected is the economic yield of resold equipment per pound of equipment that was collected. The cost/pound collected is the gross cost of collection/demanufacturing per pound of equipment that was collected.

Table 33: Resale Revenue Per Pound Collected

Collection Agency	***Resale Revenue***	***Total Pounds Collected***	***Resale/Pound Collected***	***Cost/Pound Collected***
San Jose	$1,940	61,600	$0.03	$0.38
Somerville (1997)	$962	13,723	$0.07	$0.21
Union Co. Total	$3,120	232,866	$0.01	$0.21

Note: Values for Union Co. Total are for all of the collection programs over the collection period of 18 months. The cost/pound collected for San Jose is for the scenario in which CRTs are exported for demanufacturing.

As is evident from this table, the resale revenue per pound is only a fraction of the cost per pound. Additionally, there does not appear to be any linear correlation between the amount of equipment collected and revenue from resale, which leads to the conclusion that a large amount of equipment

[16] *The San Jose Computer Collection and Recycling Pilot,* pp 9.

collected does not necessarily translate into a large amount of revenue from resale. This is likely because the quality of equipment that is collected varies depending on the specific community, its locations, and time.

4.3.2 Offsetting Costs

For these collection programs, revenue was not sufficient to offset all of the costs associated with the program's organization and operation. Most of this revenue is dependent on factors that are beyond the direct control of the collection agency, such as the market price for the extracted materials, the quality of the extracted material, and the presence of demanufacturing firms. Considering this, in order to reduce the net cost of collection, collection agencies would do best to either focus on reducing program costs, work with a demanufacturer to develop a revenue share on any resale of collected equipment, or assess the community's willingness to pay. However, it is helpful to understand how far these collection programs are from a "break-even point", i.e., the point where the revenue per pound is equal to the cost per pound. Also note that because of the disparity in the data between pilots not all costs are included and may cause the break-even point to increase.

To illustrate this, the cost per pound collected was divided by the revenue per pound collected (see Section 3.6 for these numbers) to calculate the ratio of cost to revenue. This ratio is essentially equal to how many times larger the cost is than the revenue, e.g., a ratio of 2 means that the cost per pound collected is twice the revenue per pound collected. Therefore, this ratio gives an idea as to how much the revenue per pound would have to increase to be equal to the cost per pound. These ratios are shown for all five of the collection programs in the following chart.

Since the revenue received from demanufactured materials is linearly dependent on the market price of the material, these ratios can be interpreted as how much the market price would have to increase for the revenue per pound to equal the cost per pound. This assumes that only the market values received for the demanufactured materials change and not the type and weight of materials collected or the cost for the collection program.

This chart illustrates that most of the one-day drop-off events have costs that are around twice the revenues. As the markets for some of the extracted materials develop, these programs have the potential to break even, assuming that their costs per pound stay at least the same, and they collect equipment that contain material with some market value. The other collection models have higher break-even costs, which is due both to their higher costs and lower revenues.[17] The very high break-even point for the Rahway curbside collections is mainly due to the transportation costs associated with the frequent number of collections. Since this break-even point is skewed due to the organization of this particular collection model, it should not be seen as representative of the typical curbside collection program.

[17] It should be noted that the revenue numbers for the Union County events are based on average data provided by the demanufacturer and the actual revenue values may be somewhat greater than those that are included in the analysis.

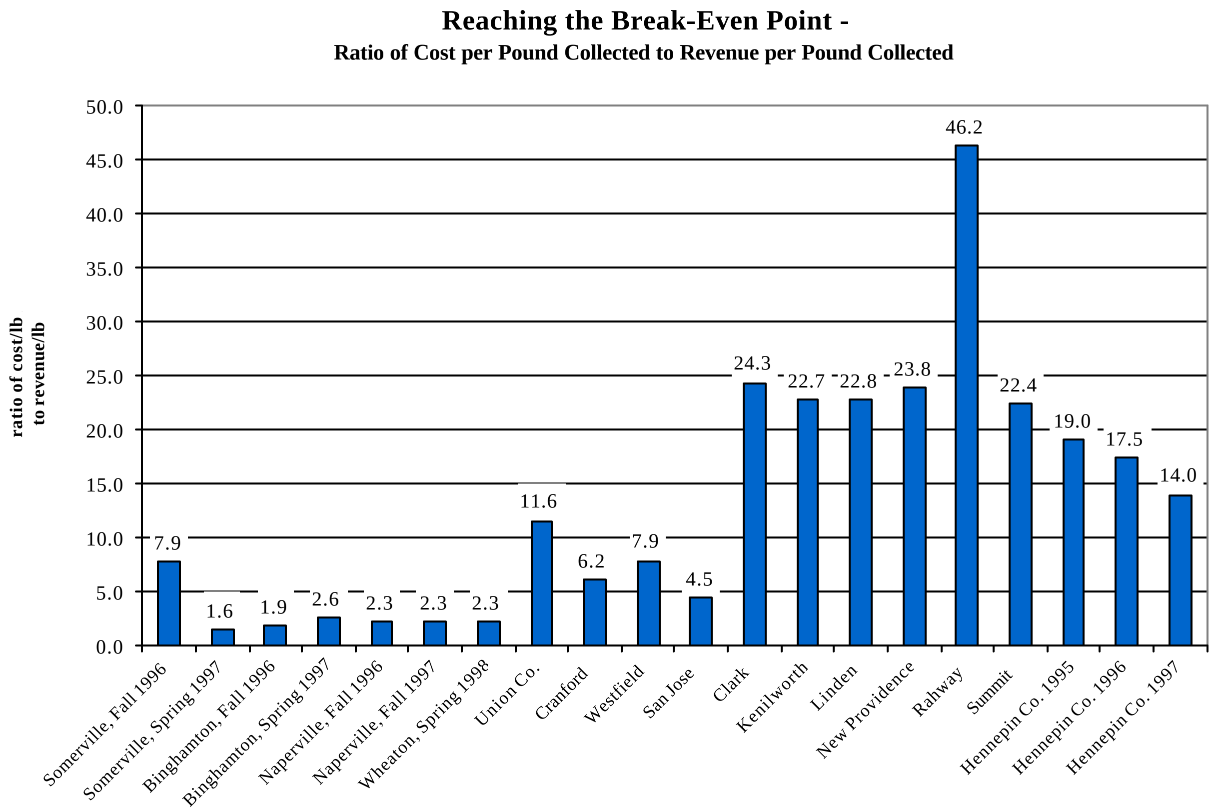


Figure 6: Reaching the Break-Even Point for Collection Models

4.4 EQUIPMENT COLLECTION

Despite the differences in motivations behind the individual collection programs, the items that each program targeted were mostly similar. The following table outlines the items that were requested by each of the collection programs (some of the programs received items that they did not target), which shows these similarities. The San Jose pilot is obviously different since the goal was to collect only computer-related equipment. Hennepin County also collects microwaves, but under its appliance collection program.

Table 34: Items Targeted by Collection Program

	Somerville/Binghamton	Naperville/Wheaton	Union County	Hennepin County	San Jose
Computer Monitors	X	X	X	X	X
Computers	X	X	X	X	X
Televisions	X	X	X	X	
Stereo equipment	X	X	X	X	
Speakers	X	X	X	X	
VCRs	X	X	X	X	
Microwaves	X	X	X		
Fax Machines	X	X	X	X	
Printers	X		X	X	X
Telephones	X		X	X	

The following chart gives some indication of the average composition of a collection event in terms of the percentage of total items collected. The average was calculated to give more weight to the collections with the greatest yield. The chart gives a rough approximation of what a collection program can expect to collect, even though it does not take into account the impacts that a particular collection model or geographic area may have on the type of equipment collected. The chart does indicate that *TVs* and m*onitors* made up almost 50% of the items collected, which as was mentioned above can substantially affect the cost of the EEE waste collection program. The substantial percentage of equipment that fits into the *Misc. Other* category shows that the range of what is collected is generally not limited to the equipment that is targeted.

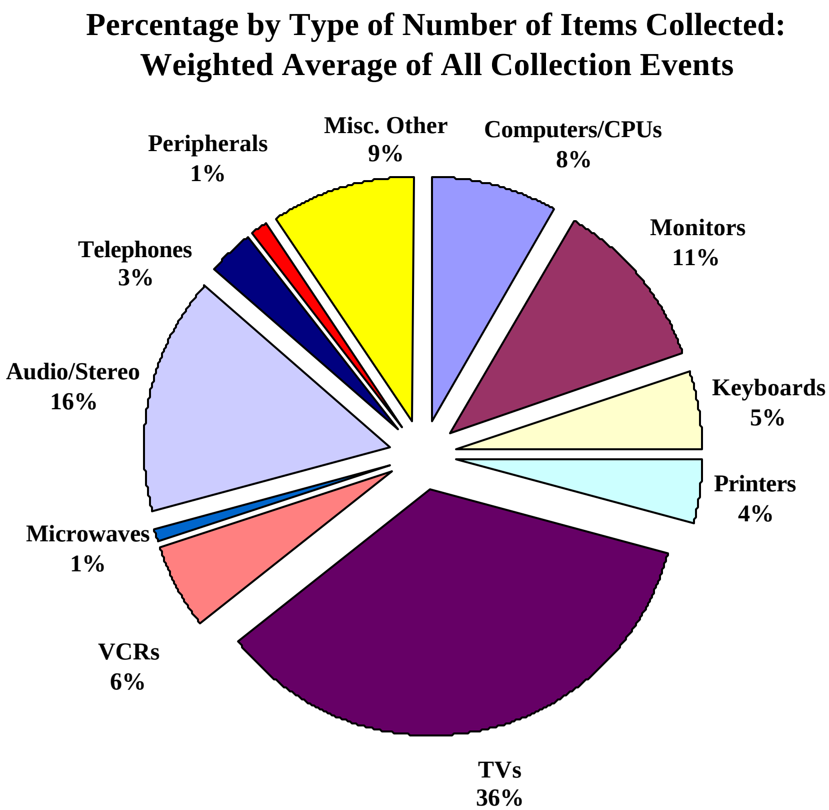


Figure 7: Percentage-by-Type of Number of Items Collected

4.4.1 Collection Efficiency

While there were similarities among the collection models in terms of what equipment was collected, they were quite different in terms of how economically this equipment was collected. One of the ways to assess these differences is to calculate the collection efficiency of a program, which is the number of items that are collected per dollar spent on the collection. The larger this value is, the more cost effective the collection model.

The following chart shows the collection efficiency values for all of the programs. The Cranford, Westfield, Somerville (1997), and Union County programs stand out because they appear to have very high collection efficiencies compared to the other collection programs. All four of these data sets come from programs that are organized as one-day drop-off events. Although these four examples would seem to indicate that drop-off events are the most efficient collection models, the low values for some of the other drop-off events contradict this conclusion. This variation within collection models is likely due to the fact that the cost values that were used to calculate the collection efficiency include demanufacturing costs. Therefore, items that are more costly to demanufacture (e.g., CRTs) can increase the cost of the program. In addition, since advertising factors and weather affect program turnout, this can affect the number of items collected, without directly affecting the program cost. Transportation costs, which depend on the distance to the demanufacturer, are also a factor that has less to do with the collection model than with the location of the municipality. Therefore, without a more detailed data set for each collection program, the impact that a particular collection model has on the collection efficiency is unclear.

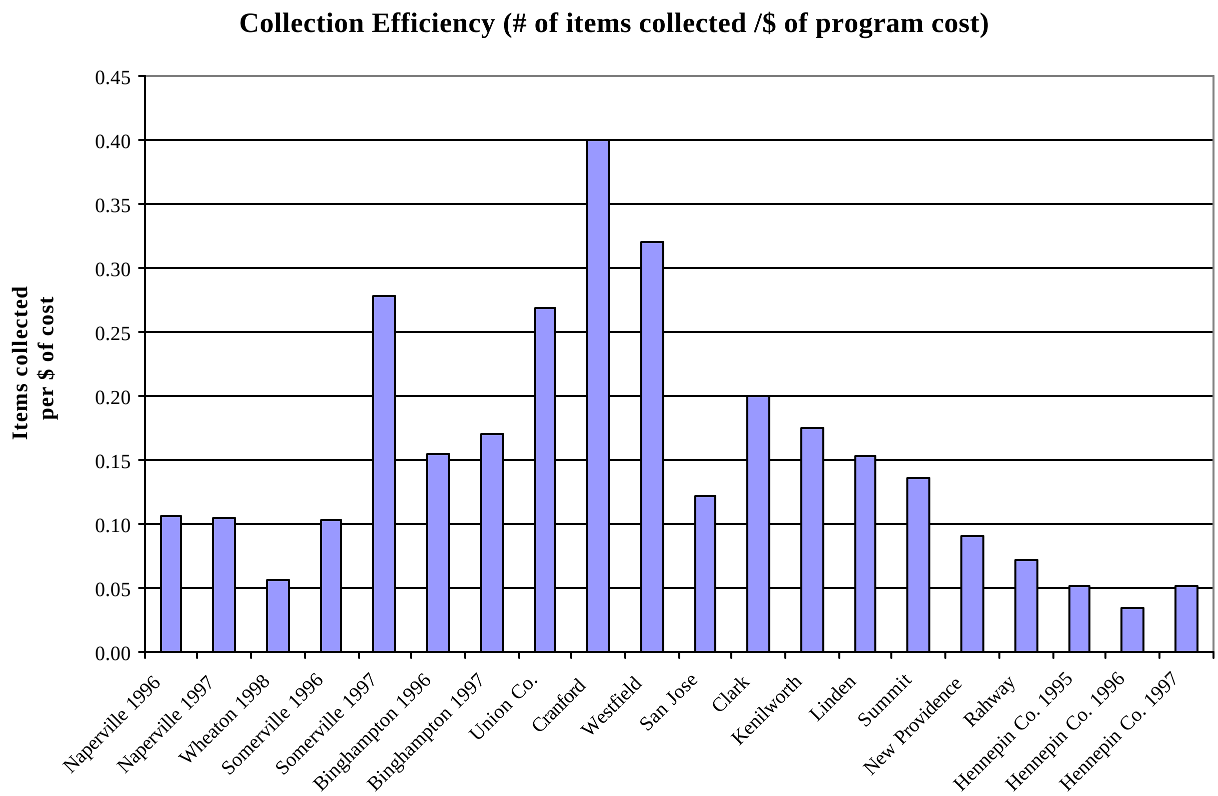


Figure 8: Collection Efficiency of Collection Models

4.4.2 Equipment Collected per Resident

Examining the weight of equipment that is collected per resident can also be used to assess the efficiency of the collection model. The following chart shows these values as they were calculated for all collection programs using summary data. That is, the pounds of equipment collected per resident for Somerville represents the total weight of equipment over both collection events. The chart indicates that the Linden, Summit, and Rahway programs collected the most per resident, whereas most of the one-day collection events (Cranford, Union County, Somerville…) collected the least. This appears to indicate that the curbside collection programs are more efficient in collecting material than the other collection models. While this conclusion seems intuitively correct, some factors independent of the collection model, such as the difference in the kinds of material collected per event (e.g., TVs or microwaves), may skew these values.

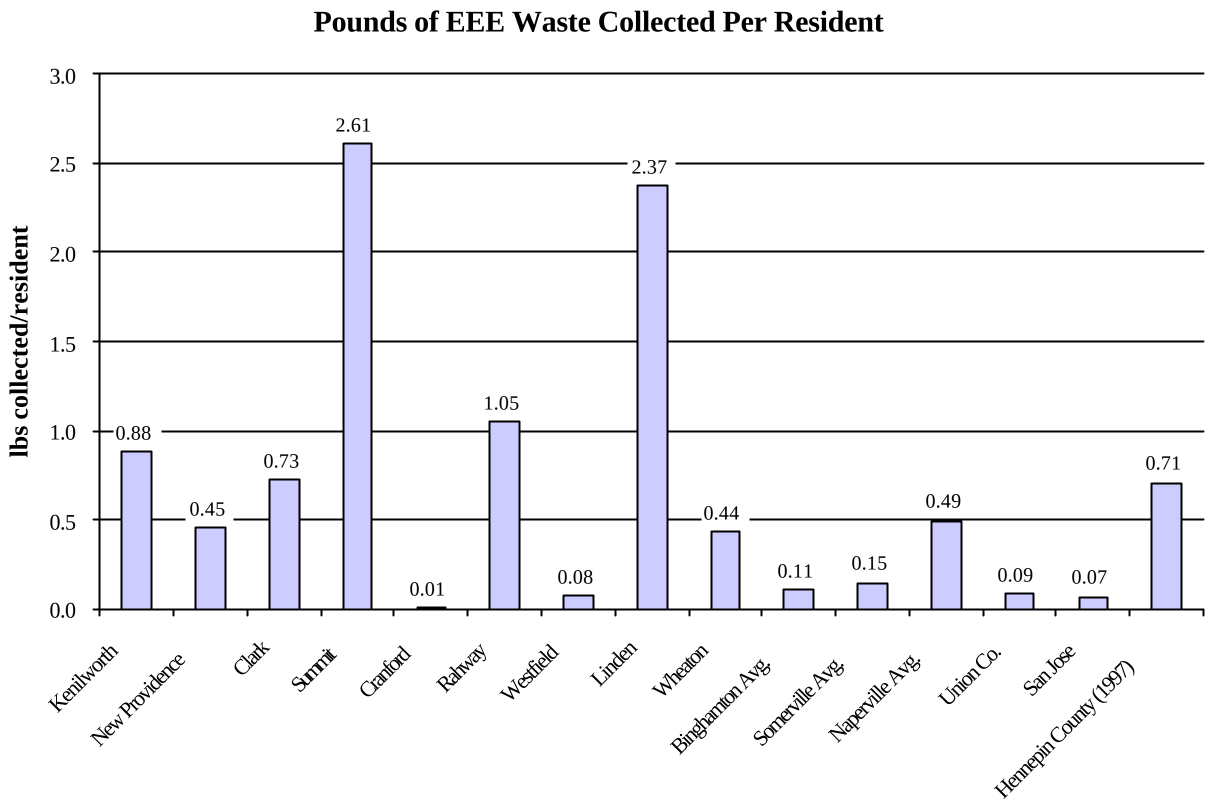


Figure 9: Pounds of End-of-life Electronic and Electrical Waste Collected Per Resident

5. BEYOND THE EXAMPLE COLLECTION PROGRAMS

In Section 4, the focus of the analysis was on the total economics of the five example collection programs. However, each stakeholder involved in the development and implementation of such a program had its own unique cost and revenue streams. Therefore, the examination of the *total cost* does not help to identify what specific costs an individual stakeholder is incurring. This section uses the examples presented in Section 3 to identify these stakeholders and outline their individual economic roles in the collection process, with the intention of highlighting the difference between their roles. The section is organized into the following sections:

Throughout this section, text boxes outlining the experiences of HHW collection programs and European EEE waste collection programs are included to supplement the information provided by the case studies.

5.1 IDENTIFYING THE DIFFERENT STAKEHOLDERS

The following graphic, repeated from section 4.1, illustrates the economic interactions among the program participants, the collection agency and the demanufacturer, as if a separate actor fulfilled each role. In this broader discussion, the term "collection agency" is used to encompass municipal and county government or retail establishments, as well as other bodies that would possibly coordinate an EEE waste collection program. Although this relationship is somewhat simplistic, since the case studies have indicated that not all of these costs are relevant to all collection models, it does indicate that not every stakeholder has the same economic concerns.

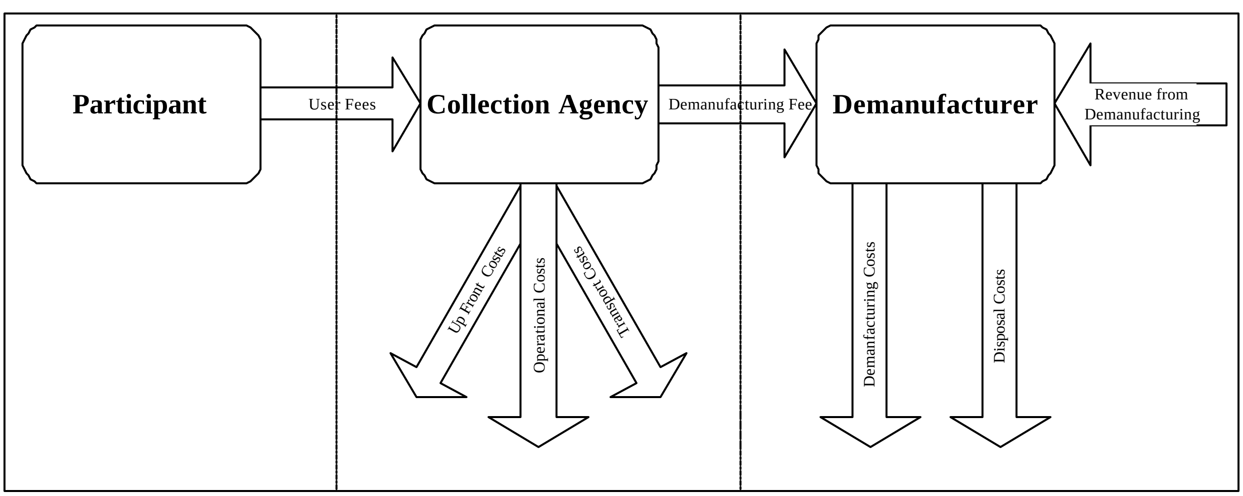


Figure 10: Economic Interaction Between Stakeholders

In determining the economics of a collection model, these three actors have the most direct influence. Other actors can also affect the economics of an EEE waste collection model as well, but not always to the same degree:

- For a point-of-purchase collection model, such as in San Jose, the retailers were the collection agent and subsequently incurred many of the costs related to the collection operation.
- State or national governments play a role when implementing regulations that either directly promote EEE waste recycling or indirectly promote it through landfill bans.
- Private industry/OEMs (aside from demanufacturers and retailers) can also play a role at either end of the collection model by affecting the market value of extracted materials or by modifying the design of the electronic or electrical equipment that they produce. OEMs have assisted in developing the demanufacturing industry to manage off-specification and return equipment.

The roles and impact of each of these actors/stakeholders are developed in more detail in the following sections.

5.2 THE DEMANUFACTURER

5.2.1 Role

The role of the demanufacturer is to take in the collected equipment and to either resell this equipment, sell the material extracted from it, or pay for disposal. The discussion in this section focuses on the economics of a demanufacturer that is separate from the collection agency. While the analysis of costs and revenue are also relevant to a demanufacturing program run by the collection agency, the focus is on the economic drivers specific to the demanufacturing.

The following graphic illustrates the revenue and cost flows associated with demanufacturing. The arrow out of the box labeled "Demanufacturer" indicates the costs to the demanufacturer, which consist of labor, disposal, storage, and permitting. Setup costs such as property, equipment or permitting are not included. The arrows pointing inward toward the box indicate the revenues that the demanufacturer receives. At "steady state" (i.e., over the long term) the sum of these revenues will at least offset the cost of the demanufacturing. This is because the demanufacturer will likely adjust its fees to offset costs that are not offset by the demanufacturing revenue. These dynamics are discussed in more detail below.

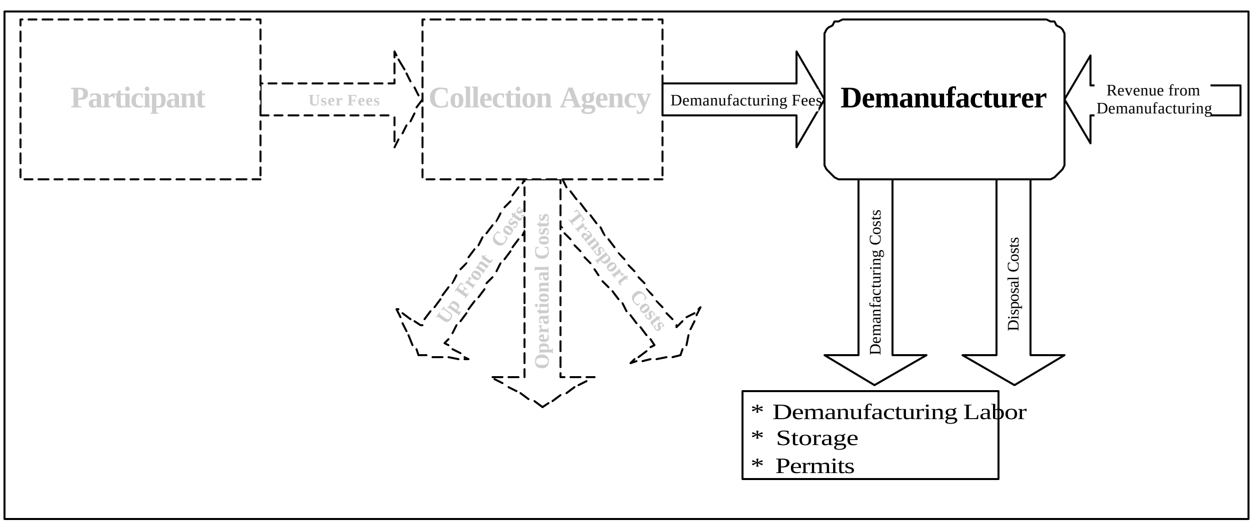


Figure 11: Cost and Revenue Streams for the Demanufacturer

Although the main motivation driving private demanufacturing is revenue (and profit), some other short-term drivers may exist. Demanufacturers were willing to participate in a residential collection pilot to evaluate entering into this type of business arrangement. Additionally, they may decide to participate for the sake of their public image. Of course, the program must provide at least the promise of stability and sufficient quantities of equipment for a demanufacturer to absorb the potential losses.

5.2.2 Demanufacturing Costs

The experiences from the collection pilots indicate that the demanufacturing program has the greatest overall impact on the net economics of a collection program. However, since few of the other costs associated with the collection programs were available for these case studies, the real costs of demanufacturing relative to, for example, program operation is not clear.

The high cost of demanufacturing is likely due to the labor-intensive nature of the process. All of the programs examined for this report used manual labor for most of their disassembly processes. This manual focus leads to a threshold of efficiency for disassembly. Since the effect of technology advances on the ability of a worker to take apart a TV or stereo is unknown, once all employees reach their maximum productivity, it can be assumed that the demanufacturer will have reached a maximum output of demanufactured material. At this point, the cost per pound demanufactured is at its lowest. Therefore, any increase in the inflow of EEE waste would require a concurrent increase in the size of the labor force, if the rate of outflow is to be maintained. While this will result in an incremental cost due to the increased labor, there will also be an increase in profit due to this increase in inflow.

There are other costs beyond the actual costs of demanufacturing labor, such as those for storage of equipment overflow. The demanufacturer may need to store some of the equipment it collects, since at least in the case of one-day drop-off collection events the demanufacturing rate is unlikely to be able to match the speed of equipment inflow. The impact and size of this cost is unknown, since it is highly dependent on the demanufacturer's capacity as well as the yield from the collection program. One demanufacturer, ERS, Inc., mentioned that storage costs for the drop-off events that it participated in had a substantial impact on the net cost, since the inflow of equipment it received was much greater than anticipated.

One other cost of relevance to demanufacturing is the cost of material disposal. It is obviously in the best interest of the demanufacturer to sell as much of the material that it extracts from the used equipment. It must dispose of all of the material that it cannot sell. The amount of waste that is produced depends on the amount of valueless material that is accepted from the collection program. The cost for this disposal varies since it depends on market prices for materials, the quality of the residential equipment that is collected, and the local disposal costs. Disposal costs may include those for refuse (plastics and wood) and waste materials (PCBs, batteries, low-grade circuit boards, CRTs, mercury switches).

The NJDEP is going to undertake research, with funding from the U.S. EPA, to expand markets for plastics derived from EEE waste collection. This research will require the assistance and participation of OEMs and plastic resin manufacturers, and may help determine ways to improve the current market for secondary materials.

5.2.3 Revenue

For the demanufacturer, revenue is the main business driver. Revenue can come from three sources: the resale of refurbished or working equipment, the sale of recovered scrap, and the assessment of a demanufacturing fee. The income from each of these sources depends on a number of variables: the market value of equipment/commodities, the efficiency of the demanufacturing program, the quality of the equipment that is collected (as well as its source–commercial versus residential), end-of-life management concerns, and relationship with the collection agency.

5.2.3.1 Resale

The evidence from the collection programs is that most of the equipment collected is either non-functional or outdated; refurbishment (i.e., repair) is generally not cost-effective.[18] However, for items that are working and have some economic value, resale can yield more revenue from an item than demanufacturing. The number of items that are available for resale is dependent on the age and type of the equipment that is collected. While there was no data on the average age of the items collected, anecdotal evidence suggests that much of it is relatively old and outdated (e.g., 286 series computers, console televisions, analog radios). Hennepin County estimates that the collected TVs are between 20 and 25 years old; the computers are 10 to 15 years old.

The data from the pilot programs indicates that there is no linear correlation between the amount of equipment collected and revenue from resale, which leads to the conclusion that a large amount of equipment collected does not necessarily translate into a large amount of revenue from resale. It is more related to the type of equipment that is collected.

While reuse of equipment can be a preferable waste management strategy, there is a potential cost that should be taken into consideration before equipment is resold. One demanufacturer commented about

REFURBISHMENT / REUSE IN EUROPE

The refurbishment of EEE waste is a well-established practice in Europe, but it is often done by OEMs and involves primarily the collection of commercial waste. One OEM has processed over 20,000 tons in a four-year period. The large scale of this operation is the key to its viability (and represents the problem for U.S. demanufacturers). The OEM handles distribution, repair, and spare parts, and assesses all of the incoming equipment in the following fashion:

1. Systems and equipment that have value on the open market are refurbished as required and then sold. The company finds that there is still demand for second-hand systems from companies that cannot afford new equipment.
2. Spare parts/assemblies from equipment that are not suitable for resale are removed and tested. Tested items are used by the OEM's repair service.
3. Components are removed and sold to traders.

The remaining materials from dismantling operations are sent to specialized recycling vendors. The OEM considers, however, that the amount of equipment recycled may increase over time, since items are becoming technologically out-of-date more quickly, making much of the collected equipment unusable.

A study in the Netherlands has shown that demanufacturing of EEE waste may be a better environmental option than either reuse in the Netherlands or export to other countries. One of the reasons cited for this conclusion is that older electronic and electrical equipment is much less energy efficient than current equipment.

SOURCE: Recovery of Waste from Electrical and Electronic Equipment: Economic and Environmental Impacts, A report produced for the European Commission DGXI, AEA Technology, AEAT/2004 Issue 1, July 1997

[18] The cost of parts and labor to repair a 286 computer, for example, generally exceeds the value of the repaired machine on the open market. No data was available on the costs or effectiveness of this option.

the problem of liability attached to the sale of working equipment received from a collection program.[19] If an item is sold and subsequently found to be defective, or if it injures the purchaser in some way, the costs of litigation would likely exceed the revenue derived from the initial sale. There are also potential liability concerns about data that may be left on an old computer system. This is an issue that should be anticipated, since the potential cost of the liability may not be worth the moderate revenue that is collected.

While the revenue that comes from the resale of EEE waste has the potential to be substantial, this was not the widespread fact in the pilots and programs examined in Section 3. There does not appear to be a positive correlation between the amount of equipment collected and the amount of revenue derived from resale. Therefore, it is not likely that this source of income will offset the costs of the demanufacturing programs. Resale revenue per pound collected is generally a fraction of the cost for collection and demanufacturing and disposal.

5.2.3.2 Sale of Scrap Material

The sale of scrap is the demanufacturer's bread and butter. The revenue from the commodities that make up EEE waste is dependent on two factors:

Revenue per commodity = commodity yield X commodity market price

While this is a simplistic relationship, the collection program can directly affect only one of its components - the commodity yield. The market price of the commodity is generally a result of elements outside the demanufacturer's control (in the short term), such as the price of virgin material or the demand for demanufactured material. However, understanding the variables that affect the yield of a commodity is useful in determining what items to target for collection.

Commodity Market Price

The following table[20] shows the ranges in revenue that can be collected for the commodity materials coming from EEE waste. The values are based on the value paid to one demanufacturer (Envirocycle, Inc.) for separated equipment at their loading dock at one point in time. The ranges indicate the *possible* value depending on market conditions and quality of the material.

In general, the higher values come from commercial EEE waste; most residential equipment that is collected will yield at most the lower of these values. In some cases, the poor quality of the residential equipment will yield no revenue or will even represent a cost. These values are presented merely to illustrate the potential range in value for these extracted commodities:

[19] Personal communication with The Electronic Resource Specialists, Inc., June 9, 1998. The demanufacturer also indicated concern about the chance that once the resold item does finally stop working, it will get thrown away rather than recycled, especially if the electronics collection is a periodic event. This would defeat the purpose of the collection program.

[20] *CSI Pilot Collection Project*. February 1998, pp 46.

Table 35: Potential Revenue for Extracted Materials

Commodity	Potential Revenue Range (per lb of material)*
Clean Plastic	$0.05 to $0.30
Printed Circuit Boards	$0.50 to $1.30
Fans	$0.07 to $0.10
Disc Drives	$0.15 to $0.25
Phone Plastic	$0.05 to $0.20
Cast Aluminum	$0.20 to $0.28
CRTs	$0.056
Metal	$0.01 to $0.025
Carcass	$0.01 to $0.05
Scrap Plastic	$0.00 to $0.01
Transistors	$0.01 to $0.05
Wire	$0.15 to $0.18
Aluminum	$0.35 to $0.40
Yokes	$0.15 to $0.19
Motors	$0.03 to $0.05
Capacitors	$0.02 to $0.05
Copper	$0.55 to $0.66
Radiators	$0.15
Power Supply	$0.06

*Prices are derived from off spec/commercial materials and not residential materials.

Essentially, the commodities with the highest value for the demanufacturer are those that have high precious metal content in their circuitry. Such is the case for a printed circuit board, which contains copper, gold, and silver, among other metals. The following table shows the average constitution of both a low grade[21] and high-grade[22] printed circuit board. Note that the low-grade circuit board reflects that quality of the material from residential collections (Section 3). The high-grade boards come from equipment that is generally collected from commercial entities.

Table 36: Circuit Board Metal Content

Metal	Low Grade Circuit Board	High Grade Circuit Board
Copper	16 to 18%	16 to 21%
Gold	<0.5 ounce/ton	2.5 to 46.5 ounces/ton
Silver	<5 ounce/ton	41.8 to 57.3 ounces/ton
Tin	Not analyzed	2.5 to 46.5 ounces/ton
Iron	Not analyzed	0 to 9%
Nickel	Not analyzed	1%
Lead	Not analyzed	0.7%

[21] Data is provided by Cheryl Lofrano-Zaske, Principal Planning Analyst, Problem Materials Program, Department of Public Works, Hennepin County Minnesota.

[22] *Mining discarded electronics*. H. Veldhuizen and B. Sippel. Industry and Environment. Volume 17, No. 3. July-September 1994, pp 9.

Arsenic	Not analyzed	0.02 to 0.03%
Cadmium	Not analyzed	Less than 0.01%

Other materials not found on circuit boards, such as copper wire or aluminum parts, also yield high revenues per pound. Under current market conditions, metals and electrical parts yield the best revenue from scrap. Based on this information, a demanufacturer needs to collect computers (containing metal parts, circuit boards, chips, and electrical parts) to gain the maximum revenue from demanufactured equipment.

All of the collection programs that were profiled focused on collecting this type of equipment.

Commodity Yield

The amount of the commodity that is extracted is also affected by the type and volume of the inflow of equipment, so the greater the participation, the greater the inflow, and the greater the volume of extracted material (assuming that demanufacturing efficiency stays constant). Therefore, one way for a demanufacturer to increase its profit is to work with the collection agency to promote the collection of equipment that is economically valuable from a commodity standpoint–computers and other commercial grade electronics.

The quality of the items that are collected greatly affects what commodities are extracted. A computer in bad condition will yield less revenue for its components than a similar computer in very good condition. A hypothesis that came from the Binghamton/Somerville report was that, as most of the older equipment is collected and leaves the residents' households, the collection events would start to take in newer equipment. This assumption has merit considering the inexpensive and disposable nature of most of today's technology. Continuing the assumption, this would mean that as time goes by, more high-grade material would be available for potential reuse, leading to higher revenues. While the validity of this scenario is unknown, there are some points that contradict this:

- There seems to be a lag time associated with the disposal of equipment. It is

IMPROVING DEMANUFACTURING

Recent studies in Japan have examined the amount of work required to disassemble electronic products. The results show that most of the improvement burden is on the OEM. For example, for PCs, the time required can be lowered by reducing the number of inter-connections, and by making fastenings, particularly screws, more easily accessible. Of course, the impact of these modifications will only have a long-term impact since these case studies have indicated that most electronic or electrical equipment is discarded when it is very old.

Also in Japan, steps have been taken to automate demanufacturing. In March of 1996 Sony constructed a pilot plant for the automated dismantling of TV sets. The $4 million plant was designed to handle around 100,000 TVs (from between 12 and 29 inches in size) a year. The size of the TV is determined using a video camera, and a circular saw makes cuts in the front and sides of the cabinet. The CRT is then dismantled using automated procedures. While no exact data is available on the cost of this system, the evidence suggests that the expense of the process outweighs its value.

SOURCE: Recovery of Waste from Electrical and Electronic Equipment: Economic and Environmental Impacts, A report produced for the European Commission DGXI, AEA Technology, AEAT/2004 Issue 1, July 1997.

logical to assume that if residents are now turning in 286 series computers or analog stereo equipment (items that are at least 10 years old) the lag in the disposal of today's Pentiums or digital VCRs would at least parallel this.

- In response to the concerns of consumers, OEMs are evaluating making computers that are easier to upgrade, which could minimize the need to buy a new computer (and dispose of the older one).
- Much of today's equipment is made with fewer precious metal components as companies try to reduce their production costs. This will lead to a smaller amount of valuable scrap material once the item is recycled.

The amount of revenue generated from the sale of commodities is dependent on the yield of revenue per commodity. To maximize this yield, the quality of the collected material must be high, the demanufacturing process must be at its optimum level, and the materials collected must contain

ELECTRONICS RECYCLING IN EUROPE AND JAPAN

Before the 1990s in Europe, the main items that were dismantled were mainframe computers for which the primary environmental concerns were relays and switches containing mercury. Items currently being disposed of contain lower concentrations of precious metals, but higher concentrations of other elements of concern, notably leaded glass from CRTs. This has lead to a change in the demanufacturing scheme: whereas originally demanufacturers paid companies for old mainframes, now companies must pay the demanufacturers to take the equipment.

The general practice in Europe is to first remove any hazardous components from the discarded equipment, such as batteries, mercury switches, and capacitors containing PCBs. Most items are then dismantled into components, one exception being products such as hi-fi equipment, which demanufacturers consider not economical for dismantling. These products are usually shredded, with metal and plastics then recovered from the shredded product.

The equipment is dismantled into four main components: metal, plastics, CRTs, and printed circuit boards. Some components are recovered for reuse. Hazardous components are sent to treatment facilities. Metal is sent to metal processors for recovery.

Circuit boards are generally sent to a copper refiner, who is able to deal with brominated flame-retardants in the circuit boards. The price paid to the smelter per board depends on their copper and precious metal contents. Shredding before smelting enables recovery of the steel and aluminum in the boards, but also distributes the precious metals between the two streams.

A technique being developed in Japan by NEC would first heat the circuit board to a temperature at which the solder melts, after which the components would be mechanically removed. The circuit board is then shredded and separated into glass fiber and copper. Whether this method is economically viable is not yet known.

SOURCE: Recovery of Waste from Electrical and Electronic Equipment: Economic and Environmental Impacts, A report produced for the European Commission DGXI, AEA Technology, AEAT/2004 Issue 1, July 1997.

commodities that have high market values. A collection agency can only directly affect the latter, and should focus its efforts on promoting the collection of economically valuable items while also evaluating relevant environmental impacts.

5.2.3.3 Demanufacturing Fee

A demanufacturing fee is charged of the collection agency running the program in order to cover the demanufacturer's disassembly costs. None of the collection pilots indicated that the participating demanufacturer charged a fee to cover the costs of its services. This is due to the fact that most of the programs were pilots, in which the demanufacturer provided in-kind services. In Hennepin County, no demanufacturing fee was charged because the county is the demanufacturer. However, it seems logical that a demanufacturer would assess a fee over the long term since in-kind services are not economically feasible for a demanufacturer. This fee would be a function of the amount of equipment taken in and the estimated revenue share and associated costs that could be obtained from that equipment. It is possible that, as the yield from the collected equipment increases and the demanufacturer begins to offset its costs, this fee could decrease over time.

5.3 THE COLLECTION AGENCY

Costs related to the setup, operation, and maintenance of an EEE waste collection program can vary, depending on the type of collection model that is in place. Most of these varying costs are directly incurred by the collection agency. For the collection agency, the program cost and demanufacturing fee appear to be the elements most affecting the net economics of their program. A user fee for service can also be evaluated on a site-specific basis.

In the following figure, the arrows leading out of the box labeled "Collection Agency" indicate the types of costs that a collection agency can incur from the organization and operation of an EEE waste collection program. The degree to which each of these individual costs affects the total cost for the program depends on the type of collection model. The costs range from short-term (up-front costs) to long-term (operational costs), and can be highly variable. Unlike the demanufacturer, the collection agency does not have many options available to offset these costs, except possibly from the implementation of a user fee (the arrow leading into the box). All of these issues will be discussed in the following sections.

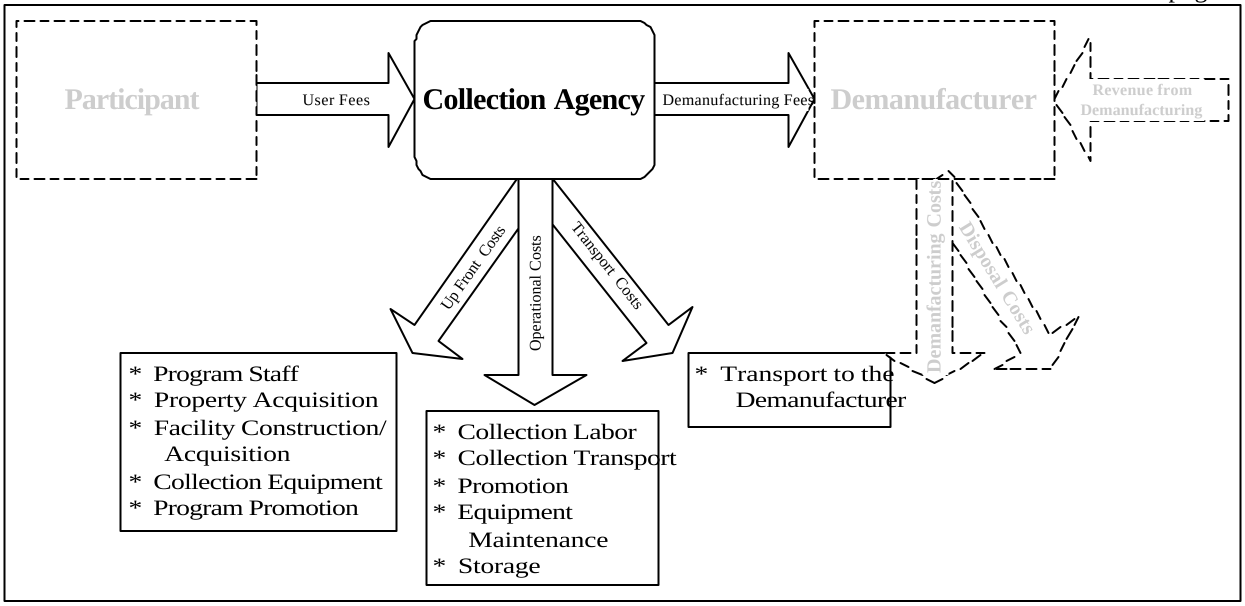


Figure 12: Cost and Revenue Streams for the Collection Agency

5.3.1 Role

The collection agency plays the central role in the design of a collection program since it organizes the program around its own needs and motivations. Prior to beginning the design and implementation of a program, the collection agency determines its overall goal. Determining the goal requires formulating not only the motivation (the 'why') behind the collection program but also the 'what to collect' and "how much to collect." The following table recaps what was covered in Section 3, and also outlines some of the motivations behind setting up a collection program.

Table 37: Motivation Behind Collection Programs: Summary Table

Motivation for the Program	***Program***
1. Feasibility of a program (CSI sponsored), resource conservation, Source Reduction	*Binghamton/Somerville; San Jose*
2. Source reduction, removal of heavy metals from MSW stream going to incinerator, resource conservation	*Hennepin County; Union County*
3. General community interest in recycling	*Hennepin County; Naperville; Somerville (post-pilot), Binghamton (post-pilot), San Jose (post-pilot)*
4. Reduction in landfilled material, resource conservation	*Naperville/ Wheaton*
5. Interest from / involvement with a demanufacturer	*Naperville/ Wheaton*

Not all of these motivations are relevant to all collection agencies; e.g., the removal of heavy metals from incinerator emissions and ash is of less concern to a community that landfills all of its waste.

It is interesting to note that all three of the CSI-sponsored events will be continuing. Since the impetus behind the continuation is public interest, it is possible that, over time, the net cost per pound collected will decrease for each of these programs.

While there are various motivations behind the creation of a program, there are essentially only three drivers behind "what to collect": the economic value of equipment, the environmental impact/toxicity of equipment, and the volume of equipment. Economic value drives the collection program only if the collection agency is the demanufacturer or if the demanufacturer's participation is dependent on the value received from the items collected. A discussion of items to collect for economic reasons is covered in Section 5.2.3.2.

For the programs concerned about the potential environmental burdens of EEE waste, the Union County and Hennepin County programs indicated that the items to target are those that contain metals such as cadmium, mercury, and lead. More specifically, these programs focused on:

- TVs
- VCRs
- microwaves
- Monitors
- keyboards
- audio/stereo equipment
- computers
- copiers
- telephones

MOTIVATIONS FOR COLLECTION: HOUSEHOLD HAZARDOUS WASTE

For Household Hazardous Waste (HHW) collection programs, one of the greatest benefits may be the fact that consumers are educated on HHW issues. According to a spokesperson for a hazardous waste handling firm, GSX Chemical Services, Inc "it is difficult to change peoples' behavior through public service announcements or pamphlets, …collection programs are attractive, and receive a lot of media attention".

This implies that collection programs have an inherent value in that they change people's behavior. The implementation of a collection program for EEE waste not only reduces the electronics in the MSW flow, but it also makes people aware of the importance of the issue and the benefits of recycling in general.

SOURCE: The Costs and Benefits of Household Hazardous Waste Collection Programs, Paddock, T.,

Finally, if the motivation is to reduce the amount of material that is landfilled, large volumes of equipment, such as TVs, monitors, computers, and microwaves, should be targeted. Of course, to reduce the volume as much as possible, all available EEE waste should be collected.

The final element for a collection agency to consider, or "how much to collect," should be based both on how much the demanufacturer can accept, and what equipment exists within the community. As was outlined earlier, once the efficiency threshold of a demanufacturer is reached, additional inflows of equipment require additional manpower. If collecting as much equipment as possible is the goal, the collection agency will need to consider the storage requirements for excess equipment. This is the case in Hennepin County, where, if the secondary smelter or any other end market shuts down, it must store the collected equipment until the demand for equipment resumes.

One important tool for determining "what" and "how much" to collect is a survey of the participating community. For example, if the participating community consists of predominately low-income residents, implementing a collection program that selectively targets computers will not likely return the greatest yield. Therefore, it is useful to determine what equipment exists in the community, and what volume is available. Unfortunately, the programs that were examined did not give much insight into the role of demographics in determining participation rates and the volume of equipment collected. All the same, it is suggested that the demographics of the community, as well as the existing solid waste infrastructure, be taken into account before the planning of a collection program.

5.3.2 Costs – Influence of Collection Method

The costs related to the method of collection are of interest to collection agencies considering an EEE waste collection program. These costs can be broken down into three categories: up-front, operational, and transport costs. Each of these categories is defined below.

5.3.2.1 Up-front Costs

The up-front, or setup, costs are the expenditures needed before the operation of a collection program. These costs can potentially include:

- Promotion of the event and public education on the program;
- Staff;
- Equipment acquisition;
- Building construction; and
- Land acquisition.

These are one-time outlays needed to cover the necessary infrastructure and setup for a program. Over time, these outlays are minimal in comparison to the operational costs. These costs are not all necessary; among the five EEE waste collection programs that were examined, only promotional costs were accounted for. In fact, the last three elements, equipment acquisition, building construction, and land acquisition are not likely to be costs that a collection agency will incur since no community would build an EEE waste collection program from scratch. They are included merely to give an idea of some of the potential costs.

5.3.2.2 Operational Costs

These costs cover the expenses of collecting, sorting, and storing the equipment, but exclude demanufacturing. They include:

- Collection labor;
- Collection transportation;
- Additional publicity;
- Storage;
- Equipment maintenance; and
- Waste management.

The operating expenses for a collection program are driven by the price of labor. The more manpower hours required collecting equipment, the greater the program cost. These labor costs can be reduced through the use of volunteer labor to cover traffic direction, vehicle unloading, equipment sorting, and the like. Additional publicity costs will undoubtedly be necessary throughout the life of the collection program. Operational costs relating to transportation, storage, and maintenance are dependent on the choice of collection model. The more action that is required by a collection agency to collect equipment, the higher these operational costs can be.

One consideration that a collection agency should keep in mind is the potential to collect equipment that may need special management. Such is that case in Hennepin County where equipment containing PCBs, older batteries and mercury switches frequently are collected. The waste management costs, depending on regulations governing the material, can potentially be high.

5.3.2.3 Transportation Costs

Transportation costs relate to the expense of transporting equipment to demanufacturing facilities. The experience pulled from these examples is that the distance that items are transported is highly variable, and is dependent on the demanufacturing scheme. Considering that the number of demanufacturers in a community may be very small, the transportation portion of the costs can have significant impacts on the net cost. While the collection agency cannot generally control the transportation distance, they can control the size of the load, which can have an effect on the transportation costs per pound.

5.3.2.4 Different Collection Models

The following sections examine the relationship between different collection models and the cost categories that were outlined above. The collection models each have a range of up-front, operational and transportation costs that depend on the *specific* structures of the programs. That is to say that not every drop-off event is going to be the same. The discussion also presents a number of the perceived advantages and barriers to the implementation of each particular model

♦ *Drop-off Events*

A drop-off event is a one-day event that is usually held over a weekend to maximize resident participation. The event generally is organized using existing municipal facilities (e.g., a parking lot, waste collection facility) and the up-front costs can be negligible. Publicity for the event is paramount since participation seems to require substantial advance warning of the event. The expense of this publicity depends on the size of the community, as well as the opportunities for free publicity. Volunteer participation during the event−for sorting, unloading, and stacking - can make operational costs minimal. Without volunteer help, the operating cost depends on the local labor rate and the turnout for the event. The transportation costs can vary greatly (see the transportation cost difference between Somerville and Binghamton) depending on the location of a suitable demanufacturer.

Barriers to the effectiveness of this model:

- Since the event is held on one day, ineffective or insufficient publicity can result in lower participation than is expected and desired.
- The timing of the event is essential to avoid creating conflicts with other events that might have a large attendance.
- Participation could be low if citizens are not used to participating in drop-off events for other recyclables.
- Work tasks for volunteers must be restricted to reduce potential liabilities (i.e., volunteers do not do any heavy lifting).

Advantages of this model:

- The up-front costs for this event can be low.
- The amount of material collected can be high, for a short amount of time.

♦ *Regional Approach*

Using the regional approach, multiple communities host coordinated events on a rotating basis. This is essentially the same as a drop-off event. The costs are similar to those for a drop-off event, except that the participating collection agencies share the costs.

Barriers to the effectiveness of this model:

- The distribution of costs related to participation can be unequal since not all communities may contribute the same amount of items to the collection.
- Rotating the location of the event may reduce participation if residents do not want to drive too far to drop off their EEE waste.
- Work tasks for volunteers must be restricted to reduce potential liabilities (i.e., volunteers do not do any heavy lifting).

Advantages of this model:

- There are economies of scale for the regional approach compared to the drop-off event model, since the cost per pound collected is split among the participating communities in the regional approach.
- Planning of the events is less complicated if the responsibility is shared.
- There is a larger base of residents from which EEE waste can be collected.

THE BENEFITS OF PERMANENT FACILITIES: HHW COLLECTION EXPERIENCES

Some communities in the United States are moving away from typical one-day collections for HHW and moving toward permanent centers that can accept the collected material. Experience from HHW programs indicates that permanent programs are more efficient because a person with waste can get rid of it properly when they have it, instead of having to wait until the next collection day. Permanent centers may also be cheaper in the long run because liaisons can be established for the reuse and recycling of wastes such as paint and used oil. The experience from HHW collection may help guide the development of programs for EEE waste collection. *SOURCE: Proceedings of the Fifth National Conference on Household Hazardous Waste Management*, Dana Duxbury & Associates, Andover, MA, November, 1990.

♦ *Permanent Collection Depot*

A permanent collection depot is essentially a year-round collection event. The up-front costs could be high for this model if the depot is developed solely for EEE waste. However, this is not likely to be the case since acquiring land, constructing a storage facility, and hiring staff are too costly for the small yield that would come from EEE waste collection. Normally the program would co-locate with a collection site for other items (glass, HHW, MSW), which would result in negligible up-front costs. The same principle would apply to operational costs. There are no costs for collection, but other operational costs, such as sorting of the materials and utilities would be split among the multiple materials. The transportation costs, of course, depend on the location of the demanufacturer relative to the collection site.

Barriers to the effectiveness of this model:

- The size of the community may not warrant the extra expense of year-round collection.
- The collection of data relative to the demographics of the participants and the type of equipment that is dropped off may require staff, which would increase operational costs.

Advantages of this model:

- Equipment can be collected year round, which could produce higher annual yields than would occur during periodic events; however, there was insufficient data to understand how much the yield would be affected.

- The collection model is more convenient for residents, who can drop off material when they prefer to do so.
- Economies of scale are possible since costs are reduced as the amount of equipment collected increases over time.

♦ *Curbside Collection*

The curbside collection model consists of the collection of EEE waste either on a periodic basis or by request. Beginning a curbside collection model from scratch would result in substantial up-front costs; however, the presence in the community of a curbside program for MSW or other recyclables would allow for an allocation of these up-front costs among the various programs. Publicity costs could be low as well since the presence of an existing program would indicate that the residents were aware of a collection program. Considering the small percentage of residential solid waste that consists of EEE waste, construction of a curbside collection program solely for these items would not make sense.

Coexistence of the EEE waste collection with an existing curbside collection program could also substantially reduce the operational costs, assuming that EEE waste collection occurs at the same time as the collection of other items. Transportation costs, as with the other collection models, vary depending on the location of the demanufacturing facility.

Barriers to the effectiveness of this model:

- Equipment sitting on the curb could potentially be stolen for parts, with any remaining material being thrown away. This would certainly affect yield from the demanufacturing.
- Even if the operation of the collection program coincides with the collection of other material, operational costs can be much higher than for other collection models.

Advantages of this model:

- Curbside pickup minimizes the "hassle" for residents, especially if they are used to curbside collection for other recyclables.
- Residents without transportation can more easily participate in the collection program.

♦ *Point-of-Purchase (Retail) Collection*

The point-of-purchase collection model implies that a retailer covers the costs for the collection and storage of EEE waste. Therefore, the only up-front costs for the collection agency consist of those for event publicity. Operational costs are minimal for a collection agency since a retailer's employees handle the operation. The transportation costs can vary, depending on the location of the retailer relative to the demanufacturer. This cost could increase if the retailer is not be able to set aside adequate storage space for the collected material and more frequent collections are required.

Barriers to the effectiveness of this model:

- The active participation of the retailer is essential to ensure good resident participation.
- Collection of data on participation is dependent on the retailer, who may not be able to collect the information.
- Logistical issues (storage space, collection from participants, etc.) can complicate the implementation.

Advantages of this model:

- The collection agency has low up-front and operational costs.
- There is the potential for a high yield, as was indicated by from the results of the San Jose pilot.
- The promotion of the program by retailers ensures high visibility.

♦ *Combined/Coordinated Collection Methods:*
This model is a combination of the various other collection models: drop-off events, curbside collection, permanent drop-off collection, and point-of-purchase drop-off. The costs of such a program is really just the sum of the costs of the individual models, so the net cost for the combined collection model should be higher than for a singular method. This approach is good when maximum coverage is desired and there is a suitable population to support the mix of models, such as in Hennepin County.

Barriers to the effectiveness of this model:

- The economies of scale are uncertain.
- The large scale of this model requires a large population to be viable.

Advantages of this model:

- The gaps created by one collection model can be filled by another model–i.e., residents who are far from a drop-off facility can participate in a local drop-off event.
- The regime allows for year-round collection of EEE waste.
- The combination may be good for a collection agency that has inhabitants spread over a large area.

Taking into consideration the analysis presented above on categories of cost, it is difficult to determine the *most* economical collection model. In fact, the choice of a model really hinges upon the goals of the program, the existing infrastructure for collection, and the demanufacturing capacity, rather than which model costs the least to run.

The following is a table summarizing the barriers and advantages of each collection model, as presented above.

Table 38: Summary of Advantages and Barriers to Collection Models

Collection Model	***Barriers***	***Advantages***
Drop-off Events	• Ineffective or insufficient publicity can result in low participation. • Conflicts with other events may affect participation. • Residents unfamiliarity with drop-off events can affect participation.	• Low up-front costs. • Short timeframe but high collection amount.
Regional Approach	• Potential unequal distribution of costs among communities.	• Economies of scale over single community drop-off event model. • Planning of the events is shared. • Larger base of residents to participate.
Permanent Collection Depot	• Not effective for every community size. • Need for staff may increase operational costs.	• Year- round collection of equipment. • Convenient for most residents. • Economies of scale are possible.
Curbside Collection	• Potential of theft of equipment for parts, and then abandonment.	• Minimal hassle for residents. accustomed to curbside collection.

	• Operational costs can be higher than other models.	• Residents without transportation can more easily participate.
Point of Purchase (Retail) Collection	• Retailers active participation is essential. • Retailer may not be able to collect the data on participation. • Logistical issues.	• Low up-front and operational costs for the collection agency. • Promotion of the program by retailers ensures high 'visibility.'
Combined/ Coordinated Collection Methods	• The economies of scale are uncertain. • Requires large population to be viable.	• The gaps created by one model can be filled by another model. • Year-round collection is possible. • Good if inhabitants are spread over a large area.

5.3.3 Minimizing Costs

The collection agency has some opportunities to minimize the cost of the collection that are not directly dependent on the collection model. The following points are relevant to nearly all collection models.

Use of Volunteers:

Using volunteers to assist with collection labor can be cost effective in that it reduces operational costs and allows more of the budget to be used for publicizing the program. The key to the effective use of volunteers is to clearly train them on their duties. This is especially true for volunteers who are charged with sorting equipment. Ineffective sorting could increase the cost of demanufacturing since the sorting would have to be done at the demanufacturing facility, which is not efficient. On the downside, liability issues related to the use of volunteers must be examined.

Assistance with Publicity:

The promotion of a collection event or program is essential to getting the maximum yield of EEE waste. The community newsletter, local chamber of commerce publications, and newspapers can be sources of free publicity. This will not only reduce the up-front costs but also promote the program to a wide audience. As an example, the news conference put on by the

OFFSETTING COSTS: HHW COLLECTION EXPERIENCES

Some communities have imposed user fees to create a fund for the management of HHW. However, these fees can be a deterrent to participation since residents in many states can legally throw HHW in the trash. In Anchorage, Alaska, for example, when the modest drop-off fee for HHW is waived during the month of May, the participation among residents jumps dramatically.

Rather than implement user fees, some states have instituted specific taxes for HHW programs. In New Hampshire, a tax on hazardous waste generators funds matching grants to communities for HHW collection. Retailers in Iowa selling products covered under a state shelf labeling law pay a $25 registration fee that covers HHW program costs.

Since it is legal to dispose of EEE waste in many states, the implementation of a user fee may lead to experiences similar to those for HHW collections. The experiences from HHW management programs should be considered when cost reduction options are examined.

SOURCE: *Household Hazardous Waste Mangement: A Manual for One-Day Community Collection Programs.* Office of Solid Waste and Emergency Response, US

U.S. EPA during the San Jose pilot received a large amount of free coverage from local papers and television stations, which sparked a surge in resident participation.

Piggybacking on Existing Recycling Program:

The existing waste collection infrastructure can make the setup costs of a curbside or permanent EEE waste collection program negligible. Operational costs can also be shared among the various collection programs, making the long-term collection of EEE waste more feasible. In a number of communities in Union County, the curbside collection program is held in conjunction with the curbside collection of bulk items, which leads to lower collection costs than would occur if the collection were solely for EEE waste. In addition, piggybacking on programs that residents are already familiar with can help to boost the participation rate for the program.

Formulating a Relationship with a Demanufacturer:

Most demanufacturers, at least over the long-term operation of a program, will charge a fee for demanufacturing services. However, if a demanufacturer becomes an integral part of the design of a collection program, it may be possible to convince that company to reduce or split any fee that they would charge. A demanufacturer would benefit from this through the ready access to a constant flow of equipment and the promotion of residential collection programs. The more collection programs that come into existence over the long run, the greater the potential economies of scale for a demanufacturer.

5.3.4 Revenue

Unless a collection agency has direct control over the demanufacturing scheme, they generally have little ability to generate revenue from a collection program. One exception is through the implementation of user fees. User fees refer to charging the participant a set fee per pound or per item of equipment that is dropped off. The effectiveness of such a tool is highly dependent on the population's desire to recycle. User fees in a community with low interest in recycling may have a deleterious effect on the overall participation rate.

For example, the Binghamton pilot implemented user fees ($2 per vehicle) during their first collection event, for which turnout was noticeably low – only 47 households out of 25,000. The user fee was abandoned during the second event, and turnout improved substantially – 128 households, of which only 10 had participated in the first event. However, whether this user fee was a disincentive to participation or not is unclear since there were other mitigating factors (the climate, construction, etc.) that affected the first event and not the second event. It is interesting to note that a high percentage of program participants surveyed in Binghamton and Somerville (over 80% in each community) indicated their willingness to pay between $1 and $5 to dispose of their EEE waste.

There are some issues to consider before implementing a user fee, particularly what alternative residents might have to paying the fee. Anecdotal data from the collection programs highlighted in Section 3 indicates that much of the EEE waste is either stored in the home because of some presumed economic value (e.g., an old computer) or is disposed of via the residential solid waste stream. These choices are relatively easy for a resident to make, especially for someone who is not overly concerned about recycling. Paying a fee for disposal can be seen as a more difficult choice to make.[23]

5.3.5 Avoided Costs

---

[23] A number of municipalities charge fees for tire or appliance disposal, which may be more viable because unwanted appliances and car tires take up large amounts of space and disposing of them in the trash is normally not an option.

Up to this point, the discussion of costs and revenue has focused on costs that were incurred either by the collection agency or the demanufacturer. There are, however, additional costs that are not easily quantifiable. These are termed the avoided costs. Avoided costs are defined as the reduction in costs of one MSW activity or path that results from use of a different MSW activity or path. Typically, avoided cost implies the reduction in the costs of collecting, transferring, transporting, and landfilling MSW that results from source reduction, recycling, composting, or waste-to-energy. The value of the avoided costs is dependent on whether the focus is on (1) specific MSW activities or paths, (2) the total costs of the entire system, (3) near-term marginal changes, or (4) longer-term major changes in the MSW program.[24]

If the focus of an assessment of avoided costs is merely a comparison of specific waste management activities, in this case EEE waste recycling and landfilling, then it is incorrect to assume that the cost per pound of the recycling should be subtracted from the avoided cost of landfilling to calculate a 'net cost' of recycling. That is, if the net cost for recycling is $100 per ton and the net cost of disposal is $90 per ton, then it is incorrect to say that the net cost of recycling is $10 per ton, taking into account the avoided cost of $90 per ton. The full costs per ton of recycling are not affected by any resulting avoided cost of landfilling. From this point of view, avoided costs for these programs cannot realistically be calculated.

However, if avoided costs are looked at on a larger scale, lower landfilling costs could occur as a result of the diversion of waste via an EEE waste collection program over a period of time. Over the long term, the recycling of EEE waste will reduce the collection agency's total outlay for landfilling. The reduction in total landfilling or incineration fees can be quantified; this value is the avoided cost. These avoided costs should not be considered as revenue, however, since they do not necessarily reduce the total costs of MSW management or the fees and taxes that residents must pay for solid waste management.

Even though the avoided costs for an EEE waste collection program should not be viewed in terms of the waste management costs that are offset, they are a good measure of the added value of a collection program. For the programs examined in Section 3, the avoided costs were associated with landfilling, whose cost per pound is small relative to that for collection and demanufacturing. However for the counties that use incineration, the avoided costs not only relate to the disposal of the ashes, but also to the avoided pollution.

Both Union County and Hennepin County initiated their EEE waste collection program based on their desire to reduce and eventually eliminate the environmental impacts of heavy metals in their incinerator ash. These programs seem to have had an effect, based on the data in the following table, which shows the calculated concentration of heavy metals in MSW, based on metals in the ash residue and air emissions. However, the specific contribution of the demanufacturing program to these reductions has not been calculated.

Table 39: Changes in Metal Concentration for Union County Incinerator Ash

Period	***Cd (mg/kg)***	***Pb (mg/kg)***	***Hg (mg/kg)***
Baseline			
Feb 94 to Nov 96	6.49	210.1	2.46

[24] *Full Cost Accounting for Municipal Solid Waste Management: A Handbook*. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response. Washington, DC. September 1997. EPA 530-R-95-041. pp. 52-55.

Since Debut of Collections			
Dec 96 to Aug 97	5.43	141.27	2.15
Apr 97 to Feb 98	3.75	117.41	2.22

Disposal of incinerator ash is controlled via Toxic Characteristic Leaching Procedure analysis that is used to determine whether or not a material is hazardous. The tipping fee for incinerator ash is dependent on this determination. Disposal of ash is typically more expensive than disposal in a solid waste landfill and the avoided costs will reflect this. Removing toxic constituents (e.g., EEE waste containing lead or cadmium) from the MSW stream may reduce the toxicity of the ash, and subsequently lead to lower management and disposal costs.

5.3.6 The Collection Agency and Demanufacturing

Just as there are drivers for a collection agency to develop an EEE waste collection program, there also are drivers that determine how the collected equipment should be demanufactured. a collection agency may take two approaches. The first is a private sector approach, which was the approach used in four of the case studies. The second is a public sector approach whose drivers are not solely economic. Both of these approaches are outlined below.

Private Sector:

The pilots have a unique relationship with the demanufacturer providing in-kind services or being subsidized by grant funding. More typically, a collection agency would enter a contractual relationship with a local demanufacturer. Ideally this relationship would allow the collection agency to transfer the collected equipment for free or even receive a portion of the revenue yield. However, it is more likely that there will be a fee based upon the volume or weight of equipment that is accepted. In this situation, the net costs for the collection agency would depend on those costs that are associated with the *collection* of the items. It is not known what a demanufacturer would actually charge a collection agency for accepting EEE waste since not enough data was available.

Public Sector/Non-profit:

This approach is the development of a public sector program to cover the demanufacturing of equipment. This could entail, for instance, the creation of a job-training program for lower-income residents or outsourcing of work to an association for the handicapped. Creating jobs and promoting job training are clear advantages to this approach. Another benefit is that any revenue from the demanufactured material can go toward offsetting the program costs. Additionally, it is possible that funding from social programs could offset some of the cost of this labor.

The difficulty with this method for most collection agencies is that they will bear all of the costs that were originally covered by the demanufacturer. As was pointed out earlier, demanufacturing costs are a substantial portion of the net costs for collection programs. The additional financial burden might be too large for most small- and medium-sized collection programs.

The following factors also influence the development of an EEE waste collection program:

Government Regulations Regarding CRTs:

The designation of some CRTs as hazardous waste by the federal Resource Conservation and Recovery Act, may limit the viability of an EEE waste collection program since items containing CRTs seem to make up a large portion of the total number of items collected. These regulations can affect the implementation of a program since permit requirements for the handling of hazardous waste restrict the number of firms that can recycle CRTs. This leads to higher overall demanufacturing costs because of high transportation and permitting costs if a remote demanufacturer is used. In the absence of an available demanufacturer to handle CRTs, the material will need to be disposed of by other means.

While this is the current situation for CRTs, some changes are occurring that may remove this barrier. In early 1999, the U.S. EPA expects to propose a rule under the Resource Conservation and Recovery Act that may streamline the requirements for managing CRTs while retaining controls to protect human health and the environment. The rule will also specify that once the CRT glass is processed such as to be usable as a raw material in CRT glass manufacturing, it is not subject to hazardous waste regulations (Appendix A). In addition, states have adopted their own policies and regulations for CRT management.

Limited Market for Demanufactured Material:

The quality and type of the equipment gathered in residential collections may also limit the market for recovered material. Currently, many local demanufacturers do not want to manage TVs. A large amount of the material that is recovered is plastic, which at the moment has little economic value compared to most of the other materials that are extracted. Additionally, few OEMs are willing to accept recycled material for use in their production processes. This is mainly due to incompatibility between different types of plastics, technical difficulties in sorting plastics, and problems with matching the colors of recycled and virgin material. In addition, some materials are a cost to market, including CRTs and low-grade boards, as well as the plastics.

5.3.7 Retailers

Retailers are crucial in the implementation of a point-of-purchase collection program, which, as presented in the case study, is really a partnership between retailers and government agencies. In this type of collection model, the retailer acts as the collection agency. The retailer absorbs many of the operational costs associated with the collection program, such as labor for sorting and storage costs. This shift allows the cooperating government agencies to focus on increasing participation to generate greater yields. Full cooperation is essential between the retailer and the interested government agencies to forge a public/private partnership.

For the retailer, there are number of benefits to participating in the collection program, namely:

- An inflow of potential customers who are disposing of used equipment;.
- A source of spare parts for equipment repair;
- Positive public relations – a "green" image; and
- Free publicity for the store via the collection agency’s promotion of the event.

The benefits retailers receive from this cooperation obviously depend on the participation rate for the program. Therefore full coordination with the collection agency is in the retailer’s best interest. In San Jose, the extensive publicity from the press conference had a marked effect on participation, which reflects an overall positive local attitude towards EEE waste collection in the area. The positive attitude of the public has motivated one the participating chains (Fry's Electronics) to continue the program at a number of its other stores.

5.4 THE PARTICIPANT

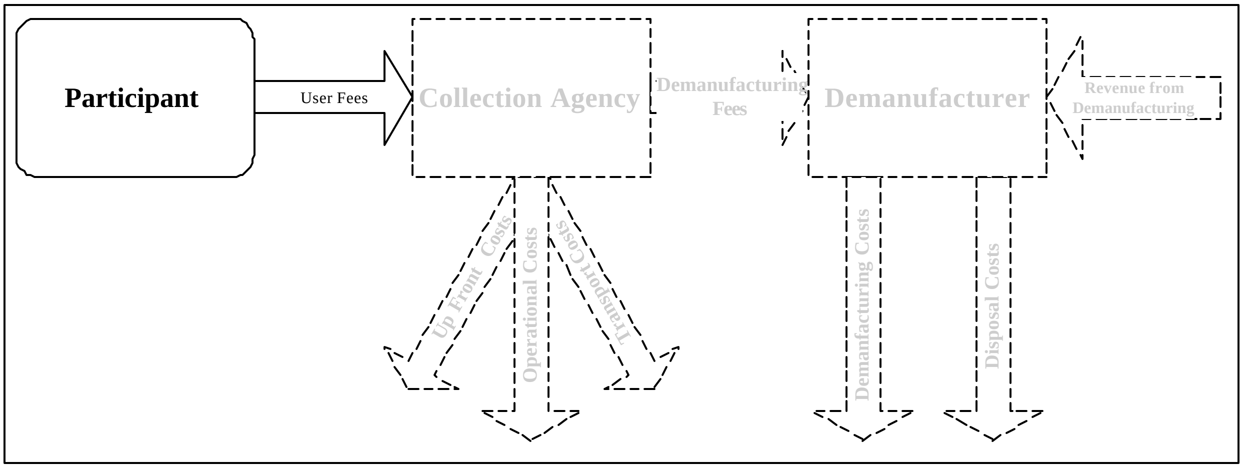


Figure 13: Cost and Revenue Streams for the Participant

Participants are essential to a collection program since strong resident turnout is vital for a program to generate sufficient amounts of equipment. A participant's involvement usually comes without any cost burden, aside from the situation where there is a user fee for the drop off of equipment (see discussion in Section 5.3.4). However, a free recycling program is not in and of itself a motivator for participation. Resident participation depends on more qualitative elements such as a predisposition toward recycling or adequate publicity for the program.

Some elements that may motivate a resident to participate may include:

- Easy access to events or drop-off facilities;
- Timing of the event to avoid poor weather or conflicting events (to the degree possible);
- Coordination of the event with other collection programs such as for tires, books, or bulky items; and
- Incentives, such as discount coupons for the purchase of new electronics or electrical equipment made available when equipment is dropped off.

The most important driver for participation is the promotion of the collection program; awareness is fundamental to a program's effectiveness. The programs that were profiled in Section 3 used a variety of methods to ensure that there was sufficient public knowledge of the event. These methods included (not an exhaustive list):

- Door hangers;
- Flyers sent to area schools;
- Articles promoting the program in local community newsletters;
- Newspaper coverage; and
- Flyers added to government employees' paychecks.

One of the methods that seemed to have the most impact on participation was the staging of a press conference in San Jose, which resulted in both television and newspaper coverage of the pilot. This allowed the program to reach a wide range of potential participants. The free press from this event provided a real boost to the collection event, which up to that point had collected no equipment. Whether any collection agency can duplicate the effectiveness of such an event is uncertain, however, since there were a number of dignitaries present at the San Jose publicity event that helped boost the coverage of the event.

According to a number of the collection program coordinators, one of the keys to effective publicity for a collection event is planning. This is certainly the case for drop-off events when a specific date has set aside for the collection. The experience of the San Jose pilot is that the lack of adequate publicity before the beginning of the event led to the zero yield during the first week.

5.5 OTHER STAKEHOLDERS

The previous sections outlined the roles that the collection agency, demanufacturer, and participant play in the development of an EEE waste collection program. Beyond these three essential stakeholders are some other actors who can have an effect on the design and function of an EEE waste collection program.

5.5.1 Government

In the context of this analysis, the federal government sponsored the discussion of EEE waste management programs under the Common Sense Initiative-Computer and Electronics Sector. However, no formal policy recommendation has been made at this time. In addition, a number of states are currently considering banning the landfilling of EEE waste or CRTs. Such a regulation would lead to the need for alternative waste management practices for such materials. This may actually force many communities to quickly implement programs that end up being costly to them in the short-term. The advantage may be that over time, an increase in the number of collection programs will lead to economies of scale as more demanufacturing firms are created to meet the demand for labor.

5.5.2 Private Industry

For the Union County program, Sharp Electronics, Lucent Technologies, Panasonic, and the Electronic Industries Alliance all provided in-kind support for the design and implementation of the pilots. However, aside from this program, private industry[25] did not play a *direct role* in the development of the EEE waste collection programs. Rather its influence has been on the upstream and downstream ends of the collection model, i.e., during the manufacturing of equipment, through the purchasing of recycled material, or in developing the demanufacturing sector to manage off-specification or return products. However, the Union County experience indicates that private industry will work directly with a collection agency to assist with the design and implementation of a collection program. Private industry could also become the collection agency via equipment take-back schemes, although the economics of this collection model is outside the scope of the study.

Private industry's indirect impacts are examined below.

<u>Upstream Impacts</u>:

[25] Private industry is includes Original Equipment Manufacturers (OEMs), their suppliers and primary materials manufacturers.

Changes in both consumer demand and technology can affect the lifespan of consumer equipment. While some of the EEE waste collected was mechanically sound, the technology was obsolete or undesirable, making reuse at end-of-life less viable than demanufacturing or disposal. Considering this, private industry has the greatest potential to make an impact on the end-of-life of this kind of waste by affecting the disassembly of the equipment. A modification in manufacturing methods, such as minimizing the number of fasteners in an item, could lead to a reduction in the amount of time required to demanufacture equipment. This reduction in time would eventually result in a decrease in the cost of demanufacturing.

Another production change that would assist the recycling of EEE waste would be the use of fewer heavy metal components in equipment. This could also have the effect of reducing many of the environmental concerns about landfilling or incinerating EEE waste. Realistically, however, OEMs and their suppliers face some limitations in how their equipment and components are designed. These upstream changes would not have an immediate impact; current changes in manufacturing will not affect collections for a number of years because of the time lag between equipment purchase and disposal. Over the long-term, however, the impact on the net costs of such a collection program would be favorable.

EEE Waste Collection and Producer Responsibility in Europe

Currently in the European Union there are discussions as to what role OEMs should play in the collection of EEE waste. Debates on a new directive on waste electrical and electronic equipment initially focused on placing most of the financial burdens of collection and demanufacturing on equipment producers. However, current plans have changed to place the burden of residential EEE waste collection on municipalities, while OEMs would still be obligated to accept the collected equipment.

Although this directive has not yet been finalized, the current debate indicates that the approach to EEE waste collection in Europe is to incorporate OEMs into the process, which will distribute the costs of the collection program.

SOURCE: Product Stewardship Advisor, Cutter Information Corp., September 4, 1998.

<u>Downstream Impacts</u>:

The most direct effect that private industry (predominantly parts suppliers and primary material producers) has on an EEE waste collection program is through the purchase of recycled material and parts. The market for some of the materials that are extracted from electronics is governed by demand from companies that produce the parts or the materials used in electronics or electrical equipment. Demand, however, is affected by concerns about the quality and quantity of the extracted material. In fact, it has become a Catch-22 since the insufficient supply of a recycled material leads to low demand by private industry, which in turn leads to fewer demanufacturers and less output of material. For private industry to assist in the expansion of EEE waste collection programs, demand for the recycled material needs to be increased. With the expansion of EEE waste collection programs, the supply of useful material will at least be guaranteed.

6. CONCLUSION

The focus of this report is to examine different collection programs and develop some general conclusions about the dynamics of an EEE waste collection program. All five of the case studies provided a large amount of information on demanufacturing costs, publicity, the volume of materials collected, etc., and although no clear picture was formed as to the best collection method, some general conclusions were reached. The precision of these conclusions, however, is limited by the data that was available. The following sections cover data gaps, future areas of research, and the general conclusions.

6.1 DATA GAPS AND FUTURE RESEARCH

One reason that a more in-depth assessment of these collection programs was not possible is that the data that was gathered for the study was not uniform. As was mentioned at the beginning of Section 4, the net cost for these programs was calculated using both demanufacturing and collection program costs. The advantage of this approach is that it gives a better picture of the true cost of managing such a program. The disadvantage is that costs that are specific to the collection agency or the demanufacturer are hidden in this net cost value. Therefore, it was difficult to break out what specific costs were the drivers for the program.

To provide for a more concise analysis in the future, the data gaps should be filled in. This would require more specific data from the collection agency on the following costs:

- Up-front costs –
  - Publicity
  - Staff;
- Operational costs –
  - Staff time allocated to the program
  - Costs of publicity for a program, including work that is completed in-house
  - Maintenance costs for facilities;
- Transportation to the demanufacturer;
- Fees paid to the demanufacturer (aside from transportation costs); and
- Ultimate disposal practices including CRT export for demanufacture and disposal.

This additional data would provide the collection agency with a clearer assessment of the real costs associated with the implementation of a collection program. This detailed information would also allow a collection agency to track the progress of its collection program.

The limitations on data also prevented an analysis of the effects that economies of scale can have on a program. With the existence of economies of scale, the expansion of a local collection program either in participation, frequency of events, or volume collected would result in a reduction in the net cost per pound collected. While this seems intuitively correct, there was not enough *long-term* data available to confirm that greater size leads to lower expenses. Data on changes in the program costs during the growth of a program would also be needed to accurately determine the effect of program size. Determining the effects of economies of scale would be important in helping to define the appropriate size of a collection program for a community.

Aside from the evident data gaps, there were a couple of areas of research, outside the scope of this report, that would provide information useful in the implementation of a residential EEE waste collection program.

One area is an analysis of the potential markets for many of the materials that are extracted from EEE waste. This would certainly be useful in the case of plastics, since a lot of the engineered plastics that are generated from EEE waste have no value in the marketplace. An analysis of potential markets for these secondary materials would allow a collection agency to determine whether the revenue from the extracted material may offset more of the program costs.

Parallel to this would be analysis of the equipment that was collected, and cost and revenue associated with each type of equipment. The results could be useful in structuring a collection program. Unfortunately, much of the data necessary for such a study was unavailable for this report.

An assessment of the environmental impact of EEE waste was also beyond the scope of this study, but could be useful in calculating the avoided or added costs associated with a collection program. It could also indicate what equipment a program should target. Considering that all of the collection programs operated at a net cost, more data on avoided costs could provide more complete information on the relative costs or benefits of initiating a collection program. An environmental life cycle assessment could also be useful in presenting the environmental trade-offs that exist for different EEE waste management options.

Finally, an investigation into the value of the regulation of demanufacturers could be another subject for future research. Representatives from both Hennepin County and the New Jersey Department of Environmental Protection have indicated that demanufacturers may be tempted to accept EEE waste and store it in warehouses, without having legitimate markets for the extracted materials. While there was no indication from the five case studies that this could be the case, the potential exists if EEE waste collection becomes a mandate in some areas.

6.2 CONCLUSIONS

While these differences in net costs among programs would seem to imply that some programs were more successful than others, differences in how the data was collected and provided for each programs makes such a judgment difficult. However, while making a comparison between these programs is not possible based a comparison of the net costs, it was still possible to use this data to make a limited assessment of the economics and dynamics of these collection programs:

- The net costs of the programs were driven by the demanufacturing costs; the operational costs for many of the case studies were either not accounted for or very small. However, since a number of these collection programs were pilots, this may not be the case for programs operating over longer periods.
- In terms of pounds of material collected per resident, the curbside collection programs appeared to be more efficient than the other collection models, while the one-day collection events appeared to the least efficient. More and better collection data is necessary to confirm this.
- In contrast to the previous point, the number of items collected per dollar of collection program cost was higher for the curbside events than for the other collection models. This was evidently due to the high transportation costs associated with collection. For the one-day collection events, the cost per item collected was lower than the other collection models. However, the one-day collection events that were studied did not incur any operating costs, which would likely narrow the differences between the two collection models.
- A weighted average of all of the collection programs indicates that over 75% of the equipment that was collected fell into five categories: 36% of the items were televisions, 16% consisted of audio

and stereo equipment, 11% were monitors, 8% were computers and CPUs, and 6% were VCRs. The remaining equipment consisted of keyboards (5%), printers (4%), telephones (3%), peripherals (1%), microwaves (1%), and miscellaneous other equipment (9%).

- The residential EEE waste collected by these programs was generally outdated and in poor condition. Consequently, the material was expensive to manage and little valuable scrap was extracted from this equipment. Of the equipment that was collected, computers and CPUs provided most of material that generated revenue for the programs.
- Items that contained CRTs (e.g., televisions and monitors) predominated in the five collection programs. Since the cost to manage these materials is quite high, the large number of CRTs had a substantial impact on the net cost values.
- Promotion and planning of the events was essential to the effectiveness of the collection programs. This was made evident by the lack of turnout for the first week of the San Jose pilot, for which there was little prior publicity. Additionally, the first Binghamton collection event was affected by a number of factors, including a local football game that was being held at the same time.
- There is apparent public interest in EEE waste collection programs. This is evident from the fact that the amount of equipment that was collected increased over time for all the programs that had more than one collection. In addition, the CSI-sponsored events (Somerville, Binghamton–one day drop off model and San Jose–retail collection model) will be continuing due to the positive public reception in their communities.

In addition to the specific conclusions from the analysis of these collection models, more general points were drawn from the information provided by these case studies. Since these general comments are based on qualitative information, additional research on these points would be beneficial.

- Most demanufacturers focus exclusively on commercial EEE waste. According to Hennepin County, the low quality of the residential equipment inhibits many demanufacturers from getting involved in a residential collection program. A collection program that takes in both residential and small business waste may generate more interest from demanufacturers, simply because the quality of EEE waste may be better.
- Total transportation, demanufacturing, and disposal costs may overwhelm all other program costs. These costs relate to the variety of material collected, local labor market, the distance required to transport materials to a demanufacturing facility, the distance to end markets, and the disposal costs of unmarketable materials.
- The loading of heavy metals in the Municipal Solid Waste stream was a fundamental driver for the two collection programs (Union County and Hennepin County) where most of the residential solid waste stream is incinerated. The counties advocate that the removal of EEE waste from the waste stream may play an important role in reducing the heavy metal burdens in the fly and bottom ash, which can result in an indirect economic benefit for the community by lowering ash disposal fees.
- The ultimate disposition of demanufactured materials should be evaluated to determine if these venues (e.g., glass-to-glass recycling, smelting, overseas disposition for CRTs) are in accordance with the objectives of the program.
- The advantages and barriers to different collection models are such that determining the best collection method is dependent on the motivations of the collection agency.

To put the current situation for these collection programs in perspective, it is useful to examine the experiences of other recycling programs. The proliferation of recycling programs in the 1980s resulted in a supply-driven market since the infrastructure required to accept recycled materials was still in development.[26] As a result, the net cost for many of these programs remained high since there was little revenue derived from the recycled materials. In the beginning, collection of recyclables tended to run ahead of capacity, with materials being made available to the recycling marketplace independent of the demand for the materials that were recovered. This mirrors the situation for EEE residential waste recycling today.

Today the issue of markets is still a critical issue. Public interest in recycling and private sector demand for products with recycled content have driven an increased industrial recycling capacity. While the capacity now exists, further market development still is needed to assure market stability and accessibility.

For the collection agency involved in recycling, it is important to understand that commodity-like marketplaces can be very volatile, sometimes demanding more scrap, sometimes demanding less scrap. Movements are traditionally difficult to predict. This volatility is driven by a number of factors. For ferrous and non-ferrous scrap metals, the price is generally related to the value of the virgin raw materials. For paper, plastic, and glass from MSW, the relationship is less direct, since it is dependent somewhat on the quality of the material. During the recovery of typical recyclables, some contamination is evident. Consequently, the recyclables may not be of as high a quality as the market demands.

The experiences collected from appliance or white goods recycling programs have some relevance to EEE waste collection. With space at a premium in the early 1990s, at least 16 states banned the disposal of white goods in landfills. This led to a jump in the recycling rate, which went from 20% in 1988 to 75% in 1995.[27] A similar growth in the recovery rate for EEE waste would not be surprising.

Like EEE waste, white goods have a high initial cost, and because of their perceived value, many people simply kept their old appliances rather than disposing of them. This is apparent when you consider that the typical age at disposal is from 10 to 20 years. Many municipalities rely on curbside collection, either through appointment or on designated days, as a means of collecting this material. However, according to a representative of the Appliance Recycling Centers of America, one-day collection events remain a popular method of collecting old units from the public.

For appliance recycling, not including the use of an auto shredder, labor costs account for 84% to 86% of the total operation costs. The labor costs are insensitive to volume, and increasing throughput has a relatively minor impact on the total cost per unit. This coincides with the current situation for EEE waste demanufacturing since it is also very labor intensive. The difference between the two types of demanufacturing is the materials that are recovered. Appliances contain a lot of ferrous metals, but little else of economic value. Electronics include a number of precious metals that makes their disassembly more cost affective, especially if markets develop over time.

Experiences with other types of recycling programs indicate that EEE residential waste collection programs are in their infancy, and have the potential to evolve and eventually become more cost effective. It could be expected that as these programs expand, and markets for the recovered materials grow, the net cost per pound collected should decrease. The potential economies of scale from the

---

[26] *The Role of Recycling in Integrated Solid Waste Management to the Year 2000*. Keep America Beautiful, Inc. Stamford, CT. 1994. pp. 5-1 to 5-6.

[27] *Handling Difficult Materials*. Waste Age. Randy Woods. May 1994. pp. 71-73.

expansion of these programs and the creation of demanufacturing businesses will also help to reduce costs. However, considering the quality and varied nature of the collected materials, it seems likely that the costs of these programs will remain high relative to other traditional solid waste disposal methods.

7 APPENDIX A: US EPA CRT RECOMMENDATION

COMMON SENSE INITIATIVE (CSI) COUNCIL RECOMMENDATION ON CATHODE RAY TUBE (CRT) GLASS-TO-GLASS RECYCLING

Based on in-depth work conducted by the CSI Computers and Electronics Sector Subcommittee, the CSI Council has determined that properly conducted Cathode Ray Tube (CRT) glass-to-glass recycling is a cleaner, cheaper, smarter approach to waste CRT management that should be increased. To facilitate accomplishing that goal, the CSI Council recommends that the U.S. Environmental Protection Agency:

1. Revise the applicable Resource Conservation and Recovery Act (RCRA) hazardous waste management regulations to facilitate CRT glass-to-glass recycling as outlined in Attachment 1. The revised CRT glass-to-glass recycling regulations should be clear and simple to understand. The Council asks that, as appropriate, EPA discuss with members of the Computers and Electronics Sector Subcommittee any new issues that arise during rule development and implementation.
2. Complete and implement this CRT rulemaking as soon as possible, and in the intervening period, take appropriate steps to realize the environmental benefits of CRT glass-to-glass recycling.

Finally, the CSI Council recognizes that there may be CRT glass recycling methods or end uses other than CRT manufacturing that are also cleaner, cheaper, and smarter approaches to waste CRT management. On the other hand, some recycling methods or end uses may pose risks to human health and the environment. The Computers and Electronics Subcommittee will be working to determine which recycling methods and end uses are preferable and to propose appropriate standards for such methods, but the Council is aware that the future of the Common Sense Initiative is undefined at this time. Thus, the Council asks that EPA consider any additional work completed by the Sector, and if appropriate, design the CRT glass-to-glass rule so that other legitimate recycling methods or end uses may be added in the future, including standards tailored to the risks and benefits of the recycling method or end use. The Council takes no position on the question of whether states should be allowed to add additional recycling methods or end uses without a prior determination by EPA.

ATTACHMENT 1: COMMON SENSE INITIATIVE COUNCIL RECOMMENDATION CATHODE RAY TUBE (CRT) GLASS-TO-GLASS RECYCLING

1. Add to the Resource Conservation Recovery Act (RCRA) hazardous waste management regulations new standards specific to CRT glass-to-glass recycling which will apply in place of the standard RCRA hazardous waste requirements. These new standards are to be structured in a manner similar to the Universal Waste rule (40 CFR Part 273). The regulation will include an exclusion from the definition of solid waste clarifying that processed CRT glass[28] that is to be reused in CRT glass manufacturing is not a solid waste subject to the RCRA hazardous waste regulations (including the new CRT standards described here). The Council recommends that EPA promulgate this exclusion because the processed CRT glass is sufficiently commodity-like based on the following factors: 1) the degree of processing the material has undergone is such that it requires little, if any, further processing, 2) the material has economic value, 3) the material is like an analogous raw material, and 4) there is a guaranteed end market for the material. Based on the information

[28] Processed CRT glass is glass that has been separated from non-glass components (e.g., TV/monitor plastic and metal components, implosion band, shadow mask, deflection yoke, electron gun, inner shield) and which has been cleaned to remove coatings (e.g., day, phosphors).

currently available to it, the Council also believes that the material is handled to minimize loss, but requests that EPA conduct whatever investigation EPA determines is appropriate to reach a final conclusion regarding this factor.

2. The new CRT glass-to-glass recycling standards will explain that they apply only to materials that are currently regulated hazardous waste. However, the standards will explain that the goal is that the standards be simple enough that one infrastructure develops for voluntarily managing all CRT materials in the same system.

3. The new CRT glass-to-glass recycling standards will define the following three categories of regulated entities:

   Collectors: Persons who collect/store whole TVS/monitors. Within this category, some requirements will apply only to large collectors (those who store 40 tons or more (~ 4,000 units) on-site for longer than 7 consecutive days).

   Processors: Persons who:
   - intentionally break CRTs;
   - manage intentionally broken CRT glass or cullet; or
   - clean coatings (e.g., dag, phosphors) from CRT glass.

   Transporters: Persons who transport TVS/monitors, whole CRTs, broken CRT glass, or cullet.

   Entities involved in refurbishment and disassembly of products containing CRTs (not to include taking apart the CRT[29]) are not subject to this standard or the RCRA hazardous waste regulations (40 CFR Parts 260 through 270) (on the basis of the CRT itself) until it is determined that these materials are not repairable or reusable. EPA will consider what safeguards are necessary, if any, to address environmental concerns associated with accumulation of large volumes of CRTs.

4. The new CRT glass-to-glass recycling standards will include the provisions illustrated in the following Table and detailed in Annex 1.

[29] EPA will consider other refurbishing activities that should be addressed in the same manner.

Table 40: Provisions Applicable To CRT Glass-To-Glass Regulated Entities

	REGULATED ENTITY		
PROVISION	**Collector**	**Processor**	**Transporter**
1. Notification	large collectors only	X	
2. Marking (on-site and for transport)	X	X	
3. Storage Limit	X	X	X
4. Shipping CRT Glass Materials	large collectors only: shipments out	X	
5. General Performance Standard	X	X	X
6. Prevent Releases of Glass Particulate		X	
7. General Good Management	X	X	X
8. Minimize Breakage	X		X
9. No Cross Contamination		X	
10. Manage Residues Appropriately		X	
11. Environmental Justice Provision		X	
12. Package for Transport	X	X	
13. Exports	X	X	

ANNEX 1: CRT GLASS-TO-GLASS RECYCLING PROVISIONS

1. **Notification**: One-time notice to the agency implementing the hazardous waste regulations (EPA or the state) of company name, location, activities, etc.

2. **Marking**: Materials must be marked in accordance with either (1) or (2) below.

   (1) CSI/CRT approach:

   (a) Whole TVS/monitors visible when looking at primary packaging (container or vehicle body): no marking required.

   (b) TVs/monitors, bare CRTs, and glass in packages (i.e., containers or vehicle bodies) or storage areas: mark container or storage area with the following words: "Cathode ray tubes (CRT) or CRT glass to be used in CRT glass manufacturing. Contains lead. Do not mix with other glass or materials."

   (2) Universal Waste approach for materials in transportation: If the state in which the shipment originated has Universal Waste marking standards (i.e., labeling with text) for the material: mark (label) the material as required under the originating state's Universal Waste program.

3. **Storage Limit**: Collectors -- 1 year + as described in 40 CFR 273.15. Processors -- 1+ year as described in 40 CFR 261.1(c)(8). Transporters -- 10 days as described in 40 CFR 273.53.

4. **Shipping CRT Materials**: Maintain records for 3 years. No specified form for records.

   Small and large collectors -- may send shipments only to other collectors or to processors in CRT system.
   Large collectors -- for each outgoing shipment, keep records of quantity, date, name and address of person shipped to, and an acknowledgment of receipt from the recipient.
   Processors -- 1) all TC hazardous glass that is technically and economically usable in CRT glass manufacturing must be sent to a CRT glass manufacturer for use in CRT glass manufacturing. 2) for each incoming and outgoing shipment, keep records of quantity, date, name, and address of person shipped to, and an acknowledgment of receipt from the recipient. 3) Annually, prepare a certified statement stating that all TC hazardous glass that is technically and economically usable in CRT glass manufacturing was sent to a CRT glass manufacturer for use in CRT glass manufacturing.

5. **General Performance Standard**: Manage and/or transport CRT materials in a way that prevents releases to the environment of glass pieces, glass particulate, other components, and materials used in processing (e.g., cleaning or sorting media). Immediately contain any releases to the environment and manage contained material under applicable waste management requirements.

6. **Prevent Releases of Glass Particulate**: For any storage or management activities involving breaking glass or managing broken glass, install and maintain systems sufficient to minimize releases of glass and glass particulate via wind dispersal, runoff, and direct releases to soil. (Examples of wind dispersal control systems may include: a good condition building; closed containers; closed tanks; keeping materials stored or managed outdoors covered, or wet, as appropriate. Examples of systems for preventing releases to soil directly may include: an impervious floor or pad; a good condition building. Examples of systems for preventing releases via runoff may include: a good condition building; implementing an approved storm-water management plan; adequate run-off controls.)

7. **General Good Management**:
   - -- Collectors, Processors, Transporters -- no disposal on-site
   - -- Collectors and Transporters -- no dilution, no treatment (dismantling, intentional breakage, processing)
   - -- Processors -- no combustion or treatment activities using temperatures high enough to volatilize lead from CRT glass, no storage or processing in surface impoundments

8. **Minimize breakage**: Collectors -- manage to minimize breakage of TVS/monitors. Transporters -- transport to minimize breakage of TVS/monitors, CRTs, glass pieces.

9. **No Cross-Contamination**: Do not mix TC hazardous CRT glass with other glass that is not going to CRT glass manufacturing. Blending of glass that is going to glass manufacturing is allowed.

10. **Manage Residues Appropriately**: Manage any components removed during dismantling, any residues separated from glass (e.g., coatings), and residues from processing glass (e.g., blast media, cleaning media, dust, floor sweepings, glass fines) under applicable waste management requirements (hazardous waste, solid waste).

11. **Environmental Justice**: For new processors -- implement a procedure for advising the local community of the nature of the activities to be conducted, including the limited potential for resident and worker exposure to lead or chemical coatings. This procedure should include notice to the community, and a public meeting if requested by the community. A local, state, or federal governmental authority must approve the text of the notice and the notice procedure, and must conduct the meeting, if any. If preexisting state or local siting/zoning or other procedures meeting these standards are followed, no additional action is necessary.

12. **Package for Transport**: Materials must be packaged in accordance with either (1) or (2) below.

    (1) CSI/CRT approach:

    (a) Package TVs, monitors, or whole CRTs in a way that minimizes breakage during normal shipping conditions. The packaging must minimize releases to the environment if unintentional breakage does occur. For example, if TVs and monitors are shrink wrapped onto pallets in such way that broken pieces of glass might not be contained, the packed pallets should be placed in an outside package (e.g., a box or vehicle body) that will minimize releases.

    (b) Package broken CRTs, CRT glass pieces, or CRT glass cullet in siftproof packaging (i.e., a container or vehicle) that is constructed, filled, and closed so that: (I) There will be no identifiable releases of CRT glass to the environment, and (II) The effectiveness of the package will not be reduced during normal shipping conditions. For example, packages should be resistant to puncture by glass pieces.

    (2) Universal Waste approach for materials in transportation: If the state in which the shipment originated has Universal Waste packaging standards for the material: package the material as required under the originating state's Universal Waste program.

13. **Exports**: For shipments of materials that are hazardous waste, other than processed CRT glass (without coatings) -- comply with 40 CFR 262 Subparts E or H (export notice and consent procedures for non-OECD and OECD countries), revised to specifically identify the recipient as a

CRT glass manufacturer, or a collector/ processor shipping to a CRT glass manufacturer (also identify the manufacturer).

Collection data for the San Francisco Area collection program was not available in time for this report. However, a summary of the program's structure and the general summary data that was available is presented below.

Collection Method:	Drop-off event and curbside collection
Number of Collections:	10 days (Oakland and San Francisco), 1 day Hayward
Collection Dates:	March 28, 1998 and May 11-22, 1998
Demanufacturer:	East Bay Conservation Corps (EBCC) in Oakland

Motivation Behind Collection:

Materials for the Future Foundation, a San Francisco area NGO, initiated three collection programs in the San Francisco Bay Area with the help of local community-based organizations and businesses. The collection program consisted of a drop-off event in the City of Hayward, a Residential Super Recycling Day in San Francisco, curbside collection in San Francisco, and curbside collection paired with bulky waste pickup in Oakland. At the time of publication, detailed information was only available for the Oakland collection pilot.

The motivation behind all of the collection pilots was to document the flow of electronic and electrical products into the residential waste stream and to determine if the recovered EEE waste could be recycled in a cost-effective manner. In addition, the collection program in Oakland was designed to determine:

- Whether a youth employment training organization (East Bay Conservation Corps) can recycle materials for the Oakland Bulky Waste Collection Program; and
- Whether Oakland residents would participate in a curbside EEE waste collection program.

Demographics:

The end-of-life electronic and electrical waste was collected in three communities. The area is a mixture of blue-collar and white-collar workers. The Oakland collection program was organized so that the collection would cover a diverse range of household income and property values.

Table 41: San Francisco/Hayward/Oakland Demographics

Municipality	*Population*	*Households*	*Median Income*
San Francisco	723,959	305,984	$40,561
Hayward	111,498	40,246	$40,246
Oakland	372,242	144,766	$37,000

Event Promotion:

The Oakland Collection program was advertised using fliers for the Bulky Waste Pick-up sent to Oakland neighborhoods approximately three weeks prior to the collection program. A special insert that outlined the EEE waste collection component was included within the flyer.

Informal interviews with residents during the collection programs indicated that the residents were aware of the EEE waste collection program. However, many appeared not to have separated the EEE waste from the other bulky waste, as was requested in the flyer.

Resident Participation:

The following table outlines the data that was collected on the participation of residents in the various collection pilots.

Table 42: Collection Program Participation Rates

Municipality	***No. of Households***	***Participation Rate***
San Francisco	13,392	4.4%
Hayward	222	0.6%
Oakland	3,692	2.6%

Collection:

The collection of EEE waste in Oakland coincided with the collection of residential bulky waste. Residents of Oakland can participate in an annual Bulky Waste Pick-up day during which Waste Management, Inc. (the city contractor) collects white goods, tires, furniture, and yard trimmings. The program collects from approximately 300 households a day. The bulky waste collection is timed to correspond with residential garbage collection. Two trucks are allocated to the collection of white goods and tires, and the rest of the collected material is picked up by a garbage truck carrying a hopper.

Materials for the Future Foundation worked with the Oakland Recycling/Solid Waste staff to coordinate the collection of the EEE waste. The collection program occurred over a period of 10 days. To accommodate the extra collection, a driver was added. The cost of the additional driver for the collection was given as $4,300 for the 10-day project. The EEE waste was collected from the curbside, and placed in Gaylords aboard a flat bed truck. When the collection truck was full, the material was transported to the EBCC location for demanufacturing. The following table outlines the equipment that was collected:

Table 43: Items Collected During Oakland Collection Pilot

	Computers	***Vacuums***	***Heaters***	***Fans***	***TVs***	***VCRs***	***Microwaves***	***Stereos***
Oakland	55	93	23	31	198	20	54	117

In addition, the collection events also took in a number of toasters, carpet cleaners, answering machines, and other equipment. In total, 15,623 pounds of equipment was collected during the 10-day program.

Transportation:

The transportation of the collected equipment occurred whenever the truck was full and generally took 15 to 25 minutes, depending on the location of the Bulky Waste collection in relation to EBCC (demanufacturing contractor). No data was available on the costs associated with the transportation.

Demanufacturing:

The East Bay Conservation Corps (EBCC), a youth employment training organization, was the demanufacturer. The collected EEE waste was off-loaded at the EBCC facility, where the employees labeled and itemized the equipment. The employees had not been specifically trained to demanufacture EEE waste, and the volume of TVs and microwaves proved to be a challenge to disassemble.

The program required a total of 4 workers and a supervisor working 40 hours per week for two weeks to demanufacture the collected equipment. The off-loading of equipment took time away from the dismantling, at least an hour per shipment. The itemizing of the equipment also took some time. Since the contract was for a limited duration, not all of the equipment was disassembled. No data was available on the cost of the demanufacturing of the collected equipment.

Revenue:

The EBCC initially anticipated that the circuit boards and other computer components might generate some revenue. However, since not enough time was available for them to disassemble the equipment, most of the material that was recycled consisted of scrap metal from vacuum cleaners, heaters, and small appliances.

Some of the plastics were sent to a company, MBA Polymers for recovery. Most of material that MBA Polymers was able to recover consisted of plastic from TV housings. No data was available on any revenue from the recovered materials.

Net Cost:

Since the only data available consisted of the additional cost of collection for the Oakland pilot ($4,300), net cost was not calculated for this collection pilot.

Project Comments:

The summary reports for all three collection pilots are not yet published, so data was not available for a more detailed analysis. According to the draft report on the Oakland collection program, there were a number of barriers and opportunities that came out of this collection program:

- The residents did not sort their material as requested in the flyers that were sent out, and subsequently the collection process took longer. The Waste Management, Inc. supervisor in charge of the Bulky Waste collection indicated that the drivers should not separate out the EEE waste.
- The demanufacturer was not prepared to demanufacture all of the equipment in the time period of the contract. A number of TVs were left on the curbside because of lack of space in the EPCC facility. In addition, off-loading and itemization of the equipment took time away from the actual demanufacturing. The EPCC employees' inexperience with disassembly may have contributed to the partial demanufacturing of much of the equipment.

- MBA Polymers, the company that accepted much of the plastic from EPCC's operations, indicated that the recovery of plastic from residential EEE waste was feasible. The television and computer housing appeared to be the best candidates for recovery. MBA stressed that a sufficient volume of material would be necessary to sustain such an operation, and that a proper level of dismantling would be required to make plastic recovery possible.

9 Appendix C: Calculating Net Cost

The cost and revenue values for each of the five collection programs were calculated using data provided by the respective program organizers. No additional data was collected for this report. The total costs and revenue were calculated according to the way in which the data was provided by the participating collection agency:

Per Event	Somerville; Binghamton; Wheaton; Naperville
Per Period	San Jose (5 week period); Union County Municipalities (6 month periods)
Per Year	Hennepin County

For calculation of the net cost, the following two equations were used:

Total Cost = $C_T + C_D + C_U + C_O$

where C_T = costs associated with the transport to the demanufacturer

C_D = costs from the demanufacturing of the equipment

C_U = upfront costs (publicity etc.)

C_O = operating costs.

Total Revenue = $R_R + R_S$

where R_R = revenue from resale

R_S = revenue from scrap.

Only those costs and revenues for which data was available were used in the equations; that is, if no upfront costs were available (C_U), the value was assumed to be zero.

The net cost per program is essentially the difference between these two values:

Net Cost = Total Cost – Total Revenue

The net cost per pound collected was calculated as the net cost divided by the number of pounds of material collected for the program.

The total cost per pound collected was calculated as the total cost divided by the number of pounds of material collected for the program.

10 APPENDIX D: BIBLIOGRAPHY

1. U.S. Environmental Protection Agency, *Residential Collection of Household End-of-Life Electrical and Electronic Equipment: Pilot Collection Project* (EPA-901-R-98-002), prepared by Northeast Resource Recovery Association for the Common Sense Initiative – Computer and Electronics Sector, Region I, Boston, MA, February 1998.

2. US Environmental Protection Agency, *San Jose Computer Collection and Recycling Pilot: Draft*, prepared by Vista Environmental for the Common Sense Initiative – Computer and Electronics Sector, Region IX, San Francisco, CA, February 1998.

3. Union County Utilities Authority, *Union County Demanufacturing Program - Semi-Annual Report*, Union County, NJ, October 1, 1997-March 31, 1998.

4. Bureau of the Census, *Census of Population and Housing, 1990*, Washington, DC, 1992.

5. U.S. Environmental Protection Agency, *Household Hazardous Waste Management: A Manual for One-Day Community Collection Programs* (EPA-530-R-92-026), prepared by the Waste Watch Center for the Office of Solid Waste and Emergency Response, Washington, DC, August 1993.

6. United States Environmental Protection Agency, *Full Cost Accounting for Municipal Solid Waste Management: A Handbook* (EPA 530-R-95-041), Office of Solid Waste and Emergency Response, Washington, DC, September 1997.

7. European Commission, *Recovery of Waste from Electrical and Electronic Equipment: Economic and Environmental Impacts* (AEAT/2004 Issue 1), prepared by AEA Technology for the European Commission DGXI, Oxfordshire, UK, July 1997.

8. Keep America Beautiful, Inc., *The Role of Recycling in Integrated Solid Waste Management to the Year 2000*, prepared by Franklin Associates, Stamford, CT, 1994.

9. Dana Duxbury & Associates, *Proceedings of the Fifth National Conference on Household Hazardous Waste Management*, Andover, MA, November, 1990.

10. H. Veldhuizen and B. Sippel, "Mining discarded electronics", Industry and Environment, Volume 17, No. 3, United Nations Environment Program, July-September 1994.

11. R. Woods, "Handling Difficult Materials", Waste Age. May 1994.

12. Cutter Information Corp., "Europe Moves Toward Integrated Product Policy", Product Stewardship Advisor, September 4, 1998.

13. T. Paddock, "The Costs and Benefits of Household Hazardous Waste Collection Programs", Academy of Natural Sciences, October 1989.