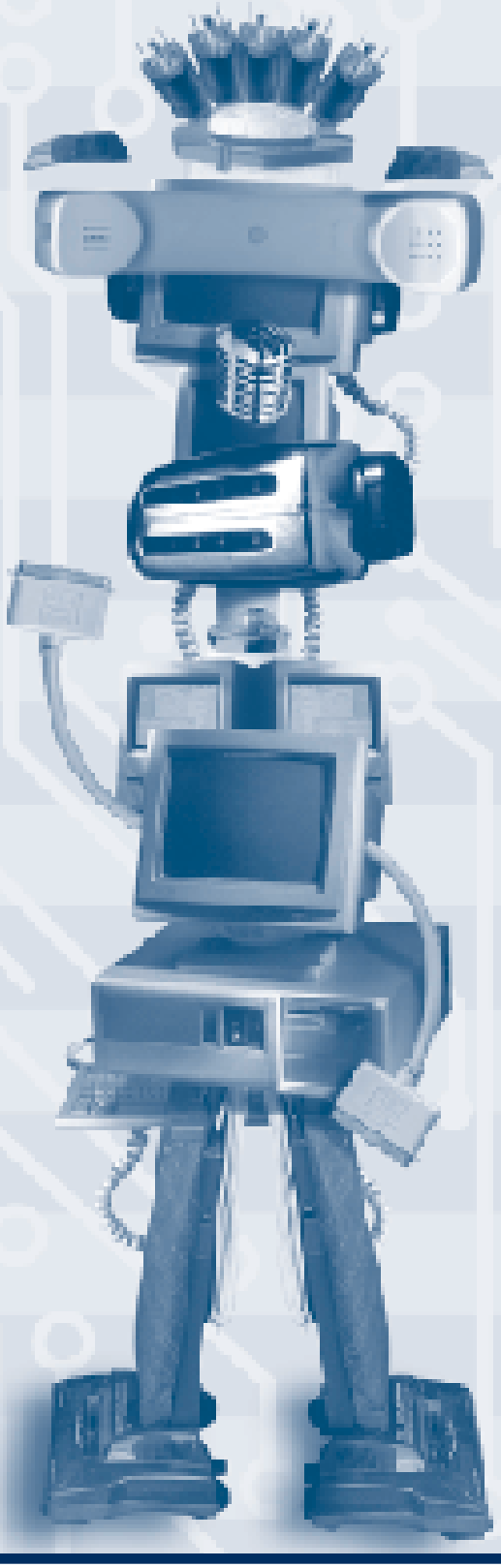

BAY AREA ELECTRONIC RECYCLING

From the corporate office to the curbside

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Introduction

In a project sponsored by the Alameda County Waste Management Authority and Recycling Board and the City of San Francisco Recycling Program, Materials for the Future Foundation (MFF) worked with community-based nonprofit organizations (CBOs) and local businesses to identify the types and quantity of electronic products discarded by residents in Oakland, Hayward and San Francisco. This project investigated how these products could be recycled to contribute to the local economy and reduce waste deposited in municipal landfills.

> MFF found that the lure of precious metals, other metals such as tin, copper and iron, and valuable parts such as computer chips found inside electronic products, has spawned a network of recyclers. In one of the first attempts to map the flow and the volume of the electronic waste stream in the Bay Area, MFF conducted waste assessments and interviewed these curbside scavengers, local recyclers, waste haulers, nonprofit retailers and corportions.

And what were we told? The amount of valuable precious metals is declining, the hard-to-recycle plastic is becoming more plentiful and the materials that are collected generally have a low value. We also found that the recycling laws, investments in local processing facilities and electronic product designs for recycling are not keeping pace with rapid changes in the electronics industry.

> The electronics industry is one of the largest manufacturing segments in the United States. Major intellectual and financial resources are invested in applying cutting-edge science to the design, manufacturing and marketing of new consumer electronic products. However, the same intellectual and financial resources are not equally invested in trying to minimize the impact of electronics on the environment. De-manufacturing, reselling and recycling electronic products are rarely considered in product design.

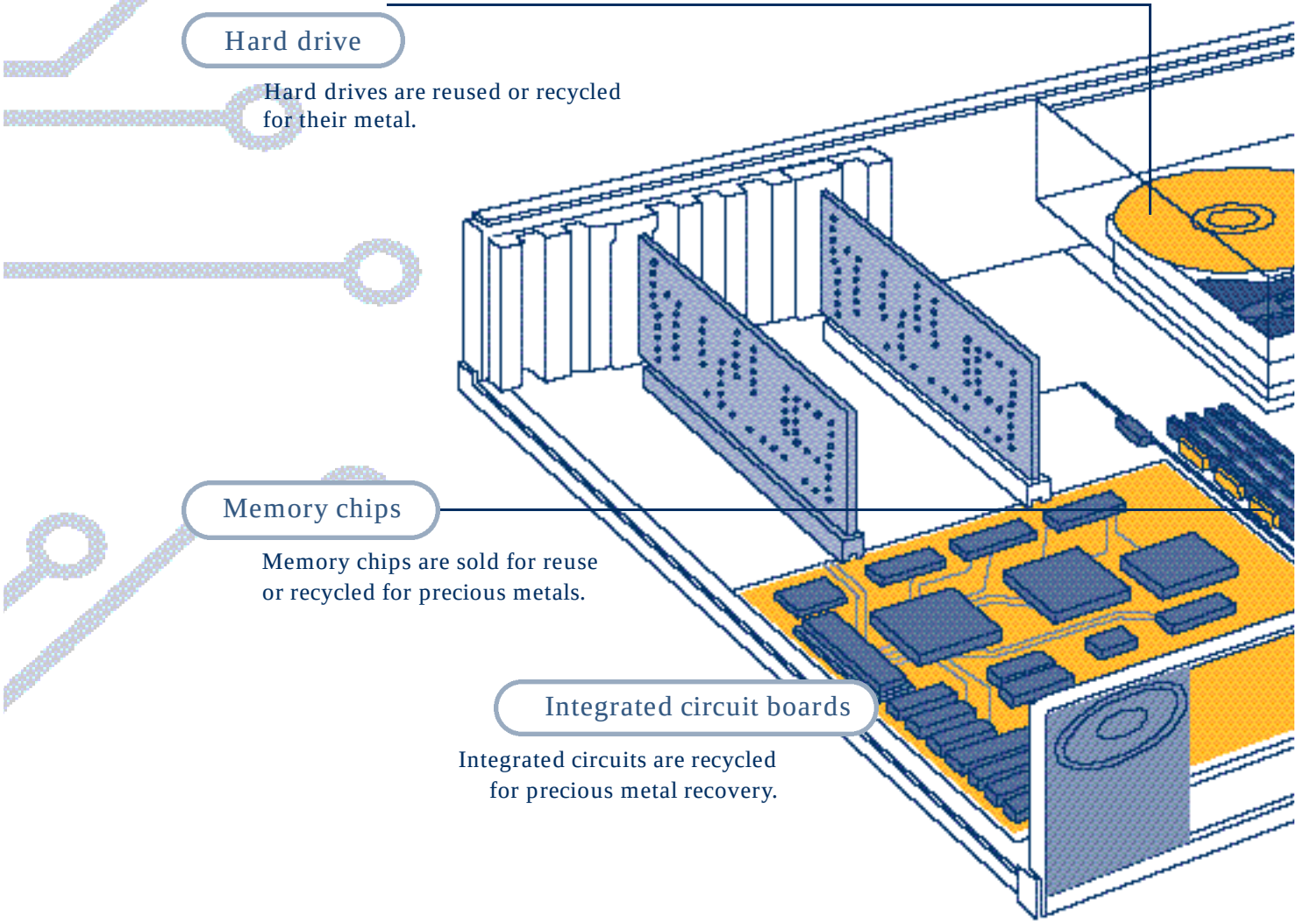
Western Europeans are addressing their environmental concerns with laws that require electronic manufacturers to take back and recycle their products at the end of the product's use. However, those in the electronics industry feel hat such a system may not be applicable for the United States where the government has instead invested in local waste management and recycling systems. An example of such an investment is the 1989 California law AB939, which mandates local municipalities to reduce materials going to the landfill 50 percent by the year 2000. Counties have responded to the challenge by implementing residential curbside recycling programs and recycling market development programs. However, local governments can only do so much.

> **Materials cannot be effectively diverted from the landfill without the participation of the industries that make the products and the consumers who buy them.** On the brink of a new millennium, the Bay Area would be remiss in not applying our strong environmental advocacy, technological know-how and can-do attitude to creating environmentally sustainable products and additional materials-recovery and recycling systems.

MFF's mission is to create jobs through resource conservation. We are excited to share what we have learned about the existing electronic recycling infrastructure and to invite government, corporate representatives, CBOs and consumers to explore ways to protect the environment and open the door for new jobs, business opportunities and technological innovations in recycling.

What materials are found in electronic

Household appliances are referred to as brown goods and large appliances such as refrigerators, stoves and washing machines as white goods. White goods are banned from landfills in California[1] and are not discussed in this document. Brown goods are recycled only when it is economically feasible and often go to the landfills. Inconsistent recycling services and processing facilities in California add to the difficulty of recycling electronic appliances.



Computers contain enough valuable advanced-integrated circuitry, high-value metals and other components to merit recycling. Consumers assign higher monetary value to computers and want to recover that value through donations or resale of their old computers. The path to a final resting

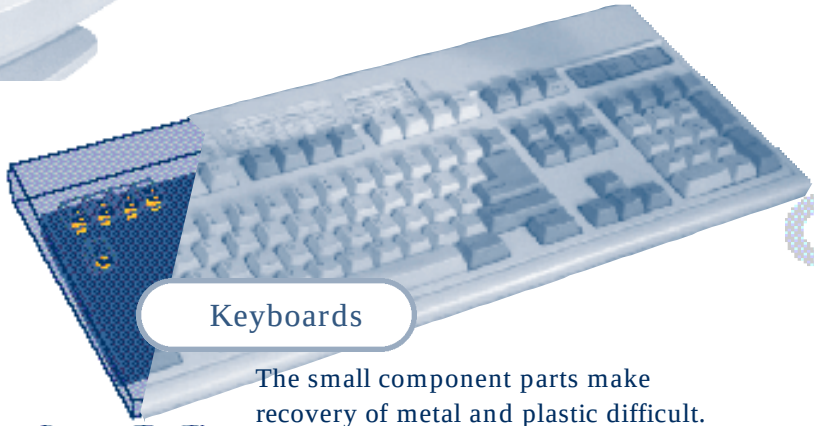
products, and which are recyclable?

Plastic housings

Metals, glues, laminates, other contaminates and a mixture of different plastic types make plastic difficult to recycle.

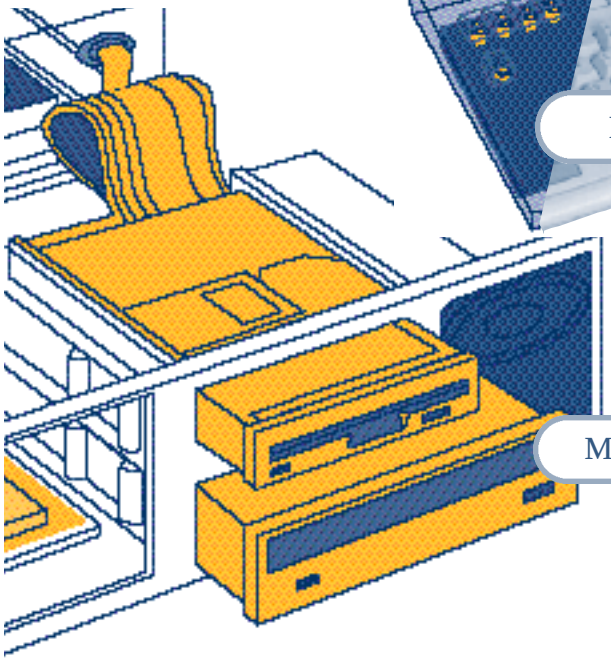
Monitors

Under certain conditions the cathode-ray tubes (CRTs) in monitors are characterized as hazardous waste and are costly to recycle.



Keyboards

The small component parts make recovery of metal and plastic difficult.



Metals

Metals from a unit's motor, frame, wires and other components are recyclable.

Processors are sold for reuse or recycled for precious metals.

place for non-computer products, which contain more varied types of plastics and lower-value metal than computers, is a bit more complicated. Electronic items first have the opportunity to be sold, donated, scavenged or cannibalized. If those options are not taken, the electronics are then landfilled or recycled.[2]

General principles of recycling

The following market demands must be met if recovered materials are to replace virgin materials in the electronics manufacturing process:

Volume: In order to make investments in processing facilities for recovered materials attractive, a consistent supply of material must be available to serve as manufacturing feedstock.

Purity: The recovered materials must be pure and uncontaminated in order to meet customer specifications and to compete with virgin materials.

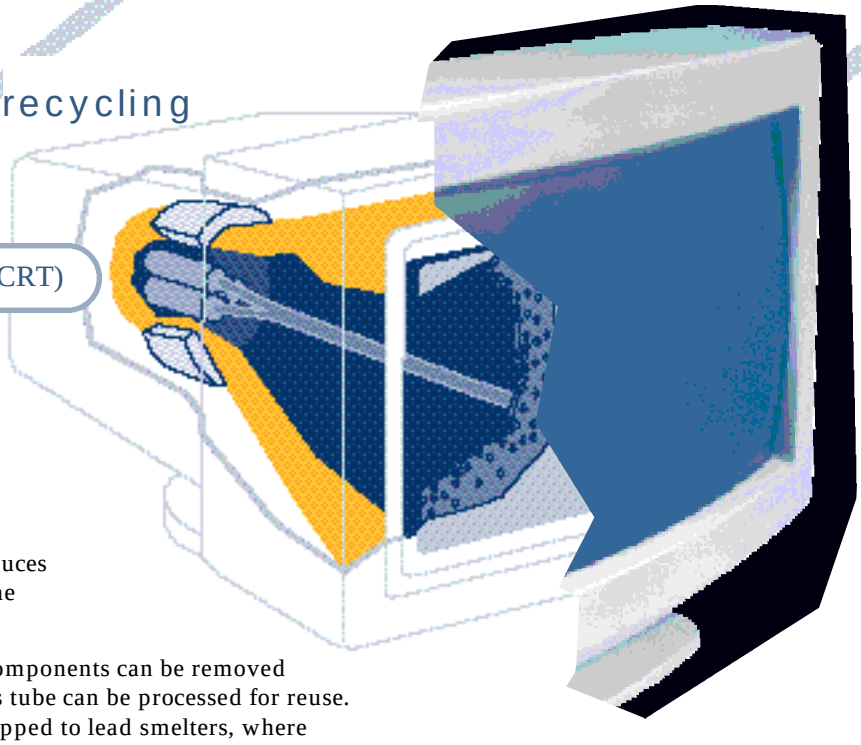
Collection and Processing: Electronic products must be collected from the customer and then processed and transported to markets in a cost-effective manner.

End-Markets: Plastics and metals recovered from electronic products are worthless unless end-users or manufacturers are committed to including recycled content in their products.

Electronic product design for recycling principles (examples):

- Use standard screw heads to eliminate the need for special tools
- Minimize number of parts to simplify upgrade, servicing and recycling
- Design products with modular components
- Design for reuse and upgrade to avoid obsolescence and to extend the product's life span [3]

Cathode-ray tube recycling



A Cathode-ray tube (CRT) is a specialized vacuum tube that contains several main components: electron guns, anodes, copper coils and a phosphor-coated luminescent screen.

The electron gun creates an electron beam, which produces images when the beam hits the phosphorescent screen.[4]

The electron gun and other components can be removed from dead CRTs and the glass tube can be processed for reuse. The CRT glass can also be shipped to lead smelters, where the lead in the glass can be removed and recovered.

Lead in the front panel glass protects the viewer from radiation. However the lead is often considered a hazardous waste for disposal.

Why are televisions and computer monitors so hard to recycle?

The CRT glass in TV and computer monitors is classified as hazardous waste under the Environmental Protection Agency's Resource Conservation Recovery Act (RCRA, 42 USC 6924) provisions because it contains lead.
The hazardous designation is given because the lead CRT glass often fails the Toxicity Characteristic Leaching Procedure, a test which determines how much lead could leak into the ground from broken CRT glass. Because CRT glass is considered a hazardous waste, it is very complicated to recycle.

Who can throw a CRT in the landfill?

The RCRA regulations are confusing; not everyone can just throw their old computers or TV monitors in the trash. Small businesses generating less than 220 pounds per month and households do not have to treat CRTs as hazardous waste. However, businesses generating more than 220 pounds per month of computer or television monitors must treat CRTs as hazardous waste.[5]
This means that hospitals, universities, large corporations and other large generators must dispose of their CRTs in an EPA-governed manner, while a family can throw its television out with the trash. MFF estimates that more than four tons of televisions and computer monitors are thrown away each week by Oakland residents.

Options for recycling CRTs in northern California

Businesses have three options for CRT disposal in northern California:

1. They can send the CRTs to Envirocycle, a CRT recycling company with facilities in Ohio, North Carolina and Pennsylvania, or a similar recycling operation. Envirocycle cleans the CRT glass and sends it back to manufacturers to be made into new CRTs. The cost to recycle CRTs at Envirocycle, including transportation from the Bay Area, is approximately $8 per CRT.[10]

2. CRT material can be sent to a shredding operation such as ECS in San Jose. ECS sends the shredded glass to a secondary smelter which will recover the metals. The shredded glass can also be sent to a primary smelter, which will use the silica and recover the lead. This option is also expensive and may not be feasible for small-scale recyclers.

3. CRTs can be sold to overseas markets for approximately two cents per pound. The buyers in countries such as China will try to resurrect and resell as many CRTs as they can. Materials that cannot be reused are recycled and the glass is ground and included in concrete and other cement-like materials.[11] The United States exports over 500 million tons of hazardous waste annually. Tracing the path of some of the exported electronic material to China and other countries in Asia reveals alarming working conditions, improper incineration and unregulated hazardous waste disposal.[12]

How can CRTs be recycled?

The glass can also be used as fill for road beds, incinerated as fuel or used as a material additive in the cement kiln process. The most desirable recycling option is to utilize the old CRT glass in manufacturing new CRTs. However, recycled materials may not have the same composition as products that are manufactured today. CRT glass is manufactured with different glass compositions by different companies. These different types of glass cannot be mixed for recycling.[6]

Several companies have developed processes to separate and clean CRT glass for reuse in new CRTs and to separate other recoverable materials. However, these companies are not located on the West Coast and the cost of transporting the CRTs from the San Francisco Bay Area to a CRT recycling facility in another state is very expensive.

The EPA expects to release a revised rule in early 1999 that will allow CRT glass that is being processed for reuse to be handled as a non-hazardous material, which will reduce the cost of recycling.[7]

Most of these recycling alternatives are not economically sustainable. Currently, CRT recycling companies charge their cutomers to recycle the CRTs. Until the market demand for CRT glass changes and CRT recycling companies are able to pay to accept the CRTs, the process is not economically sustainable.

How can CRT recycling be made easier and cost effective?

- The CRT must be designed for easy disassembly and sorting.
- The glass used in CRT composition should be consistent, so that recyclers can mix all types of CRT glass.
- More facilities that can recycle CRTs need to open in northern California, which will lower the transportation costs.
- Hazardous waste laws need to be revised so that CRT glass that is being processed for reuse can be handled (but not disposed of) as a non-hazardous material.
- Most importantly, more profitable end markets need to be developed for the components of CRTs.

What are other states doing about the CRT problem?

The Department of Environmental Protection in Massachusetts intends to prohibit the disposal of CRTs from television and computer monitors at all Massachusetts landfills and combustion facilities as of January 1, 1999.[8] North Carolina tried to pass a bill to require retailers to take back used hard-to-dispose items (CRTs are on the list) when the consumer purchases a new version of the item. The act did not pass because of opposition from the North Carolina Retail Merchants Association.[9]

Impact of new technologies on recycling

Alternative monitor technologies, collectively referred to as flat panel displays (FPDs), **may make CRTs obsolete in the next five to ten years.** FPDs are expected to consume less energy than CRT monitors and do not use leaded glass.

The environmental effects of FPDs are not yet known, although the Design for the Environment Program in the US EPA's Office of Pollution Prevention and Toxics has begun a voluntary, cooperative project with the electronics industry to assess the life-cycle environmental impacts of FPDs and CRTs.[13] However, it is clear already that as FPDs become more affordable and accessible to the general public and people upgrade to the new technology, significant numbers of CRTs will enter the waste stream, multiplying the CRT recycling problem.

Another developing technology that may contribute to the number of television monitors entering the waste stream is digital TV. Digital TV uses a completely different technology than the current analog TV to transmit and display information. While regular TV broadcasting will be around until at least 2006, many households will begin to purchase new digital TV sets or they will upgrade their personal computers to accommodate the new technology in the coming years.[14] This will also add significantly to the number of CRTs entering the waste stream.

Corporations

To keep up with rapidly improving technology, large corporations often replace their entire stock of computers every one to three years. They have difficulty disposing of all these computers because the regulations on hazardous waste are becoming more strict, making it more costly to dispose of electronics, especially computers. Computer monitors contain CRTs, which are regulated as hazardous waste.

Cathode-ray tubes and plastics

CRT processing facilities should be strategically located throughout California in order to avoid shipping hazardous materials overseas or placing CRTs in municipal landfills. This will also reduce the cost of shipping CRTs to other parts of the United States for processing.

CRTs must be designed for easy disassembly for sorting and processing. Television and computer display manufacturers should utilize recovered CRT glass and recovered plastics in their manufacturing process.

All electronic products should be manufactured with recycled content plastic. Other end-market options for CRT glass and high grade plastics should be identified.

Product innovation

Electronic OEMs take great care to market their products so that customers associate their brand names with quality, innovation and customer service. OEMs must utilize the same innovation and resources in the recovery, recycling and environmental disposition of their products.

Full-service computer reclamation centers

Computers and other electronics components tower in the warehouses of Bay Area computer recyclers that court OEMs, large corporations, and financial and other institutions for their elite, high-value electronics discards.

The reclamation centers offer a solution to corporations that want to minimize their liability of disposing of large quantities of computers and other electronic equipment that contain hazardous waste. The reclamation centers erase information from computer hard drives, dismantle systems, guarantee destruction of sensitive proprietary information or technology and provide insurance coverage for the disposal of the items. The corporate customer may also receive a monetary return on their surplus electronics, instead of paying for landfill disposal.

The full-service reclamation centers make money by purchasing excess inventories directly from the generator or on consignment and then reselling the valuable components. The reclamation center will resell memory chips and integrated circuit boards (or send the circuit boards to a smelter to recover the precious metals), dispose of CRTs properly and resell the computers and component parts.

Bay Area Corporations are diverting computers from the waste stream:

Hewlett Packard (HP)

has 16,800 Bay Area employees. HP has a product-recovery center in Roseville, Calif., and retains parts that can be reused or resold. It recycles the rest.

Sun Microsystems

has 13,000 Bay Area employees and contractors. Computers are 4 percent of its waste stream. Sun also recycles and reclaims components and entire systems to be reused internally at Sun.

Levi-Strauss

has 2,000 Bay Area employees. It discards 2,000 computers annually, recycling 30 percent and donating 70 percent.

Pacific Gas & Electric

has 13,270 Bay Area employees. It discards 2,500 computers annually; 33 percent are donated and 33 percent sold for reuse.

Bank of America

prior to merging, had 34,291 Bay Area employees. Thirty percent of its computers are reused, 60 percent are donated to nonprofits and 10 percent are recycled.

Techno philanthropy: nonprofit computer recyclers

Six Bay Area computer repair and recycling organizations fix and redistribute computers. These computer repair and recycling programs provide hands-on computer training for adults and at-risk youth in low-income communities.

The programs distributed several thousand computers to schools, charitable organizations and low-income households in 1997. Although recycling generates some revenue for the CBO, the operational expenses of warehouse space and equipment, parts for upgrades and quality instructors all contribute to the high cost of this unique form of techno philanthropy. In addition, the nonprofit often receives material that cannot be reused, which they must then dispose of properly.

Despite the challenges, these Bay Area nonprofits are forging a strong connection between technology and community service and are providing valuable job-training opportunities to disadvantaged communities.

Infrastructures

- Recyclers and municipalities must coordinate efforts regionally in order to collect the volume of material needed to make electronic recycling cost effective. The electronics industry must work with local governments, commercial recyclers, CBOs and environmental advocacy groups to site regional recycling processing facilities and to develop clean, safe collection and sorting technology.
- Corporations and OEMs that make tax deductible donations of surplus computers to nonprofit computer recyclers should also consider cash contributions and in-kind donations of spare parts, software and volunteers.

The metal yard's art of serving local customers

While the corporate reclamation centers solicit surplus computers from the high-tech elite, the local metal scrap dealers are the recipients of a steady stream of electronic products that are as diverse as the local communities they serve. Customers at San Francisco's Ace Auto include metal scavengers, weekend mechanics, people cleaning out their garages and what proprietor Bill Kennedy describes as "tribes of artists."

Ace Auto's 23,000 square feet yard is crammed with dismantled autos, machines and miscellaneous metal parts. Over the past 10 years Kennedy has seen the composition of materials that enter his yard change. Computers and electronics now constitute 20 percent of his business. At almost 20 cents a pound, computers can be more profitable than the $50-per-ton for scrapped autos. But Kennedy cannot get enough computers to stop accepting autos. Kennedy accepts low- or no-value products such as monitors, but must offset the costs by also getting higher-value materials. "Give me enough good stuff and I'll take a monitor," says Kennedy. Other electronic appliances are plentiful, but they do not consistently yield a profit.

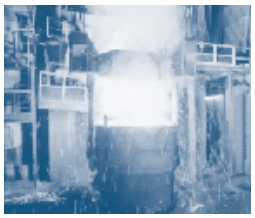
Electronic Recycling System in the Bay Area

Original equipment manufacturers (OEMs)
Recycle computers and post-industrial electronic materials.

Government, corporations, universities
Among the largest consumers of computer products.

Nonprofit Computer Recyclers
Donate computers to schools or recycle for metal value.

Parts sold for reuse
Microchips and subassemblies recovered by corporate recyclers are sold for reuse.



Smelter
Recover precious metals from circuit boards and other electronic components.

Corporate computer reclamation centers
Provide service and computer recycling for OEMs, corporations, the government, universities and others

Export
CRTs, microchips, metals, plastics are exported to Asia and other regions for materials recovery and processing.

Bay Area residents

Donate electronics to charity or dispose of electronics in garbage collection.

Waste company

Some waste companies recycle electronics for metal value.

Flea market

Vendors sell electronics scavenged from residents as well as surplus from charitable organizations.

Goodwill

Unsold electronic products from charity organizations go to the landfill or metal recyclers.

Scavenger

Collect electronics for resale, spare parts and recycling.

Metal recyclers

Recycled metals are used domestically or shipped overseas.

Landfill

Residential recycling

What is a bulky materials collection program? City Bulky Materials Collection Programs assign a day for neighborhoods to set out bulky items on the curbside for collection. These items include large appliances, scrap metal, yard trimmings, wood, furniture and electronic products.

A 1989 California law (AB 939) mandates cities and counties to reduce waste sent to the landfill 50 percent by the year 2000. San Francisco's city collection programs have reached 33 percent diversion of waste from the landfill, and Alameda County has achieved 37 percent diversion.

Oakland

We found that approximately 1.5 percent of Oakland's waste stream is electronic products.
The city of Oakland offers a Bulky Waste collection to its residents every year.
Waste Management of Alameda County notified Oakland residents that they were eligible to participate in an electronic recycling pilot project.
The 4,000 Oakland households in the pilot neighberhoods responded by setting out more than 25,000 pounds of electronic materials in a 10-day period.
Televisions and monitors constituted approximately 15,000 pounds of the electronic products on the curbside.

The East Bay Conservation Corps (EBCC), a youth employment training program, documented the types of products collected. EBCC youth were unable to salvage products for reuse due to heavy rains that damaged most of the items and scavengers who collected much of the reusable materials from the curbside.

Oakland Bulky Waste Pick-up
Top ten items collected

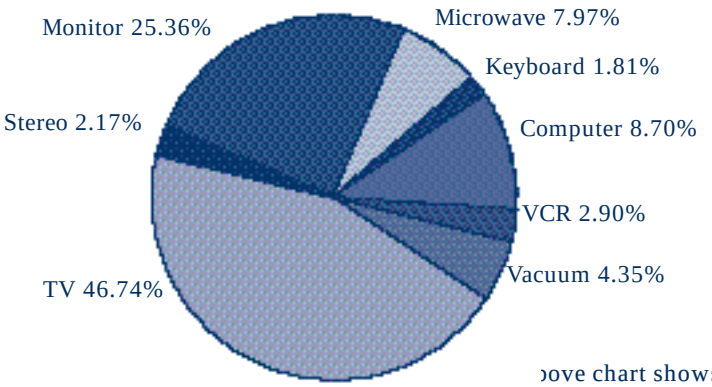
Product	Number of Manufrs. identified	% of total weight of electronics waste stream
Television	34	25.10
Other	78	21.55
Stereo equip.	38	14.83
Vacuum	18	11.79
Computer	9	7.35
Microwave	16	6.80
Fan	12	3.93
Toaster	11	3.17
Heater	13	2.92
VCR	5	2.53

More than 230 manufacturers' brand names were identified among the electronic products recovered from Oakland residents. These manufacturers must commit to designing products for recycling and invest in Bay Area recycling technologies and recycling facilities, if electronic recycling is to be economically and environmentally sustainable.

San Francisco

The San Francisco Super Recycling Day provides city residents an opportunity to set out bulky materials, met als, electronics, organic and wood debris every nine months. No separate notice was given to residents to set out their electronics, and the flyer given to residents about the Super Recycling Day states that the electronics are generally landfilled. A total of 11,000 pounds were collected from more than 13,000 households in a 10-day period.

The materials were disassembled by CURA, a Fremont, Calif.-based long-term drug and alcohol treatment program. More than 3,000 pounds of metal, 3,000 pounds of plastic, 1,000 pounds of circuit boards and 4,000 pounds of televisions and monitors were placed on the curbside.

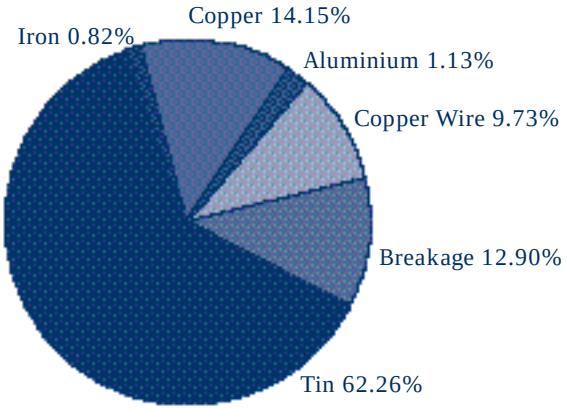


ove chart shows the top ten items (by weight) collected from San Francisco residents during the two week electronic recycling pilot project.

Hayward

Hayward residents make an appointment to participate in the Recyclable Drop-off event, held several times a year. A detailed list of acceptable and unacceptable items is provided to participants. This year participants were allowed to drop off certain electronics products as part of an electronic pilot program. Approximately 111 residents dropped off approximately 10,000 pounds of electroniics. Approximately 3,000 pounds of metals were recovered.

CURA also disassembled materials collected at Hayward's Drop-off event.



The above chart shows the percentage by weight of constituent metals found in electronic products collected during the Hayward Recyclables Drop-off event. Integrated circuit boards are included in the breakage category.

What did we learn from the neighborhood electronic collections?

- The potential for damage due to scavengers, waste collectors and weather increases dramatically once an electronic product is placed on the curbside for disposal.
- Residents are willing to participate in recycling programs when given the opportunity. Oakland residents, who were informed that their neighborhood would be included in an electronic collection and recycling pilot project, generated three times more material than San Francisco residents, who were not notified that such a project was taking place in their neighborhood.
- Community-based nonprofits could be effective at implementing regional collection projects.
- The electronic waste stream is very diverse in terms of product design and materials. In order to make recycling cost effective, recyclers need to specialize in collecting certain products in order to collect the volume of materials needed.
- A CRT repair and recycling training program in northern California could increase the cities' diversion. CRTs are found in televisions and computer monitors, which are a sig nificant portion of the waste streams we studied.
- Local communities will need OEMs to provide technical assistance and new recycling technology in order to develop effective collection and recycling systems.

Policy

- Recycling should be mandated if OEMs cannot voluntarily support local recycling efforts and invest in recycling infrastructures and programs. These mandates could include establishing recycling design standards, implementing recycled content laws, advanced disposal fees, implementing mandatory take-back programs or other recycling policies.
- An OEM's Life Cycle Analysis is often based on reducing the environmental impact of landfilling a product. However, California laws are based on reducing the quantity of materials going to the landfill. In order to expedite recycling activities, this conflict should be eliminated and shared goals discussed.
- Hazardous waste laws should be revised so that CRT glass that is being processed for reuse and recycling can be handled similarly to other products in commerce.

Curbside commerce

Drivers in dilapidated vehicles peruse the Oakland neighborhood, eyeing piles of furniture, clothing and appliances heaped on the curb for the city's Bulky Waste Pick-Up service. The driver of a red truck filled with rusty lawn chairs, broken vacuum cleaners and several soiled televisions looks as though he has selected the worst from the curbside wreckage.

But there is a science to this highly competitive form of curbside commerce, better known as scavenging. Henry, the driver of the red truck, specializes in electronics and selects only what he knows he can sell.

Although it is illegal to remove materials from the curbside in most California communities, scavengers such as Henry are praised for diverting materials from the landfill and into the market. But they are also scorned for the mess and noise they create at the curbside.

Successful scavengers will specialize in white goods, clothes, household appliances, antiques, furniture, metals or novelty items. Henry can sell televisions that are newer than 1985 for $5 to $15. A vacuum cleaner will go for $5 to $8. Certain types of VCRs can fetch up to $40. The vacuum cleaner will be resold at a swap meet for $20 to $35 and the VCRs for $50 and up.

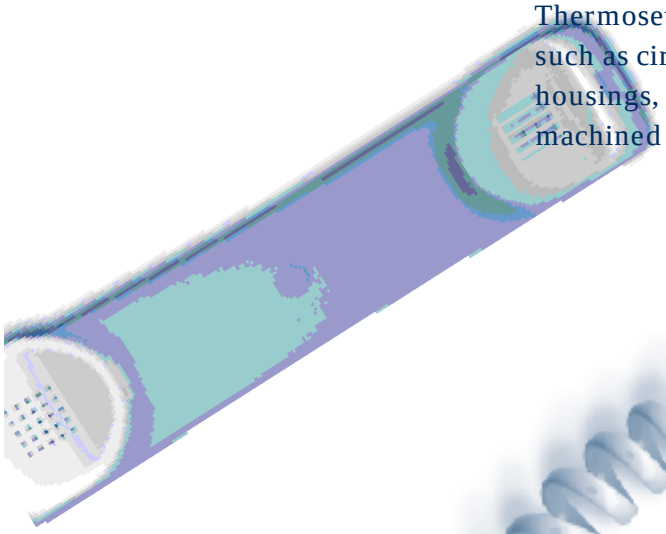
Plastics

Plastics are derived from petroleum or natural gas derivatives. Oil and gas are chemically reformed to create monomer molecules, which are the building blocks from which polymers, or plastics, are made. Polymers are blended with additives such as flame retardants and colorants to create resins, which are essentially what we see as plastic.

What are the plastics used in electronics?

The major applications for engineering plastics are durable goods (items consumers use for three years before discarding) such as transportation equipment, major appliances, computers and business equipment, building and construction materials, furniture and furnishings and, less significantly, small appliances, housewares, televisions, stereos and electronics.[15]

The two major types of resins are **thermosets** and **thermoplastics.**



cannot be remelted and formed into new products, but can be shredded and compressed into other products.[16] Thermosets are used in electronic items such as circuit boards, electrical switch housings, electrical motor components, machined gears, electrical breakers, etc.[17]

can be remelted and formed into new products and are more recyclable than thermosets.[18] Common thermoplastic resins are polyvinyl chloride (PVC) and polyethylene terephthalate (PET). Thermoplastics are used in everything from beverage containers to computers, printers and fans.

Why is plastic a problem?

Plastic can be colored, coated, made flame retardant or filled, as well as be mixed with additives, which makes it extremely versatile for everything from television monitor casings to blenders. However, the very versatility that makes plastic appealing also makes it a difficult material to recycle.

- The thousands of variations on the plastic polymers used in durable goods are difficult to identify and separate for recycling. Recyclers must gather large volumes of same-type uncontaminated plastics that can be substituted for virgin plastics in the manufacturing process.
- Because of the varying molecular properties of the monomers and the additives, polymers can vary in molecular structure, melting point, impact resistance, elasticity and strength, and cannot be mixed for reuse.[19]
- In addition to the inherent differences in polymers, manufacturers also put more than one resin in a product or add contaminants such as labels, paint, metallic coatings, foam insulation, fire retardant, and ferrous and non-ferrous metals. For example, the plastic casing of a computer may be contaminated with the materials used to print the company logo, metal screws and labels, as well as the colorants and fillers that are part of the plastic. Identification technology for sorting the resins based on weight and type is being developed, but is likely to remain too expensive for small-scale recyclers.
- Plastic is also problematic to recycle because it is difficult to sell in the market place. The end-use markets for plastic are very specialized and it is expensive to characterize plastics to match end-use applications. It is often not economically viable to characterize recycled plastic since it is available in limited quantity.

Although government purchasing agents are often given guidelines to purchase paper and other products made with recycled content, few US laws give preference to electronic products manufactured with recycled plastics. As a result, manufacturers have little motivation to utilize recycled plastics in their new products

Some manufacturers prefer not to use recycled plastic because reformed polymers can be weaker than virgin and are generally used in less demanding applications. Manufacturers also assert that there is not a sufficient or steady supply of the needed polymer, or properties such as color that may vary too greatly in recycled plastic.

For example, Hewlett Packard (HP) tried to use recycled plastics in its DeskJet printer housings two years ago but could not get a consistent supply of recycled plastic and was unable to match the colors of virgin and recycled resins. HP is now trying to use recycled material in internal components where color matching is unimportant.[20]

How can plastics be recycled?

After metals, plastics have the greatest potential scrap value in discarded electronics. An estimated 50 percent of the scrap value of electronic goods could come from plastic if it were all recovered.[21] Mechanized separation processes are being developed to make post-consumer plastic recycling more economically viable.

MBAPolymers in Richmond, Calif., has developed technologies to sort different plastics based on physical properties and is developing methods for overcoming the problems caused by metal content, paints and coatings. Other companies are developing technology to sort plastics through X-ray fluorescence, electrostatic properties and other methods.[22]

A few original equipment manufacturers in the United States have established take-back centers to recover their own retired equipment. Take-back programs are established in several European countries and provide one solution to the equipment disposal problem. If the OEM knows they will have to deal with the product at the end of its life, they will design a more recyclable product

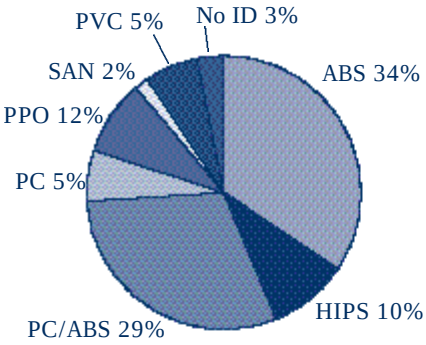
How can plastics recycling be made easier?

Post-consumer resins need to have cost advantages over virgin resins in order to compete effectively. These advantages could be advances in collection, sorting and processing techniques, which will reduce the overall cost of post-consumer resin. Manufacturers demand that prices for recycled resins be as low as 30 percent less than virgin, according to an American Plastics Council-sponsored study.[23] The solution for the plastic problem begins with the equipment designers.

The use of plastics in design for recycling

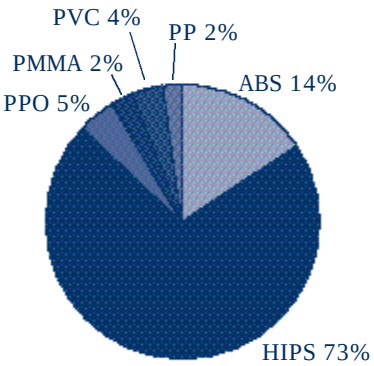
- Use recyclable thermoplastics, which have higher value and are easier to recycle.
- Use detail markings to identify resins, manufacturer and exact blend, which facilitates the reuse of these plastics in high-grade applications.
- Avoid the use of painted labels or finishes that contaminate plastics.
- Avoid flame retardants that contain polybrominated biphenyl, dioxins and cadmium.
- Reduce the number of plastic types to favor fewer polymer compositions in a single product.
- Utilize recycled plastic resins in new products.[24]

Computers and televisions represented the largest volume of electronic material deposited in the residential waste stream in the Oakland and San Francisco collections. Other materials collected



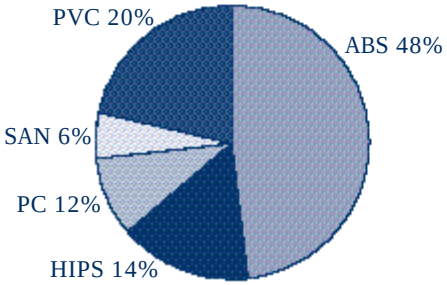
1. Computer Housing Resin

Computers contain significant quantities of ABS, PC / ABS and HIPS, which are high value resins. However, computer housings are often contaminated by paint, coatings, metal, rubber and labels, which increase the cost of processing and lower the overall value of the resins.



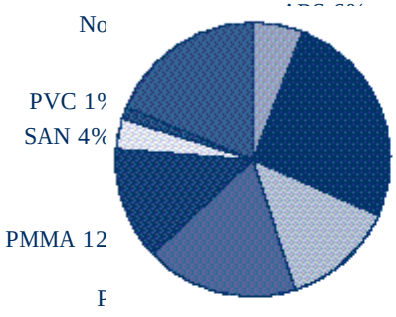
2. TV Housing Resin

More than 70 percent of plastic housings on televisions are made of HIPS. However, as soon as the plastic housing is removed from the television, the exposed CRT is characterized as hazardous waste.
Plastic recovery will be more economical when regulations are revised so that recycled CRT glass is treated like a commodity rather than a waste. TV manufacturers should also make a commitment to design televisions for easy disassembly and to utilize recovered materials in their new products.



3. Vacuum Cleaner Housing Resin Breakdown

Vacuum cleaners in the residential waste stream consist of five types of plastics and have a high potential for recovery. However, separating plastics from metal components can be labor intensive due to the glues and hidden screws.



4. Stereo Resin Breakdown

Stereos recovered from the residential waste stream contain more than eight different types of plastics.
Eighteen percent of the plastic could not be identified. The small quantities of several different types of plastics make the plastics difficult to recover.

Commonly used resins in electronics:

Polyvinyl chlorides (PVC)
Acrylonitrile-butadiene-styrenes (ABS)
Polycarbonates (PC)
High-impact polystyrene (HIPS)
Polystyrenes (PS)
Polyphenylene oxide (PPO)
Polymethyl methacrylate (PMMA)
Styrene-acrylonitrile (SAN)

Conclusion

Materials for the Future would like to share some of our conclusions concerning electronic recycling, collection and processing in the San Francisco Bay Area.

Product innovation

- Electronic OEMs take great care to market their products so that customers associate their brand names with quality, innovation and customer service. OEMs must utilize the same innovation and resources in the recovery, recycling and environmental disposition of their products.

Cathode-ray tubes and plastics

- CRT processing facilities should be strategically located throughout California in order to avoid shipping hazardous materials overseas or placing CRTs in municipal landfills.
- This will also reduce the cost of shipping CRTs to other parts of the United States for processing.
- CRTs must be designed for easy disassembly for sorting and processing.
- Television and computer display manufacturers should utilize recovered CRT glass and recovered plastics in their manufacturing process.
- All electronic products should be manufactured with recycled content plastic. Other end-market options for CRT glass and high grade plastics should be identified.

Infrastructures

- Recyclers and municipalities must coordinate efforts regionally in order to collect the volume of material needed to make electronic recycling cost effective.
- The electronics industry must work with local governments, commercial recyclers, CBOs and environmental advocacy groups to site regional recycling processing facilities and to develop clean, safe collection and sorting technology.
- Corporations and OEMs that make tax deductible donations of surplus computers to nonprofit computer recyclers should also consider cash contributions and in-kind donations of spare parts, software and volunteers.

Design for Recycling

- OEMs should design products for recycling and easy disassembly, and utilize recycled materials in their manufacturing process. Products should also have interchangeable and upgradeable components.
- Consumers should be given information about an electronic product's environmental performance.

Policy

- Recycling should be mandated if OEMs cannot voluntarily support local recycling efforts and invest in recy cling infrastructures and programs.
- These mandates could include establishing recycling design standards, implementing recycled content laws, advanced disposal fees, implementing mandatory take-back programs or other recycling policies.
- An OEM's Life Cycle Analysis is often based on reducing the environmental impact of landfilling a product.
- However, California laws are based on reducing the quantity of materials going to the landfill. In order to expedite recycling activities, this conflict should be eliminated and shared goals discussed.
- Hazardous waste laws should be revised so that CRT glass that is being processed for reuse and recycling can be handled similarly to other products in commerce.

Endnotes

1 (PRC42170) After January 1, 1994, no solid waste facility shall accept for disposal any major appliance, vehicle, or other metallic discard that contains enough metal to be economically feasible to salvage as determined by the solid waste facility operator.

2 The Electronic Industries Association and other trade organizations distinguish between electronic and electrical appliances as those appliances with integrated circuitry and those that don't have integrated circuitry respectively. MFF has elected to use the term "electronics" to represent both categories.

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5 Jones, David B., EPA Region 9 CSI Program Director, Letter to Thomas Bartell. May 30, 1997.

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9 General Assembly of North Carolina, "Retailers to Accept Goods for Disposal." Senate Bill 846 (Session 1997).

10 Holroyd, Steve. Steve Holyrod and Associates, Memo to Sheila Davis. December 15, 1997.

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22 Toloken, Steve. "MBA Tackles Recycling Obstacles." Plastics News. May 19, 1997: 1,29.

23 Toloken, Steve. "MBA Tackles Recycling Obstacles." Plastics News. May 19, 1997: 1,29.

24 Davis, Gary A. and Wilts, Catherine A. "Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention." University of Tennesse Center for Clean Products and Clean Technologies, 1997.

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