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HOUSEHOLD BATTERIES: EVALUATION OF COLLECTION METHODS

Hennepin County

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URBAN CONSORTIUM TENTH YEAR (1988-89) ENERGY PROGRAM

PREFACE

The Urban Consortium for Technology Initiatives (UC) is composed of over forty of the largest cities and urban counties by population in the United States. The Consortium provides a unique forum to define urban problems common to its member governments and to develop, apply, transfer and commercialize technologies and innovative management techniques to address those problems.

The Urban Consortium conducts its work program under the guidance of Task Forces structured according to the functions and concerns of local governments. The Energy Task Force, with a membership of municipal managers and technical professional from the Consortium jurisdictions, has sponsored over one hundred energy management and technology projects in thirty-two Consortium member jurisdictions since 1978.

To develop in-house energy expertise, individual projects sponsored by the Task Force are managed and conducted by the staff of participating city and county governments. Projects with similar subjects are organized into "units" of five to nine projects each, with each unit managed by a selected Task Force member. A description of the units and projects included in the Tenth Year (1988-89) Energy Task Force Program follows:

UNIT -- ELECTRICITY MANAGEMENT

Local governments recognize that high energy costs can place severe burdens on residents and constrain growth for both energy-intensive industries and the vital small business sector that provides the majority of today's employment opportunities. Maintaining a stable, secure and reasonably priced supply of electric energy will require strategies that include support for decentralized "small" power production, better demand management, and improved energy use efficiency. Successful implementation of such strategies will require close coordination with the utility industry and should address topics in areas of institutional relations, source flexibility and demand side management. The Tenth Year unit consisted of eight projects and are as follows:

- Chicago, Illinois -- Phased Implementation of Alternative Technologies through the Development of Energy Markets
- Columbus, Ohio -- Electricity Demand Impacts of Indoor Air Quality Standards
- Houston, Texas -- Wastewater Treatment Process Energy Optimization
- Kansas City, Missouri -- Modernization of Lighting in a Municipal Auditorium
- New York, New York -- Strategies to Reduce Electricity Cost in New Commercial Construction
- St. Louis, Missouri -- Reducing Electricity Demand through Energy Efficient Construction
- Albuquerque & Chicago -- Municipal Electric Utility Franchising Conference (Technology Transfer)
- Montgomery County, MD -- Second National Conference on Energy Efficient Cooling (Technology Transfer)

UNIT -- WASTE-TO-ENERGY

Improving the effectiveness of waste management continues today as one of the most crucial challenges facing urban governments -- a challenge that increasingly seeks solutions that can capture the potential for waste materials as continually "renewable" energy resources. To realize this energy recovery potential, it is essential to increase local capabilities for the application of commercialized technologies, to prove and improve emerging technologies, and to develop innovative management techniques that can support effective and environmentally safe recovery of energy from waste. Emphases should be placed on specific applications and technologies, well designed methods for cost and risk management, and improved means to generate both institutional and public support for implementation. The Tenth Year unit consisted of seven projects and are as follows:

- Hennepin County, Minnesota -- Household Hazardous Waste Processing
- Memphis, Tennessee -- Biogas Recovery from a Sludge Storage Lagoon
- Montgomery County, Maryland -- Yardwaste Recycling: Methods and Pilot Evaluation
- Philadelphia, Pennsylvania -- A Policy Planning Model for Integrated Waste Management
- Seattle, Washington -- Household Hazardous Waste Collection and Paint Recycling
- St. Louis, Missouri -- Feasibility Assessment of Waste-to-Energy for District Cooling (Technology Transfer)

- Public Technology, Inc. -- Risk Communication and the Role of Technical Experts in Waste Combustion Decisions (Technology Transfer)

UNIT -- RENEWABLE ENERGY

Widely supported during the oil price shocks of the late 1970's, research, development and use of renewable energy resources in the U.S. lost their substantial momentum when oil prices dropped during the 1980's. Broadly defined, "renewable" resources include both recurring alternate supplies (solar, biomass, wind) as well as techniques to reduce demand for conventional non-renewable energy resources. Effective strategies that can increase the use of recurring alternate resources while improving sound management for non-recurring resources are essential to prepare for the nation's next decade. Emphases should be placed on the synthesis of energy concerns with broader local interests in economic development, cost management and environmental quality to develop truly sustainable urban areas as the century nears its end. The Tenth Year unit consisted of five projects and are as follows:

- San Jose, California -- The Sustainable City
- Portland, Oregon -- The Sustainable City
- San Francisco, California -- The Sustainable City
- New Orleans, Louisiana -- Space Heater Conversion to Hydro-heat Forced Air Systems in the Rehabilitation of Residential Units
- New Orleans, Louisiana -- Impacts of Residential Conservation Programs on Low and Moderate Income Households (Technology Transfer)

ALTERNATIVE VEHICLE FUELS UNIT

Alternative vehicular fuels offer the very strong potential to aid in the reduction of U.S. dependence on foreign oil supplies with the concomitant benefit of decreased air pollution in urban areas. Local governments can play an instrumental role in realizing this potential through practical applied research and highly visible demonstrations for alternative fuel and technology options. Projects within this topic area should place a strong emphasis on teaming and partnership activities among cities and counties, utilities and other relevant private sector organizations with matching interests. Key elements addressed in this effort should include: markets and applications for alternate fueled vehicles; appropriate technologies, infrastructure and training; means to treat institutional barriers; and assessments of environmental effects. The Tenth Year unit consisted of nine projects and are as follows:

- Albuquerque, New Mexico -- Electric and CNG Vehicles in Municipal Duty Cycles
- Broward County, Florida -- Dual Fuel Conversion Demonstration
- Chicago, Illinois -- Northern Illinois Clean Fuel Consortium
- Denver, Colorado -- Air Quality Impacts from Alternative Vehicle Fuels and Urban Design
- Detroit, Michigan -- Fleet Assessment for Light Alternative Fuel Vehicles
- New York, New York -- Alternative Transportation Fuels: Infrastructure Issues
- Pittsburgh, Pennsylvania -- CNG as an Alternative Vehicle Fuel
- Oklahoma City, Oklahoma -- Diesel Truck Conversion to Compressed Natural Gas (Technology Transfer)
- Phoenix, Arizona -- Analysis of Programmatic Fleet Conversion to Ethanol Fuel Blends (Technology Transfer)

Reports from each of these projects are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining any of these reports or further information about the Energy Task Force and the Urban Consortium should contact:

Energy Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004

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Don Seeberger, Project Manager

CHAPTER 1

INTRODUCTION

PROJECT PURPOSE

On October 6, 1989, Hennepin Energy Resources Company, Ltd. (HERC) began operating a 1000-ton-a-day waste-to-energy facility near downtown Minneapolis. As required by Minnesota State law, Hennepin County must plan and develop programs to minimize the contaminants in incinerator air and ash emissions. In an effort to fulfill this mandate, Hennepin County is examining various methods of identifying and removing unacceptable materials from the waste stream; household batteries are one type of waste being considered for diversion.

Household batteries have not been commonly identified as a problem material in the normal solid waste stream. A battery casing is designed to safely contain the contents of the chemical cell during its working life. Eventually, however, the chemicals will corrode and eat through the casing, releasing its contents. Typically, the method of disposing of spent batteries has been to throw them into the trash which is then dumped in a landfill. This method disperses the battery cells throughout the wastes entering a solid waste landfill. While some concern has been expressed about this disposal method for batteries, little evidence is available to link soil and groundwater contamination to specific materials in a landfill. During the 1980's, the amount of available landfill space has been dramatically reduced, forcing many communities to examine alternative methods of processing their waste. As communities search for alternatives to their disposal dilemma, waste-to-energy facilities are being given greater consideration.

While it is difficult to prove that a specific material is causing contamination in a landfill, tests have been conducted at waste-to-energy facilities that indicate that the household batteries contribute significant amounts of heavy metals to both air emissions and ash residue. In a study of Swedish waste-to-energy facilities, it was determined that 30 - 35 percent of the background levels of mercury in the air near the facilities was attributable to the combustion of household batteries in the waste (Radian Corporation, 1987). Studies conducted for the U.S. Environmental Protect Agency (EPA) have found nickel-cadmium batteries account for more than half of the cadmium entering the waste stream in the United States. Cadmium is one of the heavy metals found in the bottom ash from an incinerator.

Providing a special means of removing household batteries from the "normal waste stream" requires that new policy and design issues be addressed prior to implementing a county-wide program. In an effort to address these questions and share information from its experiences, Hennepin County applied for and was awarded a grant from the Urban Consortium Energy Task Force. The grant research plan detailed a dual approach for developing and implementing a special household battery collection. The first efforts at addressing household batteries as a special waste were focused on an examination of alternative collection methods, including conducting test collections. The pilot collections gathered data to guide the development of a county-wide collection program. The second phase of the study examined operating and disposal policy issues affecting the County's ability to establish a comprehensive collection program.

REPORT ORGANIZATION

This report describes the results of the grant project, moving from a broad examination of the construction and content of batteries (Chapter 2), to a detailed description of Hennepin County's pilot collection programs for household batteries (Chapter 3), and ending with a discussion of variables affecting the cost and operation of a comprehensive battery collection program (Chapter 4).

CHAPTER 2

BATTERIES AS A SPECIAL WASTE MANAGEMENT CATEGORY

It is estimated that 160 million tons of municipal solid waste are generated annually in the United States. This means each person in the United States is discarding approximately four pounds of garbage daily (Salas et al, 1981). Already the world's highest per capita generator of municipal solid waste, U.S. waste generation rates are expected to continue to grow. Appropriately managing these wastes is a critical issue that must now be addressed by many jurisdictions. One option that is being increasingly incorporated in solid waste management plans in incineration (Table 1).

Table 1

Municipal Solid Waste Consumed by Energy Recovery Facilities

(In Millions of Tons)

1970	0.4
1980	2.7
1986	9.6
1990 projected	13.3
2000 projected	32.0

Source: Franklin Associates, Ltd. "Characterization of Municipal Solid Waste in the United States," January 31, 1989.

Developing a comprehensive waste management system requires that components of the "normal waste stream" be identified and appropriate disposal methods for each waste category be designed. Paper, yard waste, metals and food wastes are the four largest categories of materials found in the waste stream. Paper and metal products can be recycled, whereas yard waste is compostable. In a recent study conducted by Cal Recovery for the Metropolitan Council in Minnesota, it was estimated that up to 49 percent of Minneapolis-St. Paul area municipal solid waste could be recycled or composted. Waste that cannot be recycled or composted would have to be landfilled or incinerated. Some categories of waste, such as household batteries pose potential contamination problems when either landfilled or incinerated.

CHEMICAL COMPOSITION OF BATTERIES

Americans own some 900 million battery-operated devices. To keep these electronic devices running, over $2.5 billion a year is spent to replace the power source--batteries. Estimating that every person in the United States purchases eight zinc/carbon and alkaline batteries per year, it can be projected that at least 2 billion batteries are consumed. Batteries are a convenient portable source of energy that most people take for granted and few would identify as a problem for disposal.

A battery is a device that uses chemicals to produce electrical energy. Batteries are designed to store electricity in the form of potential chemical bonding between two active ingredients. As electricity is drawn from the battery, the chemical composition is changed and discharging takes place. Depending on the chemical composition of the battery, it can be classified either as a primary (those which cannot be recharged) or secondary (those that can be recharged, reversing the chemical reaction). Secondary batteries are becoming increasingly popular because they can be recharged many times, thus giving the user a sense of the battery being "recycled".

Hundreds of electrochemical pairs can be used to construct a battery but few of these pairs are feasible for the retail markets. The five most common types of batteries sold commercially are: zinc/carbon, alkaline/manganese, mercury, silver oxide, and nickel/cadmium. All these batteries are constructed of corrosive chemicals which are hazardous if they should leak from their casings. The casing of a household battery can be made from paper, plastic or metal. Regardless of the material used, the casing will eventually become corroded and leak its contents. In a landfill, this process occurs over long periods of time and could contribute to ground water pollution. Batteries that enter an incinerator will burn and release metals.

Table 2

Chemical Compositions of Household Batteries

Battery Type	Anode +	Cathode -	Electrolyte
Nickel Cadmium Rechargeable	Nickel	Cadmium	Potassium Hydroxide
Zinc-Carbon Cell General Purpose	Zinc	Manganese Dioxide	Ammonium Chloride Zinc Chloride
Alkaline-Manganese	Zinc & Mercury	Manganese Dioxide & Graphite	Potassium Hydroxide
Mercury Cell	Zinc	Mercuric Oxide	Potassium Hydroxide
Silver Oxide Cell	Zinc	Silver Oxide/ Silver Peroxide	Potassium Hydroxide, Sodium Hydroxide, Zinc Oxide

During incineration, two types of household batteries - alkaline and mercuric oxide - are of special concern. Alkaline batteries contain between one-half of 1 percent and 3 percent by weight mercury. A light coating of mercury is added to the zinc anode to prevent hydrogen gases from building up during the reaction of the metals (zinc and manganese dioxide). Without the addition of mercury, gases within the alkaline battery would tend to expand and break its outside casings, destroying the cell. While a single alkaline battery contains only a small amount of mercury, the large number of alkaline batteries entering the waste stream provide an abundant source of mercury.

Mercury batteries use zinc (anode) and mercuric oxide (cathode), which are in the form of highly compressed powders. Mercuric oxide is one of the active ingredients of chemicals that change to produce the electric current; it is, therefore, a large amount of the battery's total weight. "Button" size mercuric oxide batteries contain approximately 33 percent to 50 percent mercury by weight of the battery. Larger specialty mercury batteries (8.4 volts) may contain as much as 60 percent mercury by battery weight. Mercuric oxide and alkaline batteries have been identified as one of the major sources of mercury entering waste-to-energy facilities.

METALS AS A PROBLEM MATERIAL FOR WASTE-TO-ENERGY FACILITIES

In a literature review conducted by the City of Seattle's Office of Long-Range Planning, the effects of incineration of hazardous wastes were investigated. The report discusses hazardous materials that are either metals or organics and traces the changes that occur when burned. The major findings include:

- Incineration can reduce the volume of waste by as much as 90 percent and the weight of the material to be landfilled by 70 percent

- The major by-products of incineration are fly and bottom ash

- Not everything that enters an incinerator is destroyed--some material becomes concentrated in the ash (Denison, 1988)

- Ash composition is principally determined by the inorganic (generally metals) and organic compounds (PCB's, dioxins and furans) entering the waste-to-energy system.

Heavy metals such as cadmium, lead and mercury entering an incinerator become concentrated in the ash residue in direct proportion to the degree of volume reduction achieved (Couppis and Franklin, 1987). Metal concentrations are affected by the type of waste being processed. Two types of ash are produced from the incineration of municipal solid waste: bottom ash and fly ash.

The coarse residue remaining on the burning grate is called bottom ash and many contain metals, glass or small particle ash (Hennepin County, 1987). Bottom ash is generally cooled by passing it through a water quench tank which causes the ash to become solid slag. The slag is then disposed of in a landfill. The predominant metals found in bottom ash are iron, zinc, lead and copper. The metals of greatest concern to human health and the environment tend to be found in fly ash.

Wastes processed in a municipal incinerator are subjected to high temperatures which cause metals to partially volatilize or convert to a gaseous state. As the gases move out of the combustion chamber and into the boiler, they cool, causing the metals to condense on the small fly ash particles. Fly ash are fine particles that are transported by the flue gases through the combustion chamber and become trapped in the air quality control system of the burner. The presence of metals on or near the surface of the ash increases the potential for metals to leach after the ash is landfilled (Denison and Silbergeld, 1987). Mercury and cadmium are two metals of primary concern found in fly ash.

A 1985 EPA report cited solid waste incinerators as the primary source of cadmium emissions. Household batteries are a major contributor of heavy metals in the solid waste stream. In 1989, the EPA issued a report identifying household batteries, specifically nickel-cadmium batteries, as the single largest contributor of cadmium to municipal solid waste. Batteries are also a contributor to mercury emissions from waste-to-energy facilities.

Most of the metals are found in the fly and bottom ash but fumes or particulates in the flue gases also contain metals. Some metals, such as mercury, vaporize during combustion. Mercury vapors are the most abundant trace element found in waste-to-energy emissions (Denison and Silbergeld, 1987). Air emissions from a waste-to-energy facility are carried into the atmosphere as part of the exhaust plume. As the plume becomes dispersed in the atmosphere, mercury particles may be carried long distances. Like other air pollutants, mercury is brought back to the earth's surface by precipitation. If rain or snow containing mercury enters an acidic lake, the mercury can be converted to methyl mercury. The amount of methylation will depend on the chemistry of the lake. Converted mercury can then enter the food chain through fish.

Fish can absorb methyl mercury through their gills and also absorb it from the food they eat. Predator fish, which are often popular game fish, tend to have higher levels of methyl mercury than herbivorous fish.

In Sweden, high levels of mercury found in fish taken from lakes led the government to conduct extensive research into the causes. A result of this research identified emissions from waste-to-energy facilities as one source of mercury. Further study of emissions from waste-to-energy facilities in Sweden determined that 30 to 35 percent of the background levels of mercury in the air near the facilities was attributable to the combustion of household batteries in the waste (Radian Corporation, 1987).

Modern waste-to-energy facilities are designed to include a variety of air pollution control devices which can minimize the amount of particulate emissions. To remove mercury from the air emissions, the temperature of incinerator gases must be cooled to cause condensation and a chemical reaction must be initiated (using lime). It has been demonstrated that mercury can be removed from air emissions when properly operated scrubbers for condensation and reaction, and either an electrostatic precipitator or baghouse, are used to collect the mercury-laden particulate (Clarke, 1987). Sweden has recently mandated the removal of all batteries from the municipal waste stream entering a waste-to-energy facility, as well as requiring sophisticated air pollution controls. While constituting a small amount of the waste stream, household batteries may have a significant impact on the emissions of a waste-to-energy facility. Ironically as air pollution control equipment becomes more efficient, ash residue contains higher levels of heavy metals which must be landfilled.

LEACHATE FROM ASH DISPOSAL

Leachate is water that has filtered through landfilled ash or solid waste. As the water passes through the wastes, metals and chemicals are dissolved and become suspended in the water. Leachate is formed through a process analogous to brewing coffee. When coffee is made, water is percolated through the coffee grounds to dissolve the chemicals which give coffee its color and flavor. Variations in the amount or type of grounds used can produce stronger or weaker flavors. Similarly, water percolates through the ground to dissolve the minerals in the soils or materials in a landfill. Varying the materials or other concentrations will create a similar variation in the minerals and chemicals found in ash and possible leachate.

Leachate from landfills needs to be contained to assure that it does not migrate into surface or ground water. Leachate can contain minerals or substances which can enter the food chain and adversely affect human health. Leachate migration in older, unlined landfills has been documented by the Minnesota Pollution Control Agency in many locations and has adversely affected the water quality of wells miles from the source of pollution.

The EPA uses laboratory test methods which evaluate the potential of metals and other substances to leach from ash. These tests indicate that ash needs special handling because of its leaching characteristics.

The Federal and state regulatory agencies have not yet made it clear whether it is acceptable to dispose of incinerator ash separately in its own ash landfill or whether it should be handled as a hazardous waste.

CONCLUSIONS

Given the potential hazards of air emissions and ash, safe operation of a municipal incinerator must focus on efforts to reduce the hazardous materials contents of the fly and bottom ash (Denison, 1988). An effective way to reduce hazardous emissions is to remove materials containing contaminating constituents from the supply to the incinerator before burning occurs. The tasks necessary to remove contaminants from the waste stream entering an incinerator include: defining the problem, establishing evaluation criteria, identifying waste materials and their origin, assessing alternative collection methods, structuring an acceptable solution, implementing the solution and monitoring the results. In the next chapter, Hennepin County's experience with pilot testing special collection methods for removing household batteries from the "normal waste stream" will be explored.

CHAPTER 3

SPECIAL COLLECTION METHODS FOR WASTE BATTERIES

HENNEPIN COUNTY'S EXPERIENCE

Hennepin County is the largest county and local government in the State of Minnesota. In 1988, the County's population was just over one million, approximately one-quarter of the state's residents. The County's 47 municipalities, which include the City of Minneapolis, generate 970,000 tons of solid waste per year. Within the next decade, it is expected that this amount will increase to over 1 million tons per year. Existing landfill space within the County is quickly being exhausted and past problems with groundwater contamination have severely limited the willingness to site new facilities. Recognizing the approaching problem, Hennepin County has developed a comprehensive waste management plan which includes recycling, composting and incineration.

Hennepin County has emphasized recycling for several years. Minneapolis, with financial support from the County, initiated a curbside-collection program for glass, aluminum and newsprint in 1983. The initial results from the residential areas involved in the demonstration project were so positive that they recycling program was extended to include the entire city in 1985. The County presently offers financial and technical assistance to any of its 47 municipalities interested in developing a recycling program. The Twin Cities area now has a mandated recycling target of 16 percent by 1990. This target was imposed by the regional planning body in an effort to increase the amount of waste being recycled and to give impetus to local government efforts to initiate programs. In 1988, new recycling efforts accounted for 9.4 percent of Hennepin County's wastes.

Hennepin County has had a yard waste composting program for 16 years. Yard wastes are collected separately for storage and decomposition at two processing sites owned by the County. After the composting process is completed, distribution sites are set up around the County and residents are advised of the availability of the compost on a free-to-all, first-come, first-served basis. In 1988, more than 25,000 tons of yard waste were collected for composting.

Even with the continuing emphasis on recycling and composting, it has become increasingly evident that the County's solid waste plan must include an alternative to landfilling for materials that cannot be readily recycled. The possibility of constructing a refuse incinerator was first raised in 1974. After years of study on the economic, environmental, and health and safety impacts of an incinerator, and realizing that existing landfills will soon be full, the County Board of Commissioners decided to proceed with construction of a major incinerator.

In 1985, Hennepin County entered into an agreement with Hennepin Energy Resource Co., Ltd. for the construction and operation of a 1000-ton-per-day refuse incinerator. Under the terms of this agreement, the County is obligated to use reasonable efforts to assure that only acceptable waste is delivered to the facility. The definition of "unacceptable wastes" includes: "Hazardous Waste, and any materials which if processed at the facility would cause the bottom ash produced at the facility to be classified as Hazardous Waste." To meet this obligation and ensure that the new incinerator operates as safely as possible, Hennepin County is examining methods of removing various types of unacceptable waste. Household batteries is one waste stream being considered for diversion.

It is estimated by the Hennepin County Environment and Energy Division that in 1989, 10 million batteries were sold in the county or approximately ten household batteries for each resident. It has been conservatively estimated that batteries contribute between 1 and 2 tons of mercury and 2 and 2 1/2 tons of cadmium to the County's waste stream every year. The objective of Hennepin County's battery collection project is to remove hazardous household batteries from the solid waste stream entering its waste-to-energy facilities.

Estimated Amount of Metals in Batteries
Sold in Hennepin County During 1990
(in pounds)

	Yearly Sales		Metals	
Cell Type	U.S.	Hennepin	Hg	Cd
"Button" Cell	170,000,000	750,000	825	
Alkaline	1.93 billion	7,917,100	1,582	1,858
Zinc-Carbon	1.2 billion	4,916,436	10 - 541	10 - 541
Nickel-Cadmium	10 million	44,000		61 - 120
TOTAL			1 - 2 Tons	1,929 - 2,519

Estimated battery sales for U.S. and Hennepin based on Dodds and Goldberry 1986 report, "Outlook for Recycling Large and Small Batteries in the Future."

LITERATURE REVIEW

The first task of the battery project was to identify effective ways to remove spent household batteries from the waste stream. A literature review of the subject revealed that several European countries have researched and are operating battery collection programs. Studies from Denmark and Sweden provided the retail/return model used in Hennepin County's pilot battery collection. A synopsis of these countries' programs may also help the reader identify topics of concern not addressed by this report.

In 1987, Denmark conducted a pilot retail battery collection on the island of Bornholm. The study was designed to test both collection and sorting methods for common household batteries. Customers were asked to voluntarily bring batteries to participating retailers and place them in one of four bins which segregated them by component materials. Examination of the collected batteries showed that 75 percent of the alkaline batteries were misplaced. A survey of participants indicated that 70 percent considered themselves unable to distinguish various battery types. The same survey showed 87 percent of the respondents wanted batteries to be collected, yet only 25 percent of the estimated waste alkaline and zinc-carbon batteries were returned. The low rate of return has led the Danish government to examine deposit and rebate schemes as part of establishing permanent battery collection programs.

Sweden has instituted a wide variety of battery collection methods and developed an extensive public education program. Collection containers have been placed in heavily traveled pedestrian areas, such as subway stations, as well as offering retail/return sites. Although public containers are a popular disposal method, the program may have to be discontinued due to the amount of unacceptable debris being placed in them. Municipal collections of household hazardous waste will also accept batteries for disposal. Sweden estimates that it is removing 60 percent of all waste batteries entering its municipal solid waste stream.

HOUSEHOLD BATTERY COLLECTION PROGRAM DESIGN

Having reviewed battery collection programs operated in Europe, local program options were the next consideration. Recycling programs have been mandated by Hennepin County for all municipalities within its jurisdiction. Forty of the County's communities have curbside collection of recyclables, while four rural cities use drop-off centers. With an extensive recycling system in place, adding household batteries to the materials being collected was a logical option. Although curbside collection of batteries appeared to be possible, no models were available to verify this assumption.

The literature review and an inventory of the options available to the County raised questions that could only be answered by conducting test collections:

- Would there be differences in the number and type of batteries received through various collection methods?

- Would a combination of collection methods be necessary to maximize the removal of batteries from the normal waste stream?

- Are there implementation and operating problems which may hinder the effectiveness of specific collection methods?

- What are the costs associated with implementing alternative collection methods county-wide?

Two collection methods were selected for pilot testing--retail drop-off centers and curbside pick up. In the first scenario, residents were asked to bring spent batteries into designated retail facilities. Batteries could be placed in a covered plastic bucket with an opening protected by a spring-closed door. Curbside pick up of batteries, along with recycling materials, was the second method tested.

Two communities willing to work with county staff were selected for the pilot study. The communities were roughly demographically representative of Hennepin County's population. Demographic factors which were examined were community size, percentage of male and female, median age and number in the household (see Table 3). For the community operating the curbside pick up, negotiations with the recycling company had to be conducted to modify their contract to include periodic collections of household batteries. Cooperation of city officials was a key factor in structuring models which could be used by other County communities.

Table 3

Comparison of Community Demographic Characteristics to

General Population of Hennepin County

	County	New Hope	Golden Valley
Population	992,140	23,087	22,775
Median Age	30	28.2	34.4
Percent Male	48.1	47.3	48.3
Percent Female	51.9	52.7	51.7
Number in Household	2.35	2.6	2.48

U.S. Bureau of the Census, 1980

RETAIL DROP-OFF SITES

As a first step in implementing the pilot retail collection, the City of New Hope was asked to act as a program co-sponsor. Agreeing to be a co-sponsor, the city took responsibility for contacting community retailers who sold batteries. Managers of 15 retail stores were contacted by a city staff person to explain the project. Thirteen of the 15 retailers agreed to participate as drop-off sites and were sent a follow-up letter thanking them for their help. On November 1, 1988, the collection containers were delivered, along with a program poster, to the retail stores.

Newspaper inserts and display ads were used to advertise the battery collection sites. The advertising campaign began with an insert which explained the need to keep batteries out of their regular trash and where spent batteries could be taken for proper disposal. Display ads with a similar message were run in the local "shopper" every other week for six months. To control the dissemination of program information, all of the advertising was limited to the New Hope distribution zone.

The Optimists Club of Bloomington was asked to act as the collection agent for the retail collection. The club has been conducting a "button" battery collection in approximately 20 retail stores for five years. The club's collection approach is simple and easy; a collection bucket placed at club members' places of business. When the buckets are full, the batteries are brought to the club president to be sent in for recycling. Monies received for the batteries are put into the club's treasury to be used for charity activities. Club members were willing to coordinate their program with the County's effort in exchange for the recyclable button batteries. The club agreed to check the containers once a month and collect the batteries once a quarter or as needed. At the end of February and beginning of June, retail containers were emptied.

Collected batteries were sorted by Hennepin County Vocational Services for the Handicapped. After the first collection, Vocational Services' employees were asked to sort, count and weigh the batteries by composition type (see Table 4). Sorting after the second pick up was expanded to include total weights and counts by battery size and composition (see Tables 5 and 6).

Tables 5 and 6 revealed that 95 percent of the collected batteries were alkaline or zinc/carbon. Few nickel/cadmium (rechargeable) and "button" batteries were brought in to the retail collection sites during the six month pilot test. Large lantern batteries were left in some of the retail collection containers. These batteries account for more than 50 percent of the total weight for zinc/carbon batteries.

Table 4

Amounts and Types of Batteries Collected

During the First Six Months of the Pilot Project

1989

Golden Valley

Curbside	Number	Percent	Weights	% Pounds
Alkaline	1325	47	148 lbs. 2 oz.	49
Zinc/Carbon	756	27	132 lbs. 14 oz.	45
Nickel/Cadmium	53	2	7 lbs. 7 oz.	2
Buttons	554	20	1 lb. 14 oz.	1
Miscellaneous	104	4	10 lbs. .45 oz.	3
	2792	100	300 lbs. 5.45 oz.	100

New Hope

Retail	Number	Percent	Weights	% Pounds
Alkaline	256	59	33 lbs. 8 oz.	50
Zinc/Carbon	83	19	32 lbs. 3 oz.	48
Nickel/Cadmium	--	--	-----	--
Buttons	70	16	3.8 oz.	.5
Miscellaneous	27	6	1 lbs. 2 oz.	1.5
	436	100	67 lbs. .8 oz.	100

Total (Retail and Curbside) Collected

	Number	Percent	Weights	% Pounds
Alkaline	1581	49	181 lbs. 10 oz.	49
Zinc/Carbon	839	26	165 lbs. 1 oz.	45
Nickel/Cadmium	53	2	7 lbs. 7 oz.	2
Buttons	624	19	2 lbs. 1.4 oz.	1
Miscellaneous	131	4	11 lbs. .24 oz.	3
	3228	100	367 lbs. 3.64 oz.	100

CURBSIDE COLLECTION

The curbside collection pilot was conducted in Golden Valley, Minnesota. City officials in Golden Valley agreed to sponsor two test collections of household batteries and negotiated with their recycler to include spent batteries as part of the recycled collection responsibilities. The first of the two curbside collections was held on February 24, 1989. This date was selected to make pick up available during the months following Christmas when batteries used in gifts would begin to fail. The second collection was held June 23, 1989.

An educational campaign was designed to announce the collection and raise community awareness of proper battery management. Three months prior to the collection, each Golden Valley household received a letter which explained the need for the collection and how to prepare batteries for the recycling pick up. Residents were told to store batteries in a washed half-gallon milk carton or in one-quart Ziplock-style plastic bags. Enclosed with the letter was a bright red battery recycling sticker to be used to seal the top of the container before placing it with other recycling materials. On the collection day, the container was to be placed on top of the recycling bin with the sticker in full view. This information was repeated in the city's community newsletter two weeks prior to the pick up.

During the first pick up, the city's recycling contractor collected 300 pounds of batteries from 245 households. The average household contributed 11 batteries or approximately 1.22 pounds to the collection. Ninety-four percent of the batteries collected were either alkaline or zinc-carbon. Three percent were either nickel-cadmium or button (silver or mercuric oxide). As program awareness grew, so did the number of households participating. More than 400 households placed batteries with their recyclables for the second pickup date, a 40 percent increase in participation. The weight and number of batteries received also increased to 16 batteries per household with an average total weight of 1.6 pounds.

As sales statistics for the battery industry indicate, alkaline and zinc-carbon batteries are the most common types of batteries consumed and, therefore, disposed of in residential trash. Battery sorts conducted after the curbside and retail collections indicate that 90 percent to 93 percent of all loose batteries in a residential waste stream are either alkaline or zinc-carbon. The percentage of alkaline and zinc-carbon batteries collected was substantially higher than the overall market share (70 percent to 75 percent) for these two battery types. This discrepancy may be due to a general lack of consumer awareness of the applications for various batteries used within the home.

Table 5

Amounts and Types of Batteries Collected

During the Second Phase of the Pilot Battery Collection Project

Golden Valley

Curbside	Number	Percent	Weights	% Pounds
Alkaline	3208	49	355 lbs. 5 oz.	54
Zinc/Carbon	1300	21	255 lbs. 15 oz.	39
Nickel/Cadmium	44	1	6 lbs. 3 oz.	1
Buttons	1384	20	6 lb. 0 oz.	1
Miscellaneous	574	9	34 lbs. 0 oz.	5
	6510	100	657 lbs. 7 oz.	100

New Hope

Retail	Number	Percent	Weights	% Pounds
Alkaline	486	57	50 lbs. 11 oz.	47
Zinc/Carbon	239	29	52 lbs. 14 oz.	48
Nickel/Cadmium	29	3	2 lbs. 4 oz.	2
Buttons	72	8	6.7 oz.	1
Miscellaneous	29	3	2 lbs. 6 oz.	2
	855	100	108 lbs. 9.7 oz.	100

Total (Retail and Curbside) Collected

Alkaline	3694	50	406 lbs. 0 oz.	53
Zinc/Carbon	1539	21	308 lbs. 13 oz.	40
Nickel/Cadmium	73	1	8 lbs. 7 oz.	1
Buttons	1456	20	6 lbs. 6.7 oz.	1
Miscellaneous	603	8	37 lbs. 2 oz.	5
	7365	100	766 lbs. 12.7 oz.	100

Table 6

Numbers of Batteries Collected by Size and Type
Second Collection June, 1989

	Curbside		Retail	
	Number	Weight	Number	Weight
Alkaline				
D cell	456	135 lbs. 6 oz.	76	22 lbs. 8 oz.
C cell	505	74 lbs. 11 oz.	64	9 lbs. 9 oz.
9 volt	291	29 lbs. 10 oz.	33	3 lbs. 11 oz.
AA cell	1791	83 lbs. 6 oz.	276	14 lbs. -- oz.
AAA cell	139	3 lbs. 10 oz.	27	-- lbs. 11 oz.
N cell	11	-- lbs. 4 oz.	10	-- lbs. 4 oz.
6 volt (lantern)	12	28 lbs. 7 oz.	--	-- lbs. -- oz.
J cell	3	-- lbs. 9 oz.	--	-- lbs. -- oz.
	3208	355 lbs. 5 oz.	486	50 lbs. 11 oz.
Zinc/Carbon				
D cell	385	75 lbs. 2 oz.	84	16 lbs. 11 oz.
C cell	323	30 lbs. 1 oz.	41	3 lbs. 13 oz.
9 cell	134	10 lbs. 13 oz.	22	1 lbs. 12 oz.
AA cell	351	13 lbs. 2 oz.	69	3 lbs. 7 oz.
AAA cell	16	11 lbs. 5 oz.	--	-- lbs. -- oz.
N cell	--	-- lbs. -- oz.	2	-- lbs. 1 oz.
6 volt (lantern)	83	109 lbs. 2 oz.	21	27 lbs. 2 oz.
Odd size lantern	8	17 lbs. 6 oz.	--	-- lbs. -- oz.
	1300	255 lbs. 15 oz.	239	52 lbs. 14 oz.
Nickel/Cadmium				
D cell	11	4 lbs. -- oz.	4	1 lbs. 4 oz.
C cell	10	1 lbs. 2 oz.	--	-- lbs. -- oz.
AA cell	23	1 lbs. 1 oz.	19	-- lbs. 13 oz.
N cell	--	- lbs. -- oz.	6	-- lbs. 3 oz.
	44	6 lbs. 3 oz.	29	2 lbs. 4 oz.
Miscellaneous Type Unknown				
D cell	36	7 lbs. 5 oz.	--	-- lbs. -- oz.
C cell	11	1 lbs. 2 oz.	--	-- lbs. -- oz.
AA cell	82	3 lbs. 1 oz.	--	-- lbs. -- oz.
AAA cell	19	- lbs. 6 oz.	--	-- lbs. -- oz.
12.6 volts	6	1 lbs. 11 oz.	--	-- lbs. -- oz.
Odd sizes	37	9 lbs. 2 oz.	28	2 lbs. 2 oz.
	191	22 lbs. 11 oz.	28	2 lbs. 2 oz.
Mercury Batteries				
N	359	8 lbs. 13 oz.	1	-- lbs. 4 oz.
9 volt	24	2 lbs. 8 oz.	--	-- lbs. -- oz.
	383	11 lbs. 5 oz.	1	-- lbs. 4 oz.
Miscellaneous Total	**574**	**34 lbs -- oz.**	**29**	**2 lbs. 6 oz.**

STORAGE

The Minnesota Pollution Control Agency (PCA) is responsible for regulating hazardous wastes generated within the state. Batteries are considered by the PCA as a household hazardous waste, which, once collected for special disposal, must be managed to Federal and state standards applicable to generators of hazardous waste. If collected, household batteries must be stored, treated and disposed of at permitted hazardous waste facilities. Household batteries disposed of by an individual in the normal waste stream are exempt from hazardous waste regulation. A second exemption from the hazardous waste rules exists for waste batteries which are returned to the manufacturer for regeneration.

Necessary PCA approval was given to the County to store the collected batteries in a licensed storage facility for up to one year. Extending the storage time allowed the County to accumulate large enough quantities to assess the extent of the problem and explore recycling and disposal options. Storage space was expected to require ten 55-gallon drums. A storage area was approved by the State Pollution Control Agency, County Licensing, Inspection and Compliance Section and the fire marshal for the City of Hopkins at the County's Public Works garage in Hopkins.

Prior to storage, the batteries were sorted into five categories: zinc/carbon, alkaline, nickel/cadmium, mixed "button", and miscellaneous. Each battery category was placed in separate polyurethane barrels and marked as "hazardous corrosive materials". By sorting the batteries by type, the County was able to periodically measure mercury emissions from the stored materials.

Using a Bacharacn Mercury Vapor Sniffer, with a sensitivity of 0.01 milligrams per cubic meter, mercury was detected inside the barrels at or above the threshold limit value/time weighted average of 0.05 mg/cubic meter. The level of mercury varied depending on the type of batteries being stored and on the length of time they had been in storage. Alkaline batteries stored for up to three months had the highest concentrations of mercury vapors, registering at 0.5 mg/cubic meter. Mercury was not detected in the store room prior to the barrels being tested. As soon as the barrels were opened, mercury vapor levels in the store room increased but then rapidly dissipated. Test results indicate that the potential exists for material handlers to be briefly exposed to high levels of mercury vapors. The readings obtained for the mercury emissions indicate a need for special ventilation and handling precautions when batteries are stored for long periods.

DISPOSAL

Hennepin County has been storing all batteries collected during its pilot test in an attempt to locate appropriate processing alternatives. Few processing or disposal options are readily available and most are expensive. In an effort to avoid state hazardous waste regulations, Hennepin County has asked manufacturers if they would accept spent batteries for regeneration. At the present time, spent household batteries are not routinely accepted by manufacturers. Processing and disposal of household batteries became the major consideration for the County.

Recycling collected household batteries was the original intent of the County's battery collection program. Ideally, all spent batteries would be shipped to a recycling facility to have their metal components reclaimed. Unfortunately, the metal contents of zinc/carbon and alkaline batteries is of little economic value and recovery, if it were available, would be costly. Several companies specializing in metals recovery will accept all types of batteries for disposal but only mercuric oxide, silver oxide, lead-acid, and nickel-cadmium batteries are processed for their metals.

Concerned that metals processing companies meet hazardous waste management requirements, Hennepin County decided that potential processing facilities should be inspected. The objective of the County's visits were to:

- Review waste handling and processing methods, including analytical testing, quality control, contingency safety planning, and the generation and disposal of residual waste.
- Review the company's hazardous waste management plan as required by the state within which the facility operates.
- Meet and review state and local inspection records for the facility during the past five years.

Only three companies in the United State were found that could accept batteries and in October, 1989, inspection visits were made to these three facilities in New York and Pennsylvania. Each company visited specialized in the recovery or neutralization of batteries with electrodes that were either mercury oxide, silver oxide, nickel, cadmium or lithium. The visit summary that follows highlights some of the difficulties in reclaiming household batteries.

INMETCO

INMETCO is located 35 miles northwest of Pittsburgh in Ellwood City, Pennsylvania. The company was established in 1976 by INCO as a waste metals reclamation facility. The majority of materials processed by INMETCO is manufacturing byproducts containing nickel, iron and chromium. Hennepin County inspected INMETCO's facility on October 5, 1989, to determine if a contract should be considered for the processing of nickel-cadmium batteries collected from household and commercial businesses.

INMETCO processes approximately 38,000 tons of wastes a year using a modified smelting system. Materials entering the plant are dumped into individual floor stalls where they are analyzed for metal content. The materials are then stored until enough similar wastes are collected to be processed as a batch. Solid wastes are fed into a shredder prior to entering a pelletizing disk. After being formed into uniform pellets, the materials are transferred to a rotary hearth furnace (RHF). The RHF operates at 2300° F. to reduce oxidized metals to their original metallic form. The reduced metals are then fed into a submerged arc furnace where they are smelted for extraction of the metal components. The resulting molten metal is cast into 40 pound pigs which can be used in the manufacture of steel.

The hazardous materials accepted for processing by INMETCO required that the company have operating permits issued by the State of Pennsylvania. INMETCO has submitted its application for a Part B, RCRA permit which would license the company as a Treatment, Storage and Disposal facility (TSD). A letter provided by the Pennsylvania Department of Environmental Resources indicates that the company is in the early stages of the licensing process.

MERCURY REFINING COMPANY

Mercury Refining's processing facility is located in an industrial area in Albany, New York. Sited on the rear half of an industrial lot, the entire facility covers approximately three quarters of one acre. Three buildings were originally used to house a refractory, laboratory and storage area. In September, 1989, the building containing the laboratory was destroyed by fire. To provide adequate work space, the company has moved a trailer onto the property until a new building can be constructed. Mercury Refining has just begun the process of applying for its building permits.

When batteries are received, they are sorted according to size and type. Lithium cells are sent to BDT, Inc., for processing. Any Nicads are stored pending a processing agreement with F.W. Hemple which is located in France. The mercury and silver oxide batteries are used as spacers to help with the air flow in the extraction of sludges. Hence, storage time is minimal for the mercury and silver oxide batteries.

Mercury Refining receives mercury-bearing wastes and processes it using a three-step distillation method. The wastes are processed in batches that are baked for 18 to 24 hours. Mercury is vaporized in the furnace, condensed using a glycol-cooled condenser, and collected in a water trap. The mercury collected is then placed in a second furnace where it is again baked for 18 hours and recollected by condensation in a water trap. Recovered mercury is then treated with a dilute nitric acid solution and purged 24 hours to remove the volatile impurities. The triple distilled mercury is then marketed.

Due to the hazards of mercury, the wastes being accepted for processing at Mercury Refining require the State of New York to inspect and issue operating permits. When first inspected, Mercury Refining was out of compliance with the hazardous waste facility rules. They have since made corrections in these violations and the last inspection indicated minor paper work deficiencies.

BDT, INC.

BDT, Inc., is a privately held company located in Clarence, New York. Built in 1982, the facility was designed specifically for the handling of hazardous waste materials. BDT offers three methods of waste treatment - chemical, thermal and cylinder discharge. The majority of materials processed by BDT are reactives which must be neutralized prior to disposal. Lithium batteries and other reactives are chemically treated using a patented process.

All materials sent to BDT must meet DOT shipping requirements for hazardous materials. Each shipment is inspected and analyzed using established quality control procedures. Materials sent for chemical treatment, including lithium batteries, are loaded onto a conveyor which moves them into an explosion-proof room. The materials then pass into a Shredolyzer, a patented hydrolysis system designed by BDT. As the materials are shredded, a base solution is sprayed onto the contents, reacting and neutralizing the wastes. After shredding, the process mix enters a chemical treatment tank where reaction is completed. At the completion of the process, the solids and liquids are separated for proper disposal. Solid materials are sent to a hazardous waste landfill and the liquids are sent for further treatment.

BDT is a licensed Treatment, Storage and Disposal facility. The company received its Part B permit from the State of New York in 1986. Inspection reports received from the New York Department of Environmental Conservation for the past four years indicate that BDT has not been cited for any violations. The facility inspector from DEC stated that the company has an excellent operating record and is interested in maintaining a safe, clean environment.

Hennepin County is interested in having the metals reclaimed from household batteries. BDT's process does not reclaim any materials; rather, they are treating the waste prior to landfilling to reduce the dangerous characteristics of the battery.

CHAPTER 4

LESSON LEARNED

Hennepin County's pilot collection of household batteries demonstrates that both retail drop-off and curbside collection can remove batteries from the normal waste stream. Conducting trial collections raised a number of program planning issues that communities will need to address prior to implementing a battery collection program. How a community responds to these issues will determine the extent, design and effectiveness of its battery collection efforts.

PROGRAM JUSTIFICATION

In most communities, spent dry cell batteries are thrown into the trash and eventually find their way into a sanitary landfill, incinerator or composting facility. The first issue that a community must address when considering implementation of a battery collection program is the potential for contamination that dry cell batteries pose to their waste management facilities. As described in Chapter 1, some of the metals used in batteries have the potential to cause environmental problems if they are released in large quantities.

Assessing the risk posed by batteries entering a community's waste disposal facility is a difficult and imprecise task. Much of the information needed to accurately estimate the amounts of metals contributed to the waste stream by dry cell batteries is considered proprietary by the industry and, therefore, not readily available. Data concerning sales and quantities of metals used per battery, two necessary pieces of information for developing accurate disposal estimates, must be projected from outdated information sources. Without precise information, community officials are faced with assessing the need for a battery collection program without the aid of objective data that clearly defines the scope of the problem.

When examining risks associated with dry cell battery disposal, an often asked question is whether all types of batteries should be collected or if specific battery types containing problem materials should be targeted. This question is not easily answered and convincing arguments can be made for various collection alternatives. Alkaline batteries offer an example of the arguments for and against collection of all types of batteries.

While the amount of mercury in an individual alkaline cell is small, the number of alkaline batteries sold and disposed of each year is extremely large. It can be argued that the large volume of alkaline batteries in the waste stream contributes significant amounts of mercury to the environment. The battery manufacturers have addressed this problem by developing new technology which lowers the amounts of mercury needed in the alkaline cell. Alkaline batteries with lower mercury are not yet readily available in the United States but will be entering the market during the next five years.

Proponents of collecting batteries point out that the alkaline batteries currently on the market contain higher amounts of mercury. With a lag time of up to one year between production and sale of the battery, it could take six years before a reduction in the contribution of mercury to the waste stream by alkaline batteries is realized. To prevent any further detrimental effects to the environment, battery collection and special disposal is necessary.

Opponents to implementing collection of all types of batteries argue that special collections will not be needed once the lower mercury alkaline battery is available. Implementing a special materials collection requires expensive public education carried out over a long period of time. By the time a battery collection program is fully operational and gaining recognition, there may be no need for the program. Ending a battery collection after an extensive educational campaign could create confusion among residents and a negative opinion toward other solid waste programs. The money necessary to collect all types of batteries would be better spent on other problem wastes.

Recognizing that both arguments are valid, Hennepin County has taken a phased approach to implementing its battery collection programs. Batteries which contain significant amounts of problem metals, such as mercury and cadmium, and can have the metals reclaimed, are being given priority for collection. Hennepin County will first collect, beginning January, 1990, mercuric and silver oxide "button" batteries - those most commonly used to power hearing aids, watches and cameras. Research conducted as part of this project has identified that Mercury Refining Company will accept button batteries for processing.

In a broader effort to deal with specialty and rechargeable batteries, Hennepin County will work with the Minnesota State Legislature to develop alternative handling and disposal laws. Rechargeable household appliances are a hidden source of nickel-cadmium batteries. A lack of access to the battery also creates an illusion that the appliance operates without a power sources. When consumers are asked how many battery-operated appliances they own, most forget to include appliances with rechargeable batteries. While forgotten by consumers, rechargeable nickel-cadmium batteries are considered by the EPA to be the largest contributor of cadmium to the ash from a municipal solid waste incinerator. The National Electronics Manufacturing Association (NEMA) reports that 80 percent of all rechargeable batteries are sealed into small household appliances. The design of many rechargeable appliances makes removing the battery component difficult, if not impossible, for the user. Hennepin County will work to require that household appliances using rechargeable batteries be designed to make it possible to remove the battery.

PROGRAM COSTS

Cost is a second factor in determining whether a community should implement a battery collection program. Few communities in the United States have identified dry cell batteries as a problem material needing special collection and disposal. Therefore, information concerning program design and operating costs is lacking. Hennepin County's pilot battery collection offers insights to three factors that can affect program cost. These factors are: the scope of the program, extent of advertising, and disposal methods.

PROGRAM SCOPE

The primary goal of the County's pilot battery collection program was to examine collection methods which might optimize the number of batteries removed from the normal waste stream. Accepting all types of dry cell batteries increases the convenience for the participant but it also drives up operating costs. Batteries that are mixed together during collection may require hand sorting prior to disposal. While sorting appears to be a simple process, finding a company with adequate storage facilities and personnel is difficult.

Workers who sort and package the batteries for disposal will require training. If state regulatory agencies identify household batteries as a hazardous waste, employees will have to be provided additional right-to-know training. Workers that are sorting the batteries may have concerns about mercury vapors and corrosive oxides on the battery casings. Providing a well ventilated room and rubber gloves are simple solutions to these questions. The need to protect workers from the potential problems of handling hazardous materials makes battery sorting expensive. Sorting one pound of batteries is estimated to cost 20 cents or approximately $125 per 55 gallon drum.

One option for lowering collection costs is to limit the scope of the materials to be collected. Having identified problem metals in the waste stream, the specific types of batteries which contain those metals could be targeted for removal. Hennepin County's retail "button" battery collection program is an example of a targeted collection. While targeting mercury cells, the County will collect all button cells for metals processing. Unique sizes, shapes and uses make button batteries easily identifiable from other types of dry cell batteries. Focusing program design on the button battery's unique aspects, collection and advertising methods can be tailored to meet the needs of large volume users.

ADVERTISING

Advertising is a major factor influencing program costs. All advertising and information concerning the curbside collection was distributed through direct mail to the residents. Prior to the collection days, a letter with a program sticker was sent to each household in the city. The cost for printing and mailing 7,000 letters (not including cost of the stickers) was approximately 29 cents per household. Printing costs for the letters was covered by the pilot project, while the City of Golden Valley paid for them to be bulk mailed. Total cost for advertising the two curbside collections was $4,000. The results of the direct mail campaign were immediate, with many residents contacting the city offices requesting additional information.

Advertising for the retail drop-off sites was conducted through newspaper inserts and display ads. The ad campaign for the retail sites began with a one-page insert in the local shopping guide. Display ads were also placed in the shopper every other week for the next six months. The guide is delivered to all homes in the demonstration city. Total advertising cost for the retail drop-off was $2,000. Newspaper advertising was used to present a continuing and consistent message to city residents. Yet, the collection was slow in achieving results. The ads were less apparent when included among other advertising and provided less information.

Advertising was the second largest expense of the pilot battery collections and played a major role in participation rates. Communities can anticipate that a large portion of a battery collection budget will be used to promote the program. Ongoing battery collections will have to use a variety of advertising and public education techniques to keep residents informed of the programs. Costs for promoting a battery collection will vary according to the media used and the frequency that the message is delivered.

DISPOSAL

The vast majority of the batteries collected will have to be either stored for long periods or landfilled. In some states, household batteries are considered to be a hazardous waste requiring special disposal. If collected, batteries are to be disposed of in a hazardous waste landfill, the cost of disposal of a 55 gallon barrel can be estimated at $250 to $500 plus transportation costs. Landfills accepting the materials may also impose special packaging requirements. The batteries may have to be separated by battery type and placed in polyurethane drums or drums with plastic liners. Batteries may also have to have layers of clay or other absorbent materials in the barrel to prevent corrosion or discharge. Each additional precaution will increase the cost of disposal and may add up to $100 per barrel.

State and local government regulations pertaining to the collection, storage and disposal of household batteries will greatly affect the cost of operating a program. contacting state environmental regulatory agencies to determine what laws and rules apply to communities considering collecting household batteries for alternative disposal is a necessary step of program planning. If the state does not consider household batteries as a hazardous waste, program costs may be substantially lowered by using either a municipal or industrial landfill. It should be noted that using a less secure landfill will increase the potential for the waste to escape its container and contaminate surrounding soils.

PROGRAM CONSIDERATIONS: SAFETY AND CONVENIENCE

After determining the disposal costs and methods for collected household batteries, a community must evaluate available collection methods. Safety, convenience and efficiency need to be designed into the collection system if it is to work well and be accepted by the public. Safety procedures should be developed to address potential problems and ensure public health. Informational materials need to be provided which explain the hazard that batteries pose in the waste stream and describe appropriate methods for handling problems at all stages of the collection. Residents saving batteries will have specific questions that can be anticipated and should be addressed in the educational materials promoting the program.

Residents will want to know how to safely store and handle batteries for disposal; of particular concern will be how to handle leaking or corroded batteries. Simply instructing residents to place leaking batteries in a plastic sandwich bag, seal it with a rubber band, and take it to a collection site can alleviate their fears. Collecting small "button" batteries in the home can be a threat if the potential exists for ingestion by a child. An empty aspirin bottle with a child-proof cap can be used by residents as a "lockable" container for button batteries in the home. This type of tamper-proof container can hold from 10 to 50 button batteries.

CONVENIENCE

Convenience is a major consideration in getting residents to use a specialized disposal system for spent household batteries. Convenience can be interpreted as the ease with which an individual can segregate, store and deliver the targeted material for disposal. The overwhelming success of collecting dry cell batteries at curbside demonstrates the effects convenience can have on special disposal programs. The curbside battery collection was a variation of an ongoing residential recycling program being conducted in the test community. It simply required participants to separate spent batteries from other waste and to place them for disposal with other recycling materials. The result was six times as much material in a single curbside collection as in retail store containers kept in place for more than three months.

Convenience also affected the results from the retail collections. Discussions with retailers participating in the battery collection indicated that as employees became aware of the program, they became the initial users of the containers. It was convenient for workers to bring spent batteries from home to a collection site located in an area readily accessible during "regular" daily activities. Having a collection site at the work place, provided easy access to a drop-off container and helped increase program participation.

CONCLUSION

Extensive public education and a variety of collection methods may be needed for a community to adequately reduce the batteries entering a residential waste stream. While curbside collections may be one of the most efficient methods of picking up batteries, it will not serve the needs of an entire community. Individuals not served by recycling programs will have to be provided with an alternative method of participating. Special programs for hospitals, nursing homes and communications centers will be necessary if a community truly wishes to minimize the potential hazard caused by household batteries. Commercial businesses and institutional users of large numbers of batteries will have to dispose of their batteries in accordance with hazardous waste disposal regulations. Communities that want to collect household batteries will have to clearly define their needs in order to design programs which can achieve their environmental and solid waste management goals.

Program costs, state and local regulations, and a lack of disposal options are planning issues which a community will have to address before implementing household battery collection programs.

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REPORT AND INFORMATION SOURCES

Additional copies of this report, "Household Batteries: Evaluation of Collection Methods," are available from:

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