The Community Choice Between High and Low Technology Approaches to Resource Recovery

by

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ABSTRACT

Traditional methods for disposing of municipal solid waste, landfilling and incineration, have in many communities been unable to meet local disposal needs and various environmental regulations. In recent years, resource recovery -- the recovery of materials and/or energy from household waste -- has offered an alternative. There are two generic approaches to resource recovery: the "low technology" approach involves household separation of recyclable materials and the "high technology" approach involves processing mixed wastes to recover energy and perhaps materials.

The debate over the merits of each approach has focused on national issues of resource conservation, consumption habits, and disposal impacts. However, the decision to implement or participate in a resource recovery program is usually municipal. The thesis thus examines the appropriate technology issue from a community perspective. Using a case study approach, it observes how communities view the low-versus-high technology issue, and defines some elements of a choice process for communities considering resource recovery.

The case studies suggest that municipalities typically do not face a binary choice between low and high technology approaches. Rather, they can select combinations of resource recovery options or sequence their choices so as to best address local needs. A community's particular objectives and circumstances with respect to solid waste management will have a major influence on its evaluation of resource recovery options.

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I. INTRODUCTION

The United States generates large quantities of municipal solid waste (MSW) -- about 140 million tons annually. Traditional disposal methods -- sanitary landfilling and incineration -- have been hard pressed to keep pace, what with rising disposal costs and environmental and health regulations of disposal practices. Cost and capacity problems with traditional disposal have led many communities to consider alternatives; one attractive option is resource recovery -- the recovery of materials or energy (or both) from the waste stream.

There are two generic -- and fundamentally different -- approaches to resource recovery. The so-called "low technology" approach is labor-intensive, and involves separating household solid wastes into recyclable and non-recyclable components.* Recyclable wastes are then collected and transported separately to material markets. The so-called "high technology" approach is capital intensive; mixed MSW is processed at a centralized facility, and energy is usually recovered from the combustible portion. The choice between high and low technology approaches to resource recovery is the basis of the appropriate technology issue.

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* Or, rather, not mixing wastes at their point of generation.

Arguments for one or the other revolve primarily around national issues of disposal impacts and natural resource policy. These include: the net energy requirements of each approach, their implications for MSW disposal needs and impacts, their effect on rates of natural resource exploitation, and their effect of patterns of consumption and waste generation.

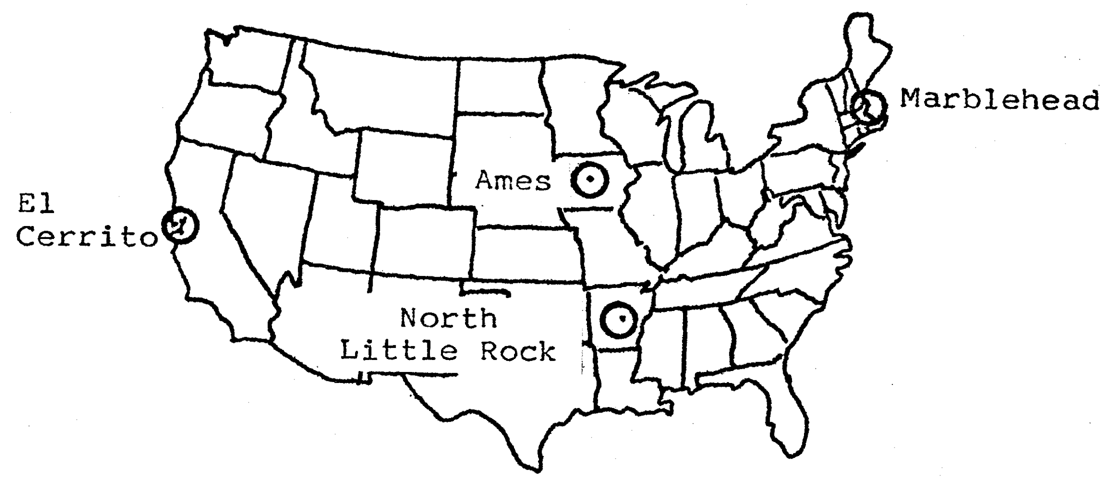
The appropriate technology issue has been addressed in previous studies and papers,[1] but in each case from either a national or non-site-specific perspective. There apparently have been no studies of this issue from a local or community perspective. Such an approach would be useful, since the decision to implement or participate in a resource recovery program is usually made by local government. At this level, most of the issues central to the national debate are external to the resource recovery choice (for example, a community should not expect its choice to influence the size of secondary material markets or consumption habits). Also, a community may find that key variables, such as MSW composition or current disposal costs, differ significantly from the national averages, on which most analyses of appropriate technology are based.

For these reasons, an analysis of the low-versus-high technology resource recovery issue from a community perspective would be helpful. The analysis is based on a case study approach, considering four cases in which communities selected and successfully implemented resource recovery systems. In each case, the choice process is examined -- circumstances leading to a decision, options considered, participants, choice criteria used, project implementation, and results of the project to date.

From the case studies, the thesis (i) observes how communities view the low-versus-high technology resource recovery issue and (ii) defines some elements of a choice process for communities considering resource recovery, in light of the appropriate technology issue. The four cases are not intended to describe all possible resource recovery options or all project selection and implementation issues. They illustrate four very different choice processes and provide mostly site-specific results. Nonetheless, they allow me to make some general comments about the appropriate technology issue and a process for community choice. Figure 1 locates the four cases.

Several conclusions are worth highlighting. First, the low-versus-high technology choice is not binary. The two approaches to resource recovery are not really substitutes, and communities tend not to view them as competing options. Second, a community's particular objectives and circumstancees with regard to solid waste management will have a major influence on its evaluation of resource recovery options. Third, the resource recovery choice is very closely tied to implementation issues. Given the high degree of interdependence

Figure 1 Case Study Locations



of various elements of a resource recovery strategy, a community must usually address specific implementation issues (such as materials and/or energy buyers) prior to selecting a particular option.

The following two sections provide background information on solid waste management practices and resource recovery options, and describe the low-versus-high technology debate in more detail. Sections IV - VII contain the four case studies; the first two are examples of the low-technology approach, and the second two illustrate the high-technology approach. Section VIII discusses the resulting conclusions, re-examining the appropriate technology question and defining a process for communities wishing to compare the two approaches in their context.

Notes

1. See, for example: Marchant Wentworth, Resource Recovery: Truth & Consequences (Washington, D.C.: Environmental Action Foundation), 1977; Congress of the United States, Office of Technology Assessment, Materials and Energy from Municipal Waste, Volume I (Washington, D.C.: U.S. GPO), July 1979; and California Resource Recovery Association, Recycling: The State of the Art (Santa Barbara: Comm. Envir. Council), 1978.

II. WHY RESOURCE RECOVERY?

The purpose of this section is to provide some background for the subsequent case studies and discussion. It therefore reviews solid waste disposal practices in the U.S., their associated problems, and various resource recovery systems. Readers familiar with these issued may wish to skip this section.

Solid waste can be conveniently divided into two categories: municipal and non-municipal. Municipal solid waste (MSW), which we concentrate upon, includes wastes generated by households, small commercial and business establishments, and institutions such as schools and government offices.[1] It specifically excludes solid waste produced by industrial, farming, mining, and demolition activities. MSW is composed of a remarkable variety of products and materials; Table 1 indicates its composition in general terms.

U.S. households and commercial sources currently generate a considerable amount of MSW -- over 140 million tons annually, or nearly 3.5 pounds per capita per day.[2] Waste generation has grown steadily in the last two decades, and is expected to continue to increase somewhat in the future. EPA predicts 225 million tons annually by the year 1990.[3] Table 1 also provides data on MSW generation in 1975.

TABLE 1 MATERIAL COMPOSITION OF MSW*

	Waste content as discarded		Net waste disposed of after recycling	
Material	Million tons	% of total	Million tons	% of total
Paper	44.1	32.4	37.2	29.0
Glass	13.7	10.1	13.3	10.4
Ferrous	11.3	8.3	10.8	8.4
Aluminum	1.0	0.7	0.9	0.7
Other nonferrous	0.4	0.3	0.4	0.3
Plastics	4.4	3.2	4.4	3.4
Rubber	2.8	2.1	2.6	2.0
Leather	0.7	0.5	0.7	0.5
Textiles	2.1	1.5	2.1	1.6
Wood	4.8	3.5	4.8	3.7
Other	0.1	0.1	0.1	0.1
Total nonfood product waste	85.4	62.7	77.5	60.4
Food waste	22.8	16.8	22.8	17.8
Yard waste	26.0	19.1	26.0	20.3
Miscellaneous inorganic wastes	1.9	1.4	1.9	1.5
TOTAL	136.1	100.0	128.2	100.0

Source: U.S. Environmental Protection Agency, Fourth Report to Congress: Resource Recovery and Waste Reduction, SW-600 (Washington, D.C.: U.S. GPO), 1977, p.18.

* 1975 data for the United States. The composition reflects considerable geographic and seasonal variation.

MSW disposal practices have improved significantly since the 1960s, when open dumping and incinerators were prevalent. The 1972 Clean Air Act resulted in the closure of most large MSW incinerators, and most open dumps were either closed or converted to sanitary landfills in response to state laws and the 1976 Resource Conservation and Recovery Act. Sanitary landfilling is an engineered method of MSW burial -- waste is spread in layers, compacted, and covered with a layer of soil.[4]

While vastly superior to open dumps, sanitary landfills nonetheless pose a variety of environmental and economic problems. Landfills can cause surface and groundwater contamination, due to surface runoff and underground leachate movement. In recent years, groundwater contamination has emerged as a serious environmental and public health issue -- currently, about half of the U.S. population is served by groundwater. Landfills consume considerable amounts of land each year, effectively pre-empting other uses well into the future.

Landfilling, once a cheap disposal method, is fast becoming a very costly one. EPA estimated the average cost of MSW collection and disposal in 1976 to be about $30/ton, -- or $4 billion per year nation-wide.[5] About 20% of this amount, or $6/ton, represents disposal costs. As state and federal regulations reduce the environmental and health impacts of landfilling, the "full" economic cost of landfilling will be more apparent. In addition to inflation and growth of the waste stream itself, disposal costs are expected to increase in the future due to rising land values and longer haul distance to new outlying disposal sites.[6] Opposition by landowners and nearby residents to landfill siting represents a serious obstacle to the long-term viability of landfilling in many areas.

There are three generic approaches to the problems of excessive MSW generation and conventional disposal: waste reduction, source separation (with materials recycling), and centralized processing (with energy recovery). Waste reduction refers to the prevention of waste at its source by redesigning products or changing patterns of production and comsumption. It can be achieved in several ways: by developing products that require less material per unit (eg. smaller automobiles), by developing products with longer average lifetimes, by substituting reusable products for "disposable" ones, and by reducing household comsumption of products. EPA estimates that 20 million tons (or 10%) of the 1985 anuual waste stream could be eliminated by a waste reduction scenario that includes refillable beverage containers, more durable automobile tires, and a 10% reduction in other packaging wastes.[7] Little progress has been made in this direction so far; mandatory beverage container deposit laws ("bottle bills") are the most visible achievement to date.

Together, source separation and centralized MSW processing constitute resource recovery -- the recovery of materials or energy (or both) from MSW. Source separation, because it is simple and requires little capital investment, is considered a "low technology" approach to resource recovery. Conversely, centralized MSW processing, using complex processing equipment and being capital intensive, is often called a "high technology". Both approaches have the effect of reducing our reliance on landfills for MSW disposal and supplementing our use of primary materials and/or energy.

Source separation (or low technology resource recovery) is defined as the setting aside of recyclable waste materials at their point of generation for segregated collection and transport to secondary material markets.[8] Transportation may be provided by the waste generator, by city collection vehicles, by private haulers, or by voluntary recycling organizations. There are two principal types of source separation programs of concern to municipalities: curbside separate collection and the community recycling center.*

Under a curbside separate collection program, recyclable materials are collected at curbside on a regular basis, saving the resident or business from having to transport the materials. A recent EPA survey found 218 such programs in the U.S. Virtually all programs collect paper (newsprint or mixed waste paper); only 16% and 14% collect glass and metal, respectively. In most cases (57%), separate collection is performed by the municipality -- private collection firms and community organizations operate 29% and 12% of the programs, respectively.[9]

With a community recycling center, the participant is required to deliver recyclable materials to a central col-

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* Other separate collection programs are more specialized: industry-sponsored recycling (such as aluminum can re-purchase programs), office paper recycling, and commercial and industrial source separation (eg. supermarkets segragating such products as corrugated paper).

lection point. Following Earth Day in 1970, thousands of recycling centers sprang up in the U.S. Typically, a recycling center will accept several materials -- paper, glass, (either mixed of color-sorted), "tin" cans, aluminum cans, and perhaps other waste products as well. The center may be municipally-operated, or, more likely, operated by a private contractor or community organization. Until recently, recycling centers did not pay for waste material; recent years have seen the establishment of a few "buy-back" programs that pay participants a per-pound price for specified materials, such as paper or aluminum.

Several communities in California use an "integrated" approach to source separation, which combines these two principal programs and perhaps others. Such a program might include curbside separate collection, a drop-off recycling center, a buy-back program, and a system of satellite drop-off facilities. This approach allows participants to select the program that they prefer, and may enhance community participation.

All of the above low-technology approaches require markets for recovered materials. Often, materials are sold on an irregular basis as storage bins fill -- in only a few cases do recycling programs have contracts with material buyers. Recycling programs currently divert about 9 million tons of MSW annually from the waste stream -- or 6% of total MSW tonnage in 1975.[10] Over 90% of this tonnage is comprised of various paper wastes. EPA estimates that source separation has the potential to divert as much as 50 million tons of MSW per year by 1985.

To summarize, recycling diverts a relatively small percentage of a community's MSW (in the range of 1-25% by weight). It has low initial cost and operating costs, and can be quickly planned and developed. It has a low opportunity cost, being flexible and adaptible to changing MSW volume or composition. It requires considerable public support and participation to be effective. Finally, it has a low financial risk, due to its low initial cost and flexibility.

High-technology resource recovery involves the centralized processing of mixed MSW, in order to separate recyclable materials and convert the remaining fraction into an energy product -- dry fuel, steam, or electricity. There are a wide variety of centralized MSW processing technologies, with varying degrees of complexity, cost, and demonstrated feasibility. Energy and materials recovery technologies can be combined in a variety of ways. Only three processes have been widely used thus far, however: waterwall combustion (mostly in Europe), composting (mostly in Europe), and magnetic separation of ferrous scrap. In the U.S., two other processes have been proven commercially to a lesser extent -- modular incineration with heat recovery, and refuse-derived fuel (RDF) processing.

In waterwall combustion, MSW is burned directly in large waterwall furnaces, generally without any pre-processing. The primary product is steam, which can be used directly (for industrial processes) or converted to electricity. In some cases, MSW is first shredded to facilitate materials recovery; ferrous metals can be recovered either before or after incineration. Waterwall units are widely used in Europe and Japan; in 1975 there were seven units completed in the U.S. Plant capacity has ranged from 300 to 1,600 tons per day (TPD); recently proposed plants have been still larger -- up to 3,000 TPD.[11]

Small-scale modular incinerators recover heat in the form of steam or hot water, usually without any materials recovery. A modular plant consists of a series of small identical furnaces. MSW is incinerated in two stages: the first stage is a starved-air combustion process, producing a combustible gas. The gas is then burned with an auxiliary fuel (oil of gas) in a secondary combustion chamber. The two-stage process reduces particulate emissions and provided more complete combustion.[12] This technology was developed for hospitals, schools, and other institutions, and was recently adapted to mixed MSW. In 1975, only three communities in the U.S. had developed modular incinerators with heat recovery; these units had capacities of 20-50 TPD. More recent plants have a wider range of capacity -- up to 200 TPD.

Refuse-derived fuel systems produce RDF by separating MSW and mechanically removing the organic (combustible) fraction -- using a "wet" or "dry" process. The fuel product is termed "fluff" RDF, "densified" RDF, or "powdered" RDF, depending on subsequent processing. RDF is used as a fuel supplement in conventional coal-fired boilers -- usually in an 80% coal - 20% RDF mixture. At an RDF plant, refuse is first shredded, and then separated into a light and heavy fraction, using an air classifier. Ferrous (and perhaps other) metals are recovered from the heavy fraction; the light fraction is RDF. There were four operating RDF plants in the U.S. in 1975, with another 20 either being constructed or at the advanced planning stage. Plant scale has varied greatly -- from a 200 TPD facility in Ames, Iowa, to a 6,000 TPD plant in St. Louis, Missouri.

Other centralized processing technologies are either commercially unproven or lack markets for their products in the U.S. -- composting is a good example of the latter situation. Several technologies are in an experimental or demonstration phase: pyrolysis (the partial decomposition of MSW to yield a gas and/or liquid fuel), anaerobic digestion (the biological degradation of MSW by micro-organisms in the absence of oxygen), and various materials-recovery processes to isolate glass, aluminum, and non-ferrous metals.

Including all centralized processing technologies, there were 21 operational resource recovery plants in 1975; another

10 were under construction, 33 were in advanced planning, and 54 were under study.[13] Centralized MSW processing has been estimated to cost $15-32 per ton depending on the technology used; energy and material revenues range from $5 to $17 per ton, leaving net costs of $3-21 per ton.[14] Given very limited commercial experience with a range of different technologies, these cost and revenue estimates are necessarily rough.

High-technology resource recovery differs strikingly in many respects from recycling. It diverts a much larger percentage of MSW (in the range of 50-90% by weight), acting more as a substitute for conventional disposal than as a way of reducing disposal needs. It has high initial costs and, partly as a consequence, requires a much longer lead time -- on the order of 3-8 years. It has a much higher opportunity cost, due to the long financing period (typically 20-30 years) and lack of operating flexibility. Finally, it has a much higher financial risk, due to the volatility of net operating costs, high initial costs, and limited experience with the various recovery technologies.

Notes

1. Michael Greenberg, "Suggestions for Evaluating Resource Recovery Proposals", AIP Journal, January 1977, p. 25.

2. Congress of the United States, Office of Technology Assessment, Materials and Energy from Municipal Waste, Volume I (Washington, D.C.: U.S. GPO), July 1975, p. 24.

3. U.S. Environmental Protection Agency, Fourth Report to Congress: Resource Recovery and Waste Reduction (Washington, D.C.: U.S. GPO), 1977, p. 20.

4. Marchant Wentworth, Resource Recovery: Truth & Consequences (Washington, D.C.: Environmental Action Foundation), 1977, p. 75.

5. U.S. EPA, op.cit., p.4.

6. U.S. EPA, op.cit., p.4.

7. U.S. EPA, op.cit., p.7.

8. U.S. EPA, op.cit., p.32.

9. U.S. Environmental Protection Agency, A National Survey of Separate Collection Programs, by David Cohen, SW-778 (Washington, D.C.: U.S. GPO), 1979, p. 2.

10. U.S. EPA, Fourth Report, op.cit., p. 32.

11. U.S. EPA, Fourth Report, op.cit., p. 47.

12. Congress of the United States, op.cit., p. 255.

13. U.S. EPA, Fourth Report, op.cit., pp. 47-49.

14. Congress of the United States, op.cit., p. 130.

III. THE ISSUE OF APPROPRIATE TECHNOLOGY

Given the two generic approaches to resource recovery described in section II, what is the appropriate technology issue and why is it important? The low-versus-high technology debate revolves aroung patterns of resource utilization and consumption as much as it does MSW disposal. Advocates of the low-technology approach find the United States' prolific rate of resource extraction and consumption untenable. They see source separation (and recycling) as a way to sensitize citizens to the problems of excessive consumption, and as a prelude to serious efforts at waste reduction. High-technology proponents see nothing amiss with U.S. consumption habits, and see centralized MSW processing as a reasonable way to cope with the resulting waste.

The debate has focused mainly on national issues of resource policy: the relative energy efficiency of low-versus-high technology approaches, their implications for levels of resource exploitation and consumption, their effect on MSW generation rates and patterns, and their effect on secondary materials markets and flows.

The appropriate technology issue also concerns scale: the size of and degree of local control over a resource recovery program. Low-technology advocates argue that large, multi-community energy recovery plants are deleterious to a community's right to manage its own affairs and problems. Until recently, high-technology meant large-scale; it was generally assumed that centralized MSW processing plants required large volumes of solid waste to be economically viable. The modular incinerator technology now makes small-scale plants possible. But centralized MSW processing is still a capital-intensive approach, requiring communities to make long-term commitments and hence reducing local control over MSW issues in the future.

Proponents of each persuasion use a variety of arguments to support their position. Low-technology advocates, including environmental organizations and community groups, argue that the high-technology approach perpetuates -- and even encourages -- high levels of waste generation, since plant economics favor the full utilization of plant capacity. Resource recovery plants are portrayed as being inflexible, unable to cope with changes in MSW composition, and precluding low-technology efforts at materials recovery. Large processing plants often require communities contributing MSW to sign long-term contracts, and virtually all high-technology systems involve long-term financing. These commitments are thought to dramatically reduce local control over a hitherto local responsibility. High-technology systems produce significant amounts of air pollutants, including potentially hazardous materials, as well as waste-water (from ash quenching) and residues that must be properly treated. Centralized processing plants are considered to be financially risky and unreliable, having high initial costs and utilizing new and often commercially-unproven technologies.

Low-technology advocates point out that source separation strategies do a better job of separating recyclable materials, producing a higher-quality product with higher resale value. Low technology systems require modest capital investment and can be implemented relatively quickly. Finally, source separation is feasible in communities too small to consider centralized MSW processing.*

High-technology advocates -- the resource recovery industry**, the beverage container industry, and some state and regional agencies -- paint a different picture. They argue that low-technology systems recover a relatively small fraction of MSW, and thus do not address the issues of land-fill capacity and cost. Recycling is considered uneconomical, depending on "free" household separation and (often) subsidized labor. It is thought to be unreliable, depending on volatile material markets (which would be saturated by any major shift to recycling). The argue that recycling will not work in dense urban areas, being viable only in affluent,

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* Recent developments in modular incinerator systems dilute this argument somewhat.

** Firms with experience in energy/materials recovery and related fields -- chemical engineering, boiler design, and pollution control, for example.

well-educated, white-collar suburbs. Finally, recycling is thought to reduce the energy value of MSW, making energy recovery less attractive.

Proponents of high-technology systems see them as a more direct approach to the problems of diminishing disposal capacity and rising energy prices. High-technology approaches reduce the amount of MSW requiring disposal dramatically, minimizing landfill needs and impacts. They point to the commercially-proven resource recovery industry in Europe. Finally, centralized MSW processing is expected to be more economical -- especially in the future, with rising landfill costs and energy prices.

Implicit in the appropriate technology debate is the assumption that low and high technology approaches are incompatible. In theory, at least, this is not necessarily so. Several recent studies argue that low and high technology approaches may be quite compatible, and that their combination may in fact be desirable. The arguments are theoretical and are based on averaged data for various parameters, such as MSW composition, since the authors can cite no actual examples of combined resource recovery systems.

EPA scientist John Skinner has demonstrated that source separation (i.e. low-technology) and energy recovery (i.e. high-technology) are compatible, at least conceptually. With a MSW composition similar to the national average, he predicts that a source separation program removing 60% of all paper from the waste stream would reduce the energy value of MSW by less than 9%.

In determining the compatibility of high and low technology approaches, sequencing matters; compatibility is more likely if high-technology resource recovery is developed after a low-technology source separation program. Effective source separation enables a city to plan for a smaller resource recovery plant without jeopardizing its feasibility. This reduces the capital cost of the plant (for a given service area) and increases the per-ton material revenues; paper is worth more as fiber than as a fuel, and source separation produces a cleaner, more valuable product in general.[1] Conversely, developing a source separation program may reduce the revenues and profitability of an existing resource recovery plant. This is especially true if the plant is designed to receive MSW with a high energy value or if it incorporates expensive materials processing equipment.

Combining high and low technology systems may in fact yield advantages. Source separation removes abrasive glass and metal from the waste stream, thereby increasing the life of resource recovery plant equipment. Source separation removes much of the non-combustible fraction, increasing the energy value of the incoming MSW. An intensive source separation program could obviate the need for processing at a central plant, reducing the capital and operating costs of some resource recovery technologies, especially RDF. Perhaps most importantly, a combination of high and low technology approaches is more flexible. It can adapt more easily to changing MSW volumes and composition due to a lower level of capitalization and fewer long-term commitments.

The prospect of the two approaches to resource recovery being compatible is of mixed value. It does not resolve the appropriate technology question, since the issues of resource utilization and consumption are largely unaffected. Energy recovery, with or without recycling, still requires a steady flow of MSW, reinforcing present consumption and waste generation habits. It does, however, provide a somewhat richer set of options for communities considering resource recovery. Some combination of the two approaches may better meet a municipality's needs and objectives than either approach alone.

Notes

1. Congress of the United States, Office of Technology Assessment, Materials and Energy from Municipal Waste, Volume I (Washington, D.C.: GPO), July 1979, pp. 83-85.

2. Marchant Wentworth, Resource Recovery: Truth & Consequences (Washington, D.C. : Environmental Action Foundation), 1977, pp. 57-58.

IV. CASE STUDY 1: MARBLEHEAD, MASSACHUSETTS

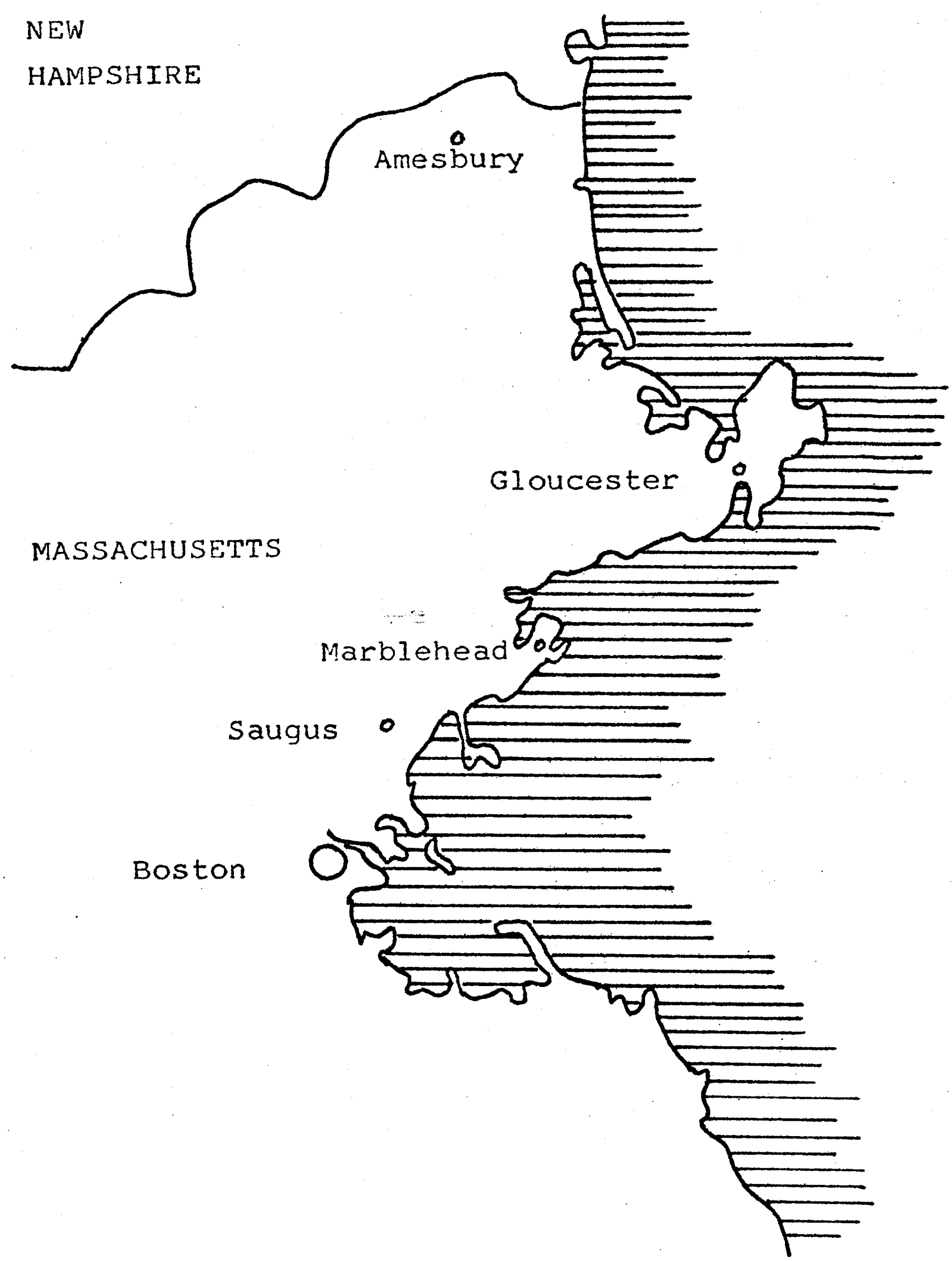
In 1972, the town of Marblehead, Massachusetts, took over a recycling program from a local community group and started a curbside collection program for four materials: newsprint, metal cans, clear glass, and colored glass. In 1975, after closing its incinerator and arranging for private hauling and landfilling, the town applied for and received a federal grant to upgrade its separate collection program. Since then, the program has enjoyed a very high participation rate, consistently diverting 25% (by weight) of the town's MSW from the waste stream, and generating a small fiscal surplus.

The case illustrates several facets of the low-versus-high technology resource recovery choice. It reinforces the importance of community support for a successful recycling program, and suggests that, where marginal disposal costs are high, recycling can reduce net solid waste management costs. The case also suggests that low and high technology approaches may be compatible, and that a community will use different criteria to evaluate each.

Background

Marblehead is an affluent suburban community in the

Figure 2 Location Map: Marblehead, Massachusetts



Boston metropolitan region about 17 miles north of Boston.[1] The town had a 1970 population of 21,300.[2] It has experienced moderate growth since 1950, and expects a lower rate of population growth in the future: the town Comprehensive Plan projects a 1990 population of 28,400. The median income in 1970 was $12,184, considerably above the Massachusetts average.[3] Seventy percent of all households live in single-family homes.

Marblehead is governed by a Board of Selectmen; major legislative decisions are made at an annual Town Meeting. Municipal employees are unionized.[4] The town has only limited commercial and industrial activity, with most residents employed outside the community. Summer tourism has declined in economic importance, but the service industry in Marblehead is an important and growing sector.[5]

The town currently (1979) generates about 9,150 tons per year (TPY) of residential MSW, including recyclables, and another 2,250 TPY of commercial MSW -- a total of 11,400 TPY, of 31 tons per day.[6] This generation rate has been relatively stable over time, with only minor seasonal fluctuations, being slightly higher in the summer due to additional summer residents. Table 2 estimated MSW generation for Marblehead over several years.

TABLE 2 MARBLEHEAD MSW GENERATION RATES

	1970	1975	1980
Population[1]	21,300	23,500	25,000
MSW (tons per year)[2]			
Residential	7,800	8,600	9,150
Commercial	1,900	2,100	2,250
Total	9,700	10,700	11,400

1. 1970 and 1975 data from Community Profile; 1980 data projection from town's Comprehensive Plan.

2. 1980 data based on personal communication with Raymond Reed, Health Department Director. Other data derived by author on a proportional basis.

Residential collection is performed by the town Health Department, under the Board of Health, a nearly autonomous agency in charge of all public health matters, including refuse collection and disposal.[7] Private firms collect refuse for commercial businesses and multiple-unit residences. The Health Department used to operate the town landfill, later the town incinerator, and now runs the recycling program and transfer station. MSW collection and disposal costs are paid from the town general fund and are included in the town's tax rate.[8]

Chronology

Marblehead acquired a small (16 acre) site for its landfill in 1955. Due to its limited capacity, the town in the early 1960s built an incinerator at the site. Its capital cost was about $275,000, spread over ten years.

Incineration residuals -- about 10% by weight -- were landfilled on the site.

In the early 1970s, the high school Ecology Club started a drop-off recycling center where residents could bring newsprint, glass, and cans on weekends. The program was quite popular and gained community attention. In 1972, a group of environmental-minded citizens, led by Carl King, a local attorney, proposed that the town sponsor an intensive recycling program.[9] At the May 1972 Town Meeting, their proposal for mandatory source separation and separate collection of recyclables was introduced by King and passed as a by-law.[10] Town officials took no strong position on the issue. The Health Board, while sympathetic to the program's resource conservation goals, was skeptical about implementation; the by-law provided no additional funds or instructions for Health Department implementation.[11]

The separate collection program commenced operations later in 1972. Due to limited publicity and a confusing collection schedule (the Department collected a different material each week) participation was only moderate, but the program nonetheless recycled about 14-18% (by weight) of residential MSW.

In 1974, EPA tested stack emissions at the town's incinerator and informed local officials that they would have to either reduce emissions significantly or phase out the plant. The Health Board decided that upgrading the plant would be too costly, and began investigating other options. The Health Department looked at several regional resource recovery projects, all still in the planning stages -- RESCO in Saugus, NESWC in Haverhill, and SESWC in Peabody -- but doubted that they would be developed in time. Two Health Board members visited Consumat's modular incinerator at Wellesley, Massachusetts, and were not impressed with facility reliability and safety.[12] The Department considered a baling process to reduce MSW volume prior to disposal at the town's existing landfill; limited capacity ruled out this option, except in the very short term. After further EPA pressure to act, the Board eventually decided to develop a transfer station and pay to have its MSW hauled elsewhere. In April 1975, the Health Board signed a five-year contract with Service Company of America (SCA), whereby SCA would (at no cost to the town) build the transfer station, and haul MSW to a private landfill in Amesbury, Massachusetts, for a tipping fee of $18.95 per ton. The station was built and the incinerator closed in August 1975.

The new disposal fee represented nearly a doubling of the town's per-ton disposal cost, and the Board was eager to reduce costs.[13] With a new incentive to reduce MSW tonnage, the Board met with a consultant -- Resource Planning Associates (RPA) -- and applied to EPA for support in upgrading their separate collection program. In June 1975, EPA awarded an $80,000 grant to the town as part of a demonstration project (also including the city of Somerville, Massachusetts). With the funds, the Department spent $40,000 on two multi-material collection vehicles, reserving the other half for project monitoring and studies by RPA.

Resource recovery system and results

The 1972 program required residents to separate MSW into five categories: newsprint, clear glass, colored glass, metal cans, and non-recyclable refuse. Each week, the Health Department would collect a different recyclable material, in addition to its twice-weekly refuse collection. The Department used existing staff and equipment (i.e. conventional packer trucks). Recycled materials were stored at the landfill site and sold on a non-contract basis directly to material buyers in the region with no intermediate processing. The alternating collection schedule was necessary because buyers needed a "clean" product, and the packer trucks could not separate materials.

After 2 1/2 years of operation, program results were mixed. The program was recycling between 1,200 and 1,600 TPY of materials, an impressive 14-18% of total residential solid waste,[14] in contrast to the U.S. average of 2% for all recycling programs.[15] Program participation was consistently good -- 30-40% of all households participated regularly.[16] These results were obtained despite minimal program publicity and the Health Board's decision not to actively enforce the mandatory separation provisions of the 1972 by-law. However, the program had a net cost of $43,000 in 1973[17] -- a figure that probably applies to other years. Total solid waste management costs (collection, recycling, and disposal) in 1973 were approximately $265,000, or about $32 per ton. Without recycling, disposal costs would have been unchanged, and slightly lower -- betwee $27 and $32.[18]

The revised recycling program started in January 1976, differed in many ways from the previous system. Recyclable materials were divided into only three groups: newsprint, clear glass and cans, and colored glass and cans. Two compartmentalized trucks allowed the Health Department to simultaneously collect several materials. Initially, the Department provided twice-weekly refuse collection and once-weekly collection of all separated materials. In mid-1977, the Department reduced refuse collection to once per week. High participation rates had reduced refuse tonnage significantly; the change offered substantial collection cost savings; and residents agreed to less frequent service.

Marblehead entered into a one-year contract with Recor, Inc. (later Matcon, Inc.) of Salem, Massachusetts, an intermediate processor willing to purchase mixed materials.* The contract specified "floor" prices for all materials, delivered to Salem by the Health Department. The contract was not renewed in 1977 when the two parties could not agree on a price

*Only mixed glass and cans required processing.

schedule, but Matcon* continued to purchase all of the town's recovered materials.[19] Matcon complained at times about the level of contamination of the paper and glass/metal products -- with other MSW -- but on the whole Marblehead's residents did a good job of separating recyclable materials.

In the first 2 1/2 years (January 1976 to June 1978), the program has consistently recycled over 150 TPM, averaging 175 TPM (or 2,100 TPY). This tonnage represents 25% of residential solid waste generated in Marblehead. The fraction of households participating has ranged between 60% and 74%[20]. The program has resulted in a net savings of $45,000 over its first 2 1/2 years. Total solid waste management costs in 1977 were about $294,000 (including collection, recycling, and disposal) -- or $34 per ton. Without the separate collection program, this total would have been about $311,900, or $36 per ton.[21] Thus, separate collection saved the town about $17,000 per year, or $2 per ton.** Table 3 gives economic results for 1976 and 1977.

This net savings, while slight, is not terribly sensitive to changes in participation rates (i.e. the percentage of residential MSW recycled). Net savings (or cost) is much more a function of market prices for recovered

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* Matcon, Inc. has since gone out of business, and Marblehead now sells mixed glass and cans to Recycle Enterprises in Oxford, Massachusetts, and newsprint to a firm in Salem.

**Separate collection program costs were more than offset by material revenues plus disposal credits.

materials. Between 1976 and 1978, market prices for glass cullet were fairly stable($10-12/ton), but due to market fluctuations for secondary materials, newsprint and can prices were quite volatile ($12-28/ton and $10-30/ton, respectively).[22]

TABLE 3 MARBLEHEAD PROGRAM COSTS AND REVENUES

	1976	1977
Recycled Materials		
Revenues		
Material sales	$35,600	$25,500
Disposal credits	40,100	41,100
Subtotal	75,700	66,600
Cost	47,900	49,800
Net Revenue (Cost)	$27,800	$16,800
Remaining MSW		
Collection Costs	149,600	146,700
Disposal Costs	124,600	123,900
Total	$274,200	$270,600

Source: U.S. Environmental Protection Agency, Multi-material Source Separation in Marblehead and Somerville, Massachusetts: Collection and Marketing, SW-822 (Washington, D.C. - U.S. GPO), December 1979, pp. 47-48.

Resource Recovery Choice

The town in fact made three separate choices concerning resource recovery -- a 1972 decision to get involved in an existing recycling program, an early-1975 decision to build a transfer station and pay for private disposal, and a 1975 decision to upgrade the materials recovery program. Each responded to a different situation and employed different criteria; they are discussed in turn.

The 1972 decision to start separate collection was made at Town Meeting with the backing of a group of "do-gooders", the new by-law was passed in the spirit of taking local action to address a national resource conservation issue. Town government was unprepared for such an endeavor, and some officials felt the proposal has been "slipped through" at Town Meeting without sufficient discussion.[23] Health Board chairman Bruce Humphrey notes that the Board had no funds to initiate a separate collection program; nobody had thought through the actual implementation of the by-law. Despite this lack of preparation, the new program held some promise for the Health Department. Incinerator stack emissions were a source of local concern and a program that reduced MSW tonnage would also reduce the level of incinerator emissions and residuals requiring disposal at the town's hard-pressed landfill.

Clearly, the 1972 decision was elective. Marblehead was not yet under pressure to modify its incinerator, and disposal costs were not excessive. Annual operating costs at the incinerator averaged $85,000 in the early 1970s,[24] or about $10.90 per ton. Recycling efforts were not intended to provide the town cost savings, either; annual incinerator costs were fairly insensitive to minor changes in tonnage.

In 1975, the town faced a much different situation. Under pressure from EPA, the Health Board had to either upgrade its incinerator or find a new disposal option. The choice was essentially a short-term one, and was made by the Health Board with no need for town approval.[25] The Board investigated a broad range of options, including upgrading the incinerator, a small "package" incinerator, MSW baling (and on-site landfilling), participation in a regional resource recovery project, and a transfer station. The Board was convinced that no new landfill sites within the town remained.

Some town officials -- ex-Board members -- favored upgrading the incinerator, given its good performance in the past and existing staff commitments. But the plant did not come close to meeting federal air quality standards, and the Board agreed that this option was too costly. Board chairman Humphrey was also reluctant to improve the facility with no guarantee that it would subsequently meet emissions standards. Another Massachusetts community had recently paid for extensive incinerator modifications and still exceeded federal standards. Humphrey, and possibly other Board members, felt hemmed in by EPA, and doubted that <u>any</u> local disposal strategy -- incineration or landfilling -- would meet EPA standards.

Needing a short-term solution, the Board could not wait for regional resource recovery to become a reality. Most of the then-proposed projects were not close to construction, and Health Department director Raymond Reed expected RESCO (in Saugus) to be too expensive, given its distance from Marblehead and anticipated tipping fees.

Also, regional resource recovery was seen as a "political football"; town officials expected facility siting to be a major obstacle.[26] Overall, the Board found the transfer station option preferable on several grounds: it provided an immediate solution to their acute disposal problem; SCA would build the facility at no cost to the town (other options required considerable front-end investments); and it had a very low opportunity cost. The last factor was particularly important; given that local disposal was thought to be infeasible, a transfer station was needed in any case, and the Board wanted to be able to join in a regional resource recovery program if one should prove successful in the future.

The town's existing materials recovery program was not a factor in this choice. The program was diverting a relatively small fraction of total MSW tonnage, and was not in itself a disposal option. Marblehead's recycling program was not, however, an impediment to participation in planned regional plants. Although the town made no commitment to any of the several regional proposals, its MSW composition (and the recycling program's effect on composition) was not an issue during discussions.[27]

Having selected an option which substantially increased per-ton disposal costs, the town in 1975 had a strong incentive to reduce MSW tonnage via its separate collection program. Unlike the 1972 choice, the town now stood to gain significant cost savings for each ton of MSW recycled (and hence diverted from the transfer station). In economic terms, the marginal cost of disposal was high -- $19 per ton -- and provided economic incentives to generate less solid waste. Regardless of disposal costs, the recycling program had remained quite popular since it inception, and Marblehead's resource conservation efforts were a source of pride to both residents and town officials. Therefore, when Humphrey learned of EPA's demonstration grant program for materials recovery, the Board readily agreed to apply for such a grant. The Board's choice to upgrade its program was a fairly direct result of the incentives created by its disposal decision earlier that year.

Notes

1. U.S. Environmental Protection Agency, Multi-material Source Separation in Marblehead and Somerville, Massachusetts: Collection and Marketing, by Resources Planning Associates, Inc., SW-822, December 1979, p.2.

2. Massachusetts Department of Commerce and Development, Massachusetts Profile of Marblehead, 1970.

3. Massachusetts, op.cit.

4. U.S. Environmental Protection Agency, Source Separation: The Community Awareness Program in Somerville and Marblehead, Massachusetts, SW-551 (Washington, D.C.: U.S. GPO), November 1976, p.4.

5. Town of Marblehead, Marblehead Comprehensive Plan, 1970.

6. Personal communication: Raymond Reed, Director, Marblehead Health Department.

7. U.S. EPA, Community Awareness Program, op. cit., p. 4.

8. Personal communication: Raymond Reed.

9. Personal communication: Bruce Humphrey, Chairman, Marblehead Health Board.

10. Town of Marblehead, Ch. 39 of By-Laws and Amendments.

11. Personal communication: Bruce Humphrey.

12. Ibid.

13. U.S. EPA, Community Awareness Program, op.cit., p. 25.

14. Town of Marblehead, Health Department, Recycling: Marblehead, Massachusetts, undated brochure.

15. U.S. EPA, Collection and Marketing, op.cit., p.1.

16. U.S. EPA, Community Awareness Program, op.cit., p.26.

17. U.S. EPA, Collection and Marketing, op.cit., p. 15.

18. Author's estimate, assuming collection and disposal costs unchanged by recycling program.

19. U.S. EPA, Collection and Marketing, op.cit., p.15.

20. U.S. Environmental Protection Agency, Multi-material Source Separation in Marblehead and Somerville, Massachusetts: Citizen Attitudes Toward Source Separation, by Resources Planning, Inc., SW-825, December 1979, p.5, and personal communication: Raymond Reed.

21. Author's estimate, based on EPA data.

22. U.S. EPA, Collection and Marketing, op.cit., pp.36-38.

23. Personal communication: Bruce Humphrey, Chairman of Marblehead Health Board, and Alan Robbins, Chairman of Marblehead Planning Board.

24. Personal Communication: Raymond Reed.

25. Ibid.

26. Personal communication: Bruce Humphrey.

27. Personal communication: Raymond Reed.

V. CASE STUDY 2: EL CERRITO, CALIFORNIA

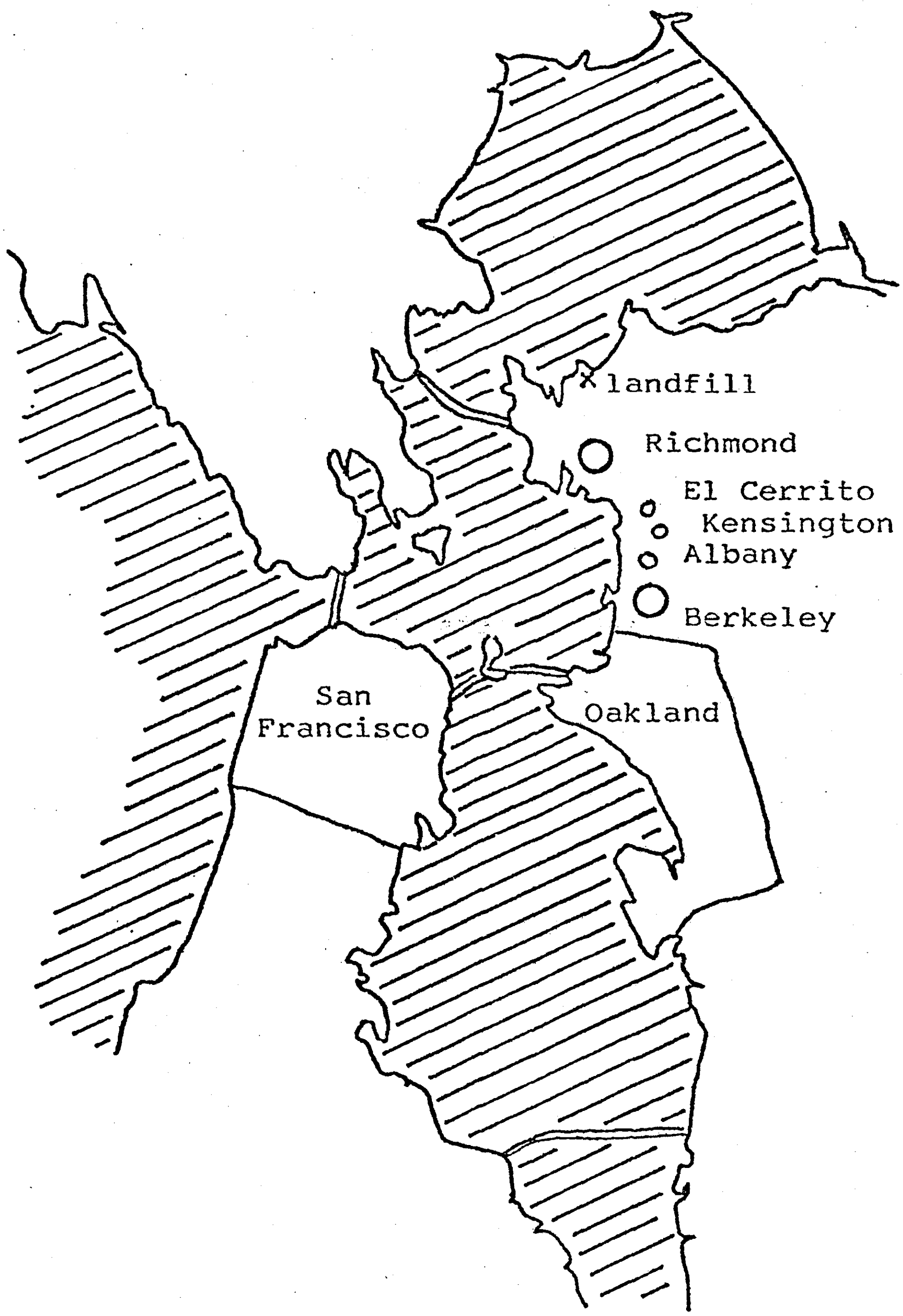
El Cerrito has a fairly long history of recycling, beginning with a volunteer-run recycling center in 1972. The city assumed control of the program in 1977, expanding it significantly as a demonstration project in multi-material recycling within a small community. As part of a long-range community plan to reduce MSW tonnage by 25%, the center now receives about 350 tons per month (TPM) of recyclables, and predicts 500 TPM in the near future. The program currently diverts about 18% of El Cerrito's MSW.

El Cerrito's experience underscores the importance of strong community support and able program administration and leadership. Also important were good secondary material markets and the availability of various grants to help the program get started. El Cerrito's choice about resource recovery was elective; it was not forced of hastened by high disposal costs or a serious shortage of landfill capacity.

Background

El Cerrito is a suburban community about eight miles north of Oakland, California, and is part of the heavily urbanized East Bay area. It borders the cities of Albany and Richmond, and Kensington, an unincorporated community.

Figure 3 Location Map: El Cerrito, California



El Cerrito had a 1975 population of 23,000, slightly less than the 1970 level.[1] The 1975 median income was $15,056; both this and the average level of education are above the U.S. average.

Refuse collection in El Cerrito is performed by the East Bay Sanitary Service under a long-term franchise agreement, which permits annual rate adjustment. Kensington and Albany have similar franchise arrangements. El Cerrito residents currently pay $5.00 per month for one-can-per-week service and $2.00 per month for an additional can. East Bay Sanitary Service hauls refuse directly to a regional landfill in Richmond -- the West Contra Costa county landfill, privately owned and operated, and located about five miles from El Cerrito. Commercial haulers are charged a $4.00 per ton tipping fee. The West Contra Costa county landfill is located in a wetland area, and has up to 40-50 years of remaining capacity, despite frequent violations of state environmental standards and a running legal battle with the State Lands Commission over title to part of the site.[2]

El Cerrito generates an average of 690 TPM of residential and 110 TPM of commercial refuse, a total of 800 TPM of MSW -- or 9,600 tons per year.[3] The recycling program also serves the towns of Kensington (1975 population of 5,300) and Albany (population of 14,700), each generating 100 and 650 TPM of MSW respectively.

Chronology

El Cerrito's recycling program began in 1972 when Ken Little, a city employee, started a small recycling center -- E.C.ology -- with the support of city councilmen Gregg Cook and Ernie Del Simone. It was a weekend drop-off facility, staffed by volunteers, accepting a variety of materials. The program was well-received and attracted users from nearby Albany and Kensington. A glass crusher was added, and the center received a small but steady supply of glass, paper, and metal cans -- about 15 TPM.[4] Local environmentalists in 1974 persuaded the center's founders to establish a Board of Directors to administer the program and coordinate its activities with other local environmental programs.[5] The volunteer Board was intended to create more visible links with the El Cerrito community.

At this time, El Cerrito had several unfilled CETA positions, and Charles Papke, a local resident and activist, proposed to the city's Parks and Recreation Department that he be hired to develop plans for an expanded recycling program. City officials were interested because of the state legislature's 1972 Solid Waste Management and Resource Recovery Act, which among other things mandated local solid waste management plans and proposed a 25% reduction in the amount of MSW requiring disposal by 1980. The city council approved Papke's hiring, but reluctantly. Council members supported the small private recycling center but were not ready to commit city funds to such a project.

Working under Parks and Recreation Department director Joel Witherell, Papke established a Citizen's Solid Waste Advisory Committee. The Committee was composed of community leaders and city officials, and was intended to oversee planning efforts and develop community awareness of and support for the recycling program. Papke studied other intensive recycling programs -- in Modesto and Davis, then the two largest programs in California. Surveys by the Parks and Recreation Department showed a large majority of households in El Cerrito willing to participate in a curbside collection program for recyclables.[6] Papke proposed an "integrated" recycling program having several components, including drop-off facilities, a buy-back program, and a curbside collection program. In this way, Papke hoped to combine the profitability of the buy-back approach with the high participation rates of the curbside collection approach.

Papke and the Committee also examined material markets and grant sources. Kaiser Aluminum at that time had a nation-wide system of aluminum buy-back centers to promote aluminum can recycling; Kaiser was willing to consider an arrangement whereby the E.C.ology program would perform this function in the East Bay area. The 1972 state Act also established a state Solid Waste Management Board (SWMB) and made the Board responsible for allocating funds from a demonstration grant program for resource recovery projects. The Parks and Recreation Department in 1976 applied for a SWMB grant to finance the capital improvements recommended by Papke.

The Department also applied for grants from CETA and the state Employment Development Department to staff the proposed expansion.

A central feature of Papke's long-range plan was that the city would assume control of the recycling program. There were several reasons for this proposal. The Advisory Committee was convinced that program administration would be crucial and time consuming; the volunteer Board of Directors lacked both organization and resources.[7] The Board, lacking non-profit corporate status, was also unable to secure grants from various state and federal programs. In addition, Kaiser Aluminum made their participation as a materials buyer contingent on city involvement. In May 1977 the E.C.ology Board of Directors agreed with Papke, recommending that the city's Parks and Recreation Department take over the program in order to spur more rapid expansion.[8]

The full city council was less enthusiastic about the proposal. Chief among their concerns was the city refuse collector's opposition to the plan. East Bay Sanitary Service, while unfamiliar with the plan's details, was sure that a major and ongoing recycling effort would hurt its business in the long run. The city's Public Works Department also opposed the plan, noting that the proposed expansion was risky, and that the program shouldn't be directed by the Parks and Recreation Department in any case.[9] The council also worried about financing the program; they had no assurance of a grant from the SWMB and were unwilling to commit an unspecified amount of city funds to the program's success.

Events in the following months lessened the council's concerns. Papke and others were able to allay some (but not all) of the city refuse collectors' fears so that the franchisee offered to provide separate collection service. The city concluded a one-year contract with Kaiser Aluminum, under which Kaiser would pay the E.C.ology program $12,000 and a per-ton price for aluminum scrap. Program proponents could point to a ready source of financing, at least in the short-term. Finally, the council and the Advisory Committee held several joint workshops to inform community residents of the proposal and gauge public response. The workshops were well attended, and demonstrated to the council broad support for the recycling proposal.

With a favorable recommendation from director Witherell, the city council in July 1977 voted 3-2 to have the city's Parks and Recreation Department assume responsibility for the E.C.ology program in accordance with the plan prepared by Papke for the Department. While clearly still divided on the issue, a majority of council members were persuaded of the program's viability, community support, and short-term financial soundness. The council's approval was for a one-year trial period; the council members wanted to be able to end city involvement after a year if the program proved financially unsound. The council also decided to let

E.C.ology do curbside collection of recyclables. East Bay Sanitary Service had offered, for an extra dollar per month per participating household, to collect recyclables, but only on a trial basis, and with city guarantees to cover any extra costs. Not knowing what additional costs to expect, the council declined the firm's offer.

Later in 1977, the city received a $45,000 grant from the state SWMB, and the Parks and Recreation Department began administering the E.C.ology program with 12 CETA staff, the SWMB grant, the Kaiser contract, and a modest advance of funds from the city.[10] Program expansion was preceded by an extensive promotional program, including paid advertisement and door-to-door canvassing. Monthly tonnage rose dramatically in late 1977, and has increased steadily as the program has expanded.

El Cerrito received a second state SWMB grant of $92,200 in May 1979 to reach a stated goal of 500 TPM, which the city thought would enable the program to be self-supporting. The program also received additional CETA staff, and the state Department of Rehabilitation awarded a special grant to a non-profit community health program to provide staff assistance to E.C.ology. To accomodate its increasing volume and in response to complaints about excessive traffic in the neighborhood of the current location, the center will soon move to a new site in El Cerrito -- one with improved road and rail access.

Resource recovery system and results

The 1972 recycling program consisted of a drop-off center at the city's corporation yard. Staffed by volunteers and open one Saturday per month, it accepted a variety of materials: aluminum and tin cans, newsprint, magazines, and color-sorted glass. Materials were sold to local buyers on a highest-bidder basis when a sufficient volume had accumulated. Over the course of several years, the center was upgraded somewhat -- a glass crusher was added and volunteers were paid for their work. During its first four years the program received a fairly steady flow of materials, averaging 15 TPM -- or 180 tons per year.

The 1977 program expansion increased the center's work area and provided new staff and equipment. The drop-off program hours were expanded to every weekday, and four new programs were added. A curbside collection program was made available to all El Cerrito residents for a fee of $1.00 per month (in addition to refuse collection fees) -- this fee was dropped several months later to increase participation. Six household-separated materials were collected each week: mixed glass, newsprint, magazines, aluminum cans, tin cans, and reusable wine bottles. The program was expanded to Kensington in June 1978 and to Albany in September 1979.

A buy-back program, also open on weekdays, accepted ten different consumer-sorted materials: bundled newsprint, corrugated cardboard, color-sorted glass, tin cans, aluminum cans, pure aluminum scrap, mixed aluminum scrap, and reusable wine bottles. The program paid an advertised per-pound price for each material, usually making a 25-50% mark-up on its subsequent sale.[11] Two other activities were added: a commercial program, which collected materials from commercial businesses in 2 cubic yard bins, and a satellite program, which placed similar bins in smaller outlying communities and multi-unit apartment complexes.

Program expansion also increased the service area -- the drop-off and buy-back programs serve residents of west Contra Costa county and north Alameda county, with a combined population of 150,000. From a pre-1977 level of 10-15 TPM, materials volume grew to 100 TPM by July 1978, 250 TPM by April 1979, and 350 TPM by October 1979.[12] The curbside and buy-back programs account for the majority of this tonnage -- 45% and 44% respectively. Given different service areas for different programs, calculating the reduction in MSW requiring disposal is not straightforward. Witherell estimates an 18% reduction in El Cerrito's tonnage; alternatively, assuming that all recyclables originate in the three-town area, this area has achieved a 23% reduction.[13] Witherell estimates that 50% of El Cerrito's households participate in the curbside program; this figure is 60% in Kensington.

The 1977 expansion also provided additional processing equipment -- a paper baler and aluminum shredder -- which reduced transportation costs and enabled the program to get higher prices for its materials. Over its lifetime, E.C.ology has had access to good secondary material markets. Consequently, the program has sold materials on a non-contract basis to the highest bidder. Table 4 lists firms that regularly purchase recycled materials.

TABLE 4 EL CERRITO PROGRAM MATERIALS MARKETS

Material	Buyer	Location
Paper fiber	Consolidated Fiber	Bay Area
	Engineered Waste	"
	Sonoco	"
Ferrous metal	M&T	Bay Area
	BHR	"
	Levin	"
Aluminum	Reynolds Aluminum	Bay Area
	Simon & Sons	Tacoma, WA
	Custom Alloy	Bay Area
	BHR	"
Glass	Owens Illinois	Bay Area
	Brockway	"
	Circo	Madera, CA
	Encore	Bay Area
Oil (used)	Ecotek	Bay Area
	Liquid Gold	"

Source: City of El Cerrito, State Grant Application, California Solid Waste Management Board (for E.C.ology Recycling Center), December 1979, page 3.

E.C.ology usually ships materials to buyers. Much of the paper fiber is sold for export, which explains the Bay Area's strong secondary paper market.

Describing the economics of the E.C.ology program is complicated by several factors: a lack of comparable data since its 1977 expansion, relatively large and intermittent capital costs, and a rapidly growing volume of materials processed by the facility. Accurate information is not available for the program's first fiscal year (1977-78); Table 5 shows actual economic data for 1978-79 and the program's 1979-80 budget.

TABLE 5 EL CERRITO PROGRAM COSTS AND REVENUES

	1978-79	1979-80
Costs [1]		
Labor		
City funded	$46,000	$122,000
CETA and Phoenix	A	90,000
Subtotal	A & 46,000	212,000
Operating expenses [2]	57,000	57,000
Administrative services	30,000	30,000
Capital improvements	0	92,000
Purchase expenses [3]	110,000	240,000
Total	A & $243,000	$631,000
Revenues		
Sale of materials	$219,000	$469,000
CETA and Phoenix grants	A	90,000
State SWMB grant	0	92,000
Total	A & $219,000	$651,000
Net Revenue (Cost)	($24,000)	$ 20,000

Source: City of El Cerrito, State Grant Application, California Solid Waste Management Board (for E.C.ology Recycling Center), December 1979, page 9 and City of El Cerrito E.C.ology Recycling, Income Statement for FY 1978-79, July 18, 1979.

1. Information on the CETA/Phoenix contribution in 1978-79 is not readily available. Labeled "A", it is in the range $50,000 to $100,000.

2. "In-kind" services provided by the city including free use of the site, fleet insurance rates, and management services.

3. Cash outlays from the buy-back program.

As the table indicates, the program expects net revenues of $20,000 in 1979-80, which will be used to reduce the outstanding loan from the city. In 1978-79, the program produced a small deficit. Clearly, the program is labor intensive; this is largely due to the availability of CETA and Phoenix employment development grants. In 1979-80, labor subsidies represent 20% of the basic budget. The Department plans to reduce this labor component and increase its use of processing equipment when these grants end.[14] This strategy, coupled with increases in per-month tonnage processed, is expected to make the program self-supporting by 1982.

Material prices are quite high; they average $113 per ton in 1979-80. The center receives about $900/ton for aluminum; $80/ton for cardboard, wine bottles, and used oil; $65/ton for newsprint; $30/ton for glass and mixed paper; and $25/ton for ferrous metals ("tin"cans).[15] California is considered an "aluminum rich" state -- along with Arizona, New Jersey, and some southern states -- due to its large soft-drink market; as a result, aluminum constitutes a larger than average fraction of MSW tonnage. As might be expected, total project revenue is strongly affected by material prices, which have increased significantly since 1977. But revenues are also very sensitive to the aluminum fraction -- the percentage of total recycled tonnage which is aluminum -- due to its high per-ton price. At E.C.ology, the aluminum fraction is 5-10%; this 5% range represents a 40% change in average per-ton revenue.*

*Author's estimate, based on E.C.ology records.

Resource Recovery Choice

El Cerrito's resource recovery choice was an elective one. The city faced no pressures to change its solid waste management practices; low disposal costs and ample landfill capacity gave it no cause to consider disposal alternatives While future enforcement of state landfilling standards at the West Contra Costa county landfill could change both conditions dramatically in the future, this possibility did not enter into the city's decision. The state's goal of reducing the amount of MSW requiring disposal was not binding on communities, relying instead on goodwill efforts by cities and counties (in fact many local governments have made no or minimal effort to meet this goal).

El Cerrito's choice was fairly uncomplicated: whether or not to assume control of an existing recycling program. The city council made its formal decision in July 1977, but city involvement in the program goes back to 1972, when the city provided a site for the new center. The Parks and Recreation Department devoted increasing attention to the program, hiring Papke to study expansion options and applying for state and federal grants on its behalf. By the time that the city council was considering the proposal for city involvement, many city staff and officials had already devoted considerable energy to the project.

That is not to say that city council approval was anticlimatic. The council had several serious reservations about involving the city in the E.C.ology program, and were more-or-less satisfied with each issue before giving their approval. A major concern was the city refuse collector's opposition to the recycling proposal. Over several months, this opposition subsided, following a lengthy interchange between East Bay Sanitary Service and Parks and Recreation Department staff. Community participation was another concern. Papke's prior surveys of citizens' willingness to participate were reassuring in this respect, and the early 1977 series of workshops convinced the council that the recycling proposal enjoyed wide community support.

In addition, the proposal received the endorsement and support of several key officials. Two city council members had helped start the recycling center in 1972 and remained enthusiastic. Ex-councilman Ray Cook, who had the respect of the council in general and was a popular public figure in El Cerrito, also supported city involvement.[16]

Project viability was another concern of the council: would the project work, and could it be successfully administered by the city? The city council found Papke's plans for expanding the recycling center reasonably complete and accurate, and the contract with Kaiser Aluminum assured the city of an aluminum market in the short term. Witherell assured council members that his Department would have no trouble administering the program; the council's approval was in part an expression of their confidence in him.

Finally, council members were concerned about the extent of the city's financial commitment; they did not want to in effect issue a blank check for the recycling program. Although the SWMB grant and additional CETA allocations had not yet been awarded, the council was reassured by the $12,000 Kaiser grant. Their use of a one-year trial period further limited potential city expenditures.

Notes

1. City of El Cerrito, California, State Grant Application, E.C.ology Recycling Center, to State Solid Waste Management Board, December 1979, p. 2 (henceforth "Grant Application").

2. Personal communication: Charles Papke, Resources Management Associates, El Cerrito(and former city employee).

3. Grant Application, op.cit., p. 2.

4. Personal communication: Joel Witherell, Director of Community Services Department (formerly Parks and Recreation Department),City of El Cerrito.

5. Personal communication: Charles Papke.

6. Ibid.

7. Personal communication: Joel Witherell.

8. City of El Cerrito, Community Services Department, E.C.ology Recycling, undated brochure (ca. 1979), p. 2.

9. Personal communication: Charles Papke.

10. Personal communication: Joel Witherell; and E.C.ology Recycling, op.cit., p. 2.

11. Personal communication: Joel Witherell.

12. E.C.ology Recycling, op.cit., p. 3.

13. Author's estimate, assuming 350 TPM throughput.

14. Personal communication: Joel Witherell.

15. Grant Application, *op.cit.*, p. 9.

16. Personal communication: Charles Papke.

VI. CASE STUDY 3: NORTH LITTLE ROCK, ARKANSAS

In 1976 the city of North Little Rock signed contracts with an energy-recovery equipment vendor and a wood products manufacturer to develop a small-scale modular incinerator with heat recovery. The 100 TPD facility was designed to incinerate all the city's refuse and supply steam to the manufacturer, with the possibility of expanding to serve new industries in the city's industrial expansion area. The plant commenced operations in 1977 and, despite management difficulties and a smaller-than-expected market for steam, has operated successfully for two years, at a cost competitive with landfill costs in the area.

North Little Rock's decision is of interest for several reasons. City officials saw the energy recovery system more as a way of promoting economic development in a region facing a natural gas shortage, and less as a method of waste disposal. The equipment vendor, and not the city, took the lead in proposing and assessing the feasibility of energy recovery. Several key individuals were crucial in gaining support for the proposal and resolving obstacles to negotiations between the city and the energy buyer.

Background

North Little Rock is located in the middle of the state,

Figure 4 Location Map: North Little Rock, Arkansas

across the Arkansas River from Little Rock, the capitol and largest city in the state. North Little Rock's 1975 population was 64,400 -- eleven percent above the 1960 level. Residential densities are relatively low -- about 2,000 people per square mile. The city supports a diversity of small industries, and is the center of the Missouri-Pacific Railroad's repair and maintenance facilities.[1] Median income in 1970 was $8,467, significantly below the national average.

The city in 1975 generated a total of about 200 tons per day (TPD) of solid waste -- 70 TPD of residential MSW and the remainder commercial and industrial waste.[2] Residential waste was collected by the city's Sanitation Department, and commercial and industrial waste by private haulers. In the early 1970's, the Department hauled MSW to a private landfill several miles north of town. This landfill closed after reaching capacity, and the city was forced to utilize a more distant landfill in Jacksonville, about 12 miles north of the city. The Jacksonville landfill, privately owned and operated by the Arkansas Waste Disposal Company, charged a tipping fee of $3.00 per ton.[3]

City collection was financed by user fees, paid by residents to the city. The Sanitation Department had a budget of about $600,000; a 1975 study showed the Department with an annual deficit of $42,000.[4] In December 1975, in order to make the Sanitation Department self-supporting, the city raised the fees to $2.00 per month per household.

Chronology

In 1971 North Little Rock purchased two 12.5 TPD modular incinerators (without heat recovery) from Consumat Systems, Inc., a major vendor of modular incinerator equipment. City officials hoped to reduce hauling distances (and thereby reduce collection costs) by establishing "satellite" incinerators at different locations.[5] North Little Rock's large area and low population density made this proposal attractive. The city undertook no extensive analysis prior to their purchase. The two units were never installed due to siting problems; city officials failed to find a site that was acceptable to various neighborhood organizations. North Little Rock already had several "smoke belching" industries, and residents feared another.[6]

In mid-1974, U.S. Recycle Corp. (USR), the franchise dealer for Consumat in Arkansas, through the city Chamber of Commerce, learned that Koppers Company was a major user of steam for industrial processing. The Forest Products Division of Koppers manufactured creosote-treated wood products at its North Little Rock plant. USR proposed an energy recovery plant burning municipal refuse that could give Koppers a dependable steam supply. Koppers company officials expressed considerable interest; they were aware of an impending natural gas shortage in the Southeast, and wished to avoid natural gas curtailments.[7]

Later in 1974, USR approached then-mayor Eddie Powell with its energy recovery proposal. USR argued that the system offered significant cost savings for the city in the form of reduced MSW hauling costs. USR had already successfully developed two other small-scale modular energy recovery systems which sold steam to small manufacturing firms -- in Siloam Springs and Blytheville, Arkansas. City officials, especially the city council, were skeptical of the proposal; they knew nothing of the technology and doubted that the proposal could compete economically with landfilling. But city officials were nonetheless willing to consider the proposal; they wanted to do something about the two units purchased in 1971 (which the city had been storing), and they realized that Koppers Company was important to the city, providing jobs and substantial tax revenues.[8] Mayor Powell was optimistic that the plant would produce excess steam which could be used to attract new industrial development, a high priority for the economically depressed town.[9]

Initial discussions between the city and Koppers were encouraging; Koppers re-affirmed its support for the project and persuaded city officials that the plant could reliably meet their steam requirements. During this period (1974-75), tipping fees at the private landfill in Jacksonville rose dramatically -- from $3 to $11 per ton.[10] This increase in disposal costs did not cause city officials to worry about future landfill shortages, but it did make USR's proposal more economically attractive.

In early 1975, USR became concerned about the city's MSW collection system, fearing that a haphazard system would not provide a reliable stream of MSW to the energy recovery facility. At the firm's urging, North Little Rock sponsored a study of the city's solid waste management activities, using funds from a HUD-funded Management Assistance Program.* The city's planning consultant in turn subcontracted the work to USR, citing the latter's familiarity with the city's solid waste situation.

USR made its report to the city in August 1975, recommending 26 actions to improve the efficiency and revenue-producing ability of the Sanitation Department. USR recommended that the city discontinue landfilling as soon as practical, and that MSW collection fees be increased to cover the Department's costs. The report posed a choice between landfilling and energy recovery, suggesting that the latter was economically competitive, if not cheaper.[11] Local newspapers questioned the impartiality of the report, noting that USR was also in the business of selling energy recovery equipment. But city administrators received the report favorably and implemented most of the reforms suggested, including a higher MSW collection fee. The mayor and city council, without a specific commitment, agreed to pursue the energy recovery proposal further.

* The city planning department had already planned a modest study of the sanitary division under the MAP program, then in its third year.

The proposal was much more appealing to both city officials and residents after Koppers offered to provide the city a site adjacent to its plant location (and the city's industrial expansion area) for the recovery plant. City officials recalled their siting difficulties in 1971, and thought of the economic development the plant might spur. The Koppers plant already caused severe odor problems, and city residents doubted that a resource recovery plant could make matters worse at that location. Many nearby residents worked at Koppers and supported the proposal.[12]

Negotiations between the city and Koppers continued through the fall of 1975. Koppers' plant manager and a company executive from the firm's Pittsburgh headquarters focused on the need for reliable steam delivery. The city, represented by Mayor Powell and the city's attorney, wanted assurances that Koppers would either purchase all steam produced by the plant or pay for unused steam (a "take or pay" arrangement). Negotiations also centered on finding an acceptable way to determine steam price. USR participated in the negotiations, even offering legal services in drawing up agreements, and worked with the state Department of Pollution Control and Ecology (DPCE) to facilitate permit applications.[13] By late 1975, it was clear that all parties would reach a satisfactory agreement.

In what marked the city's first formal commitment, the city council in November 1975 voted to solicit bids for a proposal to design, build, and equip the modular incinerator plant.* Bids were received in January next year, but only two were judged to meet the qualifications. USR's bid included Consumat equipment and the Baldwin Construction Company (a local firm), plus an offer of a full refund for the two previously-purchased Consumat units. The other -- and lower -- bid was made by another local firm, Custom Sheet Metal, using Sunbeam equipment.[14]

Koppers informed the city council that it found the Sunbeam proposal technically unacceptable. At this point, the council could have rejected the low bid for not responding to the bid qualifications; instead, it rejected both bids and bypassed the competitive-bid, turnkey-procurement process.[15] In April, the council signed a memorandum of understanding with USR for equipment purchase, deferring arrangements for plant design and construction. The mayor and council, in selecting USR, felt that the firm had already put considerable effort into the project, and had a commercially-proven product.

Negotiations between the city and Koppers continued. One major area of disagreement remained; whether Koppers would guarantee to purchase a specific amount of steam. Koppers, being uncertain of its own future steam needs and future

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* This is the so-called "turn-key" procurement approach; the bid solicitation also listed qualifications which eligible bidders had to meet -- previous experience with modular systems, and so forth.

energy prices, was reluctant to do so. The firm promised that it would meet all of its steam requirements from the city's plant, but refused to guarantee to purchase any specific amount. The city declined to press the matter, and decided to rely on the firm's goodwill. The city's bond underwriter argued that the marketability of the necessary revenue bonds would not be affected by lack of a specific guarantee, and city officials wanted to hasten project implementation.

In June 1976, the two parties signed a contract for site leasing and for the long-term purchase of steam. Later that year the city issued $1.3 million of revenue bonds to finance capital costs. The project contractor began construction in late 1976; initial testing of the plant took place in September 1977, and the plant was fully operational three months later.

Resource recovery system and results

The North Little Rock facility is a small-scale modular combustion system with a capacity of 100 TPD. It is equipped with four controlled-air modular combustion units, each with a 25 TPD capacity. These units are paired with two boiler heat exchangers, each capable of producing 10,000 pounds of steam per hour at 150 pounds per square inch (psig). Each combustion unit is equipped with an automatic ash removal and wet ash conveyor system, but ash may be removed manually, if necessary. The facility is designed to permit a doubling in the number of combustion units and boiler heat exchangers if future expansion is desired. Consumat Systems, Inc., designed and manufactured the equipment.

Full plant operation requires a staff of nine. Incoming refuse is dumped on the floor of the plant in front of each pair of units, where it is loaded. The combustion process is a combination of pyrolysis, volatization, and gasification of hydrocarbons; natural gas is used as an auxiliary fuel in the second stage of combustion.

This process results in minimal odors and very low stack emissions of particulates and other pollutants.[16] Incineration reduces MSW weight by about 70%.[17] After quenching, residual ash is hauled to a disposal site. The city does not recover any materials from MSW -- either before or after incineration. Because of its largely inorganic nature, the ash need not be dumped at a sanitary landfill. North Little Rock, for at least the first two years of operation, dumped residual ash at a state-certified, privately-owned site by the Arkansas River.

The plant is intended to supply steam to Koppers 24 hours per day, five days per week. The 1976 contract with Koppers requires the city to deliver a minimum of 15,000 pounds per hour of steam, at 110-150 pounds per square inch (psig), saturated. Koppers is not obligated to purchase a minimum amount of steam, however.

The plant had capital costs of $1,530,000 (1978 dollars).

The city received a refund for the two incinerator units purchased earlier, and raised the remaining $1,350,000 by issuing 20-year revenue bonds, at interest rates ranging from 5.75 to 6.75%.[18]

Because the North Little Rock plant only began regular operations in late 1977, and data are not yet available for 1979, operating results are only available for 1978. The facility processed an estimated 15,125 tons of refuse in 1978, or an average of 58 TPD.[19] Most of this tonnage was residential MSW delivered by the Sanitation Department. Private haulers were charged a tipping fee of $0.90 per cubic yard (or about $8.00 per ton), a price thought to be competitive with nearby landfills. Initially, the daily throughput was only 40 TPD, but this had risen to 80 TPD by October 1978, in response to equipment modifications and operational changes that increased hourly throughput of MSW at the plant.

The energy recovery facility has complied with state standards for air quality thus far. Sulfur and nitrogen oxide levels in stack emissions have been negligible, although chloride emissions have been recorded.[20] The incinerator units are not subject to federal air quality standards, being below the size threshold that would qualify them as new sources.

Table 6 presents annual cost and revenue data for 1978. Estimates of operating costs are based on several months experience in 1978, and include annual debt service of $44,000. Project revenues are derived from two sources: steam sales and dump fees from commercial haulers who used the facility -- the latter are a relatively minor fraction. Revenues were not as great as originally anticipated by USR, due to lower than expected steam demand by Koppers. Under optimal operating conditions, an independent research group predicted a net processing cost of $2.73 per ton -- significantly below the $10.53 result in 1978.[21] The calculation assumed that the facility runs at near-capacity and sells all steam produced.

TABLE 6 NORTH LITTLE ROCK PLANT COSTS AND REVENUES

	Annual(1978)	per-ton[2]
Costs[1]	$365,000	$20.45
Revenues	177,000	9.92
Net costs	$188,000	$10.53

Source: U.S. Environmental Protection Agency, Small Modular Incinerator Systems with Heat Recovery: A Technical, Environmental, and Economic Evaluation, by Systems Technology Corp., SW-177c, November 1979, pp.117-120.

1. Includes operation and maintenance costs, and debt service costs.
2. Assumes 17,850 tons per year (or 69 TPD).

Initially, USR proposed that it be allowed to manage and operate the facility for the first two years. A successful plant at North Little Rock was important to the firm's marketing efforts, and USR doubted that the city had qualified staff to operate their equipment.[22] The city administration, however, facing an employee surplus, declined USR's offer in order to avoid layoffs. In retrospect, city officials and USR agreed that city operation was unwise. Plant workers lacked the necessary training, and management changed too often to develop any experience. As a result, equipment maintainence was inadequate, and major equipment breakdowns occured. In late 1979, plant operation deteriorated seriously, and the facility was forced to close. At Consumat's request the city council agreed to let Consumat operate the plant. Consumat spent $200,000 on repairs* and reopened the plant in May 1980.[23]

During the first year of plant operation, Koppers relied entirely on steam from the recovery plant. But surge problems -- peak demands for steam by Koppers that the plant could not accommodate -- caused Koppers to re-activate one boiler, and reduced steam purchases accordingly -- from 15,000 pounds per hour to 10-12,000 pounds per hour.

Resource Recovery Choice

North Little Rock was interested in resource recovery, and specifically in USR's proposal, for several reasons. While the city was not worried about the availability of landfill facilities, disposal costs had increased recently, and were expected to keep rising. USR pointed out the long-term economic advantage of energy recovery in this respect. The city, especially Mayor Powell, saw USR's proposal as a way to improve the efficiency of the Sanitation Department, by reducing hauling distances and improving collection vehicle reliability.** North Little Rock also suffered from a depressed

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*Includes new rolling equipment, replacement of refractory walls, and extensive interior cleaning.

** Sanitation Department trucks often became mired or suffered tire damage at the Jacksonville landfill, increasing vehicle operation costs and reducing collection efficiency.

local economy, and Mayor Powell saw the energy recovery plant as a way to promote much-needed economic development. Given pending natural gas shortages, the proposed facility would make the city more attractive to new industry seeking a location with dual energy sources. Finally, the city wanted to recover its 1971 investment in modular incinerators.

The city's resource recovery choice was elective, and was based mainly on long-term considerations. While the Sanitation Department's collection program was perhaps inefficient, there was no pressing need to change collection practices. Similarly, the city expected to continue hauling MSW to the Jacksonville landfill for some time. Future MSW collection and disposal costs, plus future economic development, were the main factors motivating the city's choice.

For the reasons noted above, city officials were interested when USR presented its energy recovery proposal in 1974. Full city support of and participation in the project awaited the resolution of several issues, however. City officials were unsure of how reliable the system would be. They doubted that the plant would have a lower net disposal cost than landfilling. Both city officials and residents worried about siting, and the city needed some promises from Koppers demonstrating its commitment to the project.

All but the last of these concerns were resolved by late 1975, however. Koppers assured the city that steam from the proposed plant would meet its requirements. The city was reassured by a concurrent EPA study of small-scale modular incinerators, which supported USR's claims about technical feasibility and economics. Also, city councilmen were able to visit three similar USR plants already under construction or in operation elsewhere in Arkansas.[24] USR predicted a low initial per-ton tipping fee and rising steam revenues, in contrast to increasing landfill and hauling costs.

As noted earlier, Koppers offered a site for the plant which satisfied city officials and residents. By late 1975, the city had successfully negotiated most aspects of an agreement with Koppers, with the important exception of a Koppers' guarantee to purchase minimum amounts of steam. The mayor and city council were thus willing to commit themselves to the proposal and solicited bids for plant development. City officials faced little or no community opposition to their decision. Earlier, local newspapers were concerned about USR's apparent conflict of interest, but Koppers' site offer and the prospect of a serious natural gas shortage dulled these objections.

What is somewhat surprising about the city's choice is that so few options were examined. City officials investigated only one alternative to the status quo in detail: the modular incinerator technology, and USR's proposal in particular. Other options -- such as incineration without heat recovery, MSW compaction and hauling, and other energy recovery technologies -- and alternative steam buyers or arrangements were apparently not investigated. North Little Rock's size precluded large-scale energy recovery, and USR was the main equipment vendor in Arkansas for modular incinerators. Nonetheless, it is not clear that the city had to limit its options so severely.

Perhaps the most interesting feature of North Little Rock's resource recovery choice is the fairly passive role taken by the city itself. The city was one of several participants, rather than the instigator and lead party, in considering resource recovery options. USR, and later Koppers Company, initiated the idea of energy recovery. USR located a potential steam buyer, made the initial proposal, conducted various technical and economic studies, assisted the city and Koppers in subsequent negotiations, and cleared the way for necessary state permits. Koppers verified technical feasibility, advocated strongly for USR's proposal, and offered the city a site for the plant.

City involvement increased, however, during negotiations with Koppers, and the mayor took a personal interest in the project's success.[25] The city's less prominent role can be partly attributed to the fact that the energy recovery project served two functions, being both an energy supplier and a MSW disposal facility. As such, the plant had to meet the needs of both users.

Several key individuals were largely responsible for the project's consideration and eventual implementation.

Mayor Powell used his political strength to gain the support of the city council. Powell felt it was important to improve the efficiency of city services in general, and saw the USR proposal as a way to do this, at least in the area of solid waste management. Koppers' plant manager, Mr. Radcliffe, took the lead in defining Koppers' steam requirements and certifying that the USR proposal would meet those requirements. His support for the modular incinerator proposal gave credibility to the project. R. Michael Butner, president of USR, had a key role in suggesting the proposal originally, conducting the necessary studies, and persuading both the city and Koppers of the proposal's merits.

Notes

1. U.S. Environmental Protection Agency, Resource Recovery Project Implementation: Case Studies of Five Processes, by Development Sciences, Inc.,(Washington, D.C.: U.S. GPO), 1977, p.1 (henceforth "Case Studies").

2. Personal communication: R. Michael Butner, president of U.S. Recycle, Little Rock, Arkansas; and U.S. Environmental Protection Agency, Small Modular Incinerator Systems with Heat Recovery: A Technical, Environmental, and Economic Evaluation, by Systems Technology Corp., SW-177c, November 1979, p.45.

3. U.S. EPA, Case Studies, *op.cit.*, p. 16.

4. *Ibid.*, p. 16.

5. Personal communication: Robert Seay, former director of North Little Rock Public Works Department.

6. Personal communication: John Culp, DSI-Resource Systems, Inc., Boston.

7. U.S. EPA, Case Studies, *op.cit.*, p. 7.

8. *Ibid.*, p. 15.

9. Personal communication: John Culp.

10. Personal communication: Ray Hagar, Director of North Little Rock Sanitation Department.

11. U.S. EPA, Case Studies, op.cit., p. 16.

12. Personal communication: John Culp.

13. U.S. EPA, Case Studies, op.cit., p.17.

14. Personal communication: Robert Seay.

15. Ibid.

16. U.S. EPA, Case Studies, op.cit., p. A-1.

17. Ibid., p. A-3.

18. U.S. Environmental Protection Agency, Small Modular Incinerator Systems with Heat Recovery: A Technical, Environmental, and Economic Evaluation, by Systems Technology Corp., SW-177c, November 1979, pp.112-113, (henceforth "Small Systems").

19. U.S. EPA, Small Systems, op.cit., p. 45 (assuming a 260-day year).

20. Ibid., p. 4.

21. Ibid., pp. 175-176.

22. U.S. EPA, Case Studies, op.cit., p. 25.

23. Personal communication: R. Michael Butner, president of U.S. Recycle, Little Rock, Arkansas.

24. U.S. EPA, Case Studies, op.cit., pp. 9-10.

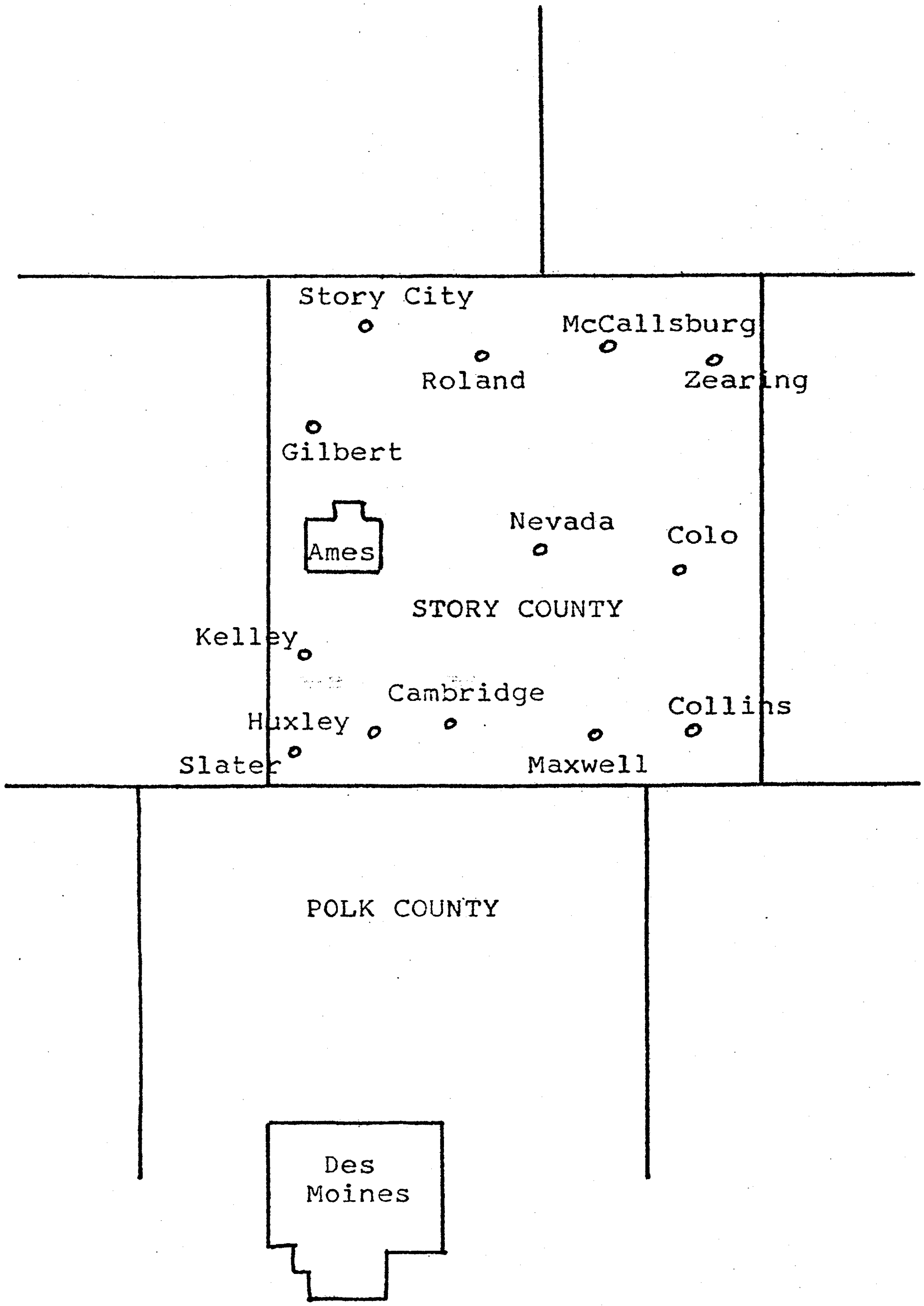
25. Personal communication: John Culp.

VII. CASE STUDY 4: AMES, IOWA

Since 1975, the city of Ames has operated a 200 ton per day (TPD) refuse processing plant, one of the first such facilities in the U.S. The plant receives MSW from Ames and the rest of the county, and produces a refuse derived fuel (RDF), which is fired as a supplementary fuel at the city's electric utility plant. Despite persistent technical difficulties and net operating costs of $13-16 per ton, over twice those projected, the plant has met the county's disposal needs since it began operation.

Ames' resource recovery decision was motivated in part by an impending shortage of landfill capacity and strict new state regulations affecting MSW disposal. But the city council took a broad view of the disposal problem, and sought to provide a long-term, environmentally sound solution to the city's disposal needs. The city's choice was motivated by non-economic criteria, both environmental and political, although technical and economic feasibility were both issues influencing the council's decision. Probably the most important factor leading to the city's choice was the fact that the city owned its own utility, which made the RDF technology attractive early in the planning process, focused attention on this option, and guaranteed a market for a then-

Figure 5 Location Map: Ames, Iowa



untested fuel product.

Background

Located in central Iowa about 32 miles north of Des Moines, Ames developed as a farming center at the intersection of two railroad lines in western Story County. Ames is now the principal city in Story County, with 63% of the county's population. The 1970 population of Ames was 39,000 - 46% above the 1960 level.[1] Growth during the 1970s was equally brisk, but the future rate of increase is expected to be slower.

Iowa State University (ISU) is located in Ames, and is a major part of the community. About half of the town's residents are students at ISU, and many other residents have some affiliation with the university. In addition to ISU, several state and federal agencies are headquartered in Ames, and the city supports a range of manufacturing and agricultural industries. Median income in 1970 was $10,126, slightly above the state and county average.[2] Ames has a weak mayor form of government, with a six member city council (the mayor being the seventh -- and non-voting -- member). Considerable responsibility for city administration rests with the city manager and his staff.

Traditionally, municipal solid waste is collected by private haulers throughout Story County. Some towns have a franchise arrangement with one hauler; others merely license haulers and allow open competition. Ames has no franchise requirement, and residents pay a monthly fee directly to the hauler for refuse collection. In 1970, this fee was $3.00 per month per household; it has since risen to $5.50.[3]

In the early 1970s, most Iowa communities had one (and in some cases two) open refuse dumps. Open burning was widely practiced. Ames was using a former farm, acquired in 1956, to dump its MSW. A city operated facility, the dump was then one of the better-run facilities in the state: MSW received periodic earth cover. No accurate records of waste tonnage were kept, but the city Public Works Department estimated that disposal costs were about $2.00 per capita per year (or $2.50 per ton).* Disposal costs were almost non-existent in other towns where open dumping and burning were practiced.[4]

Chronology

A 1970 act of the state legislature provided the impetus for a local review of MSW disposal practices. The act prohibited open dumping and burning and required communities to have approved disposal plans by late 1972.[5] The act created a Solid Waste Disposal Commission within the state Department of Health to implement the legislation, and required communities to obtain disposal permits by July 1975. The Commission in 1971 promulgated rules and regulations -- for both landfill operation and new landfill siting -- plus

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* Author's estimate, assuming 0.8 TPY per capita.

local plan guidelines. Its early enforcement activities virtually ended open burning, which in turn aggravated disposal problems for many communities.

In 1970, in response to the new legislation, Ames' City Manager J. R. Castner conducted a study of the city's landfill, discovering that the site sould reach capacity in only 3-5 years and a new landfill would be needed.[6] Castner realized that Ames' situation was not unique and initiated discussion with Story County officials and representatives of 14 other towns in the county, proposing a county-wide landfill. Because of its broader jurisdiction, county participation was considered crucial. The proposal died after county officials declined to pursue the matter (on the advice of the County Engineer).[7]

At the same time, Castner's staff was investigating possible sites for a new city (or county) landfill. The results of their 1971 survey were pessimistic. New state standards for landfill siting ruled out marginal lands because of infiltration and leachate problems. The only alternative was prime agricultural land, which was considered too costly at $3,000 per acre. The new site would have to be outside the city, and Castner and others anticipated serious opposition from nearby landowners and residents.[8]

As a consequence, the city council in late 1971 created a task force to consider other options that might obviate the need for acquiring a new landfill site. The task force was an informal group, consisting of two city council members -- Joe Maxwell and Dean Huston, Public Works Director Arnold Chantland, and three professors from the ISU departments of civil engineering and mechanical engineering. The group investigated a variety of options, including more efficient methods of landfilling as well as energy recovery alternatives. Task force members visited several facilities in the U.S., including a MSW shredding and landfilling operation in Madison, Wisconsin, a materials recovery plant in Franklin, Ohio, and a refuse derived fuel plant in St. Louis, Missouri. The group was impressed with the St. Louis facility -- a joint EPA-city demonstration project that used the burnable portion of the city's MSW to generate electricity. A preliminary check showed that the city's own coal-burning utility could be adapted to burn a mixture of RDF and coal.

In late 1972, the task force concluded its research and recommended to the city council that they authorize a more detailed study of the promising RDF idea.[9] Other city council members agreed that the proposal merited further study; they too expected great difficulties in siting a new landfill and were anxious to find an alternative. In October, the council hired the firm of Gibbs, Hill, Durham, and Richardson (GHDR) of Omaha, Nebraska, to study the technical and economic feasibility of a RDF plant. Primarily an architectural and engineering firm, GHDR had designed recent additions to the city's electric utility.

In February 1973, GHDR submitted its report to the city council, concluding that the RDF proposal was indeed feasible -- the city generated a sufficient amount of MSW, a waste processing plant would work, and the resulting RDF product could be successfully burned at the city's utility plant.[10] The report suggested that disposal costs could be reduced if the facility received waste from the entire county (about 55,000 TPY), due to economics of scale. Councilman Huston and others were apprehensive about the proposal; they realized that the then-unproven technology represented a financial risk. Nonetheless, the council was unanimous in its acceptance of GHDR's report and support of the RDF concept. Councilwoman Koerber and others considered landfilling environmentally objectionable and favored, in principle, an approach that recovered energy and materials from MSW. The council resolved to pursue the proposal further.

Meanwhile, the state's disposal regulation program was gathering momentum. In early 1973 regulatory functions were transferred from the Health Department to the newly-created Department of Environmental Quality (DEQ). DEQ pursued a policy of consolidation -- closing small dumps and encouraging area-wide landfills. DEQ closed the Story City dump in 1973, forcing Story City to use Ames' landfill and dramatizing the need for a county-wide facility.[11] Communities in Story County had few options; upgrading each small dump would be prohibitively expensive and the county was not interested in a common landfill. City Manager Castner thus found town officials entuhsiastic when he met with them to discuss their participation in the city's RDF project. Castner assured them that the facility would be less costly than a regional landfill.[12]

Ames' city council was already convinced of the feasibility and desirability of the project. With informal commitments from these communities, the council in May 1973, hired GHDR to design the refuse-processing plant. Councilwoman Koerber opposed GHDR's selection, feeling that the firm lacked the necessary ability, but Castner assured the council that no other firms were available and interested in the project.

In April 1974, GHDR's designs were completed and Ames signed 25-year contracts with six towns -- Maxwell, Rowland, Gilbert, Kelley, Story City, and Cambridge.[13] The contracts required each town to have its MSW delivered to the Ames RDF plant and provided for a per-capita sharing of net operating costs. Ames promised to receive MSW even if the plant failed completely, but made no promises about net operating cost, predicted at the time to be about $5 per capita per year.

Also in April, the city council unanimously approved the issuance of general obligation (G.O.) bonds to finance most construction costs. Due to an unfavorable bond market, the bonds did not sell. Ames successfully petitioned the state legislature to raise the maximum interest rate payable on municipal bonds -- from 5% to 6%. In February 1975, the council again approved the issuance of G.O. bonds in the amount of $5.3 million. These were sold successfully. Construction began, using city funds, and the contractor completed RDF plant construction and utility-boiler modification in August 1975. The Public Works Department started shakedown operations at the plant and it was fully operational by late 1975.

Resource recovery system and results

Ames' refuse processing plant is designed to produce a fuel supplement (RDF) and to recover various processed materials -- ferrous metals, aluminum, paper products, and woodchips. The plant has a 200 TPD capacity, serves all of Story County, and operates five days per week (hence 52,000 TPY capacity). It is modeled after an earlier RDF plant in St. Louis, of a similar scale, and operated jointly by EPA and the city. The Ames plant supplies RDF to the Ames Municipal Power Plant, a city-run utility which burns a mixture of 20% RDF and 80% coal.

Refuse entering the plant goes through a sequence of processing subsystems: a primary shredder (breaks refuse into six-inch chunks), a ferrous recovery unit with electromagnets, a secondary shredder (reduces refuse to two-inch chunks), an air classifier (separates light and heavy, noncombustible items), and an aluminum recovery unit. The system also includes a wood chipper and paper baler.

Packer trucks and private vehicles dump refuse on the tipping floor, and pay a nominal tipping fee of $1.00 and $.50 per load, respectively. Bulky and hazardous items are set aside at this point. After processing, the RDF is sent by pneumatic tubes to a storage bin, and from the bin to the utility boilers; the bin allows the utility to use RDF on a continuous basis. The non-combustible (or "heavy") fraction is hauled to the Ames landfill. Because of its inorganic nature, this waste does not need to be covered daily, and disposal is a simple matter.

At the utility plant, all three boilers have been modified to burn RDF as a fuel supplement. Two boilers are stoker-fired (coal and RDF are burned on a continuously moving grate); the third is suspension-fired (coal and RDF are shot into the boiler and burn in suspension). Suspension-firing of RDF did not work well, and the city later added a special grate in this boiler. The utility uses all of the RDF that the processing plant can produce, and pays a per-ton price equivalent to its fuel-offset value -- that is, the value of the conventional fuel it displaced. This price varies as a function of the heat content of the RDF and the cost of coal and natural gas used by the utility; it averaged $10 per ton in 1976.[14]

Ames contracted with Vulcan Materials Co. of Indiana, which buys recovered ferrous metals for a fixed percentage of the market price of highgrade steel scrap. In 1976, the price averaged $20 per ton. Ames also contracted with Alcoa

Aluminum to purchase shredded aluminum at a price of $300 - 400 per ton, depending on the quality of the material.[15] The city has no contracts for paper or woodchips.

Total capital costs for the refuse processing plant were $6,310,000 (1975 dollars), including $4.12 million for the plant itself and $1.6 million for the RDF storage bin and utility modifications.[16] Other capital cost items included land, rolling equipment, architectural and engineering costs, and start-up costs. The project was financed by $5.3 million of G.O. issued by the city in 1975; the bonds have a 20-year duration at an interest rate of 5.3% per year. The remaining $1 million came from city funds reserved for solid waste disposal activities.

Ames' plant has provided a steady supply of RDF to the city utility (meeting 10% of the utility's fuel-energy needs), and has reduced MSW tonnage requiring disposal by over 90%. At the same time, the plant has faced serious technical and financial difficulties. The city and GHDR expected some technical problems, given the lack of experience with RDF production and firing at that time. Much of the equipment was designed for different uses and had to be adapted to meet plant needs. Still, it was hoped that most problems would be resolved after a brief shake-down period.

But many problems persisted. Equipment failures (especially in the air classifier and RDF conveyor units) caused considerable down-time -- over 20% in the last half of 1976.[17]

"Bridging", or the piling up of RDF material upon itself, frequently caused pneumatic lines to become clogged, requiring the whole system to be shut down until the line was cleared. Plant design did not include dust control, and the city was forced to take remedial steps, installing a disc-screen separator after the primary shredder in order to isolate dust and grit. The aluminum recovery unit was plagued with problems -- including broken magnets and inefficient cooling systems -- and has not produced a saleable product since start-up.[18]

Despite technical difficulties, the plant has turned away very little MSW tonnage. Table 7 shows MSW tonnage received during the plant's first three years of operation.

TABLE 7 WASTE TONNAGE PROCESSED BY AMES RDF PLANT

	Tons per year(TPY)	Tons per day(TPD)[1]	Percent of capacity
1976	40,900	157	79%
1977	48,300	186	93%
1978	37,700	145	73%

Source: Resource Recovery: The Ames Experience, Financial Summary (Update)

1. Assumes 260 operating days per year.
2. Plant has 200 TPD capacity.

Of the incoming MSW tonnage, 84% becomes RDF, 7% is recovered as ferrous metals, and 9% is rejected and hauled to the landfill. Recovered paper, aluminum, and woodchips are a negligible fraction of the total. The plant recovered about 3,000 TPY of ferrous metals over the three-year period, at a price of $30-35 per ton. Because of very poor market prices for paper during this period, the plant recovered only about 120 TPY of paper.

The city utility encountered no major problems using RDF as a fuel supplement. An average of 36,000 TPY of RDF was burned during the 1976-78 period, supplying about 10% of the utility's fuel needs -- in terms of BTU. RDF has a high ash content but a low sulfur content. When burned with high sulfur coal, it decreases sulfur (di)oxide emissions, allowing the city to use a greater percentage of cheaper, high-sulfur local coal (rather than Wyoming or Eastern coal). But RDF firing also increases particulate emissions significantly; when the state DEQ re-tested stack emissions in 1978, the plant exceeded particulate standards (with and without RDF).[19] Even after modification, the utility does not consistently meet these standards; the state DEQ and Ames are still trying to resolve this issue.

Net operating costs have been more than twice those estimated by GHDR in the 1972 feasibility study ($5.68 per ton), as Table 8 shows.

TABLE 8 AMES RDF PLANT COSTS AND REVENUES

	1976	1977	1978
Revenue			
RDF revenue	319,500	353,300	322,300
Ferrous metals revenue[1]	97,900	102,300	89,300
Other material revenue[1]	4,400	10,200	3,200
Tipping fees[2]	32,200	49,600	61,400
Other[3]	10,500	7,400	84,600
Total	$464,500	$522,800	$560,800
Costs			
O&M	626,700	690,900	689,500
Debt service	482,800	465,400	463,600
Equipment reserve	12,500	12,500	12,500
Total	$1,122,000	1,168,800	1,165,600
Net cost	657,300	646,000	604,900
	$16.06/ton	13.38/ton	16.04/ton

Source: Resource Recovery: The Ames Experience, Financial Summary (Update)

1. Woodchips and paper, mainly.
2. At RDF plant and sanitary landfill.
3. 1978 figure included $75,000 EPA grant for equipment modification.

There are several reasons for these unexpectedly high costs. GHDR, in its 1972 study, overestimated MSW generation rates in Story County, predicting 55,000 TPY. In fact, yearly tonnage has been much less; the plant has operated well below capacity, and major fixed costs have been allocated among fewer tons of refuse. Second, the RDF plant received low per-ton revenues for RDF. GHDR estimates of fuel-offset prices assumed that RDF would be fired with 100% coal, but an unexpected availability of cheaper natural gas lowered the utility's per-BTU fuel cost. The plant received essentially no revenue from recovered aluminum or paper (due to equipment failure and low market prices, respectively). Third, rapid inflation in 1974 and 1975 almost doubled GHDR's 1972 estimate of capital costs. This plus a higher interest rate on G.O. bonds increased debt service dramatically.

Because of the plant's cost-sharing plan, Ames and the other participating communities in Story County have had to finance these extra costs, usually from city tax revenues. Unaccustomed to sizeable disposal fees, the participating towns were quite distressed by the high per-ton costs.* Two communities -- Huxley and Gilbert -- tried unsuccessfully to break their respective 25-year contracts with Ames in early 1977. Both Ames and the other towns sought state and federal grants in 1977, arguing that the RDF plant was of national importance and a valuable demonstration project. Later that year, Ames received a multi-year $600,000 demonstration grant from EPA.

Resource Recovery Choice

Several characteristics of Ames' resource recovery choice are noteworthy. The city's choice, unlike those in other cases, was not elective. The city council knew that within five years, Ames would need a new disposal site (or technology).

The council's decision to develop and RDF plant was a conscious and positive act; the council regarded the city's

* These communities were concerned over predicted $5 per capita per year costs, never mind $10-12 costs. By way of comparison nearby counties pay $4-8 per ton for landfilling (or $3-6 per capita per year).[21]

MSW disposal situation as an opportunity. Faced with an essentially short-term disposal problem, (i.e. how to expand landfill capacity), the council took a longer view and sought a solution that would be beneficial to the city in the long-term.

The city council made no single, identifiable decision. Rather, council members were initially attracted to one option, and subsequent studies served only to reinforce that attraction. There are several reasons for this early narrowing of options. The most obvious alternative -- landfilling -- was considered undesirable on environmental, economic, and political grounds. City manager Castner and the council thought the new state landfill standards would make landfill siting both expensive and politically difficult.* Des Moines was in the process of siting a new landfill and faced lawsuits from landowners and resolutions opposing siting from nearby communities.** Other resource recovery options were very limited in the early 1970s; the 1971 task force had very few examples to evaluate or observe. The successful operation of the St. Louis RDF plant and the availability of a willing RDF user in Ames (the utility) made this technology very attractive to the city council.

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* Other local and state officials discount landfill siting difficulties, however, citing an abundance of open space and little history of citizen opposition.[23]

** Public works director Chantland predicted $6 per ton disposal costs.

The nature of Ames and the time at which the decision was made influenced the criteria used by the city council to evaluate the RDF proposal. Ames is a college town: many residents have ties to ISU. Residents are receptive to unique and innovative solutions, and often support creative or experimental approaches to municipal problems.[22] This attitude is reflected in the city council. In this sense, the Ames case is atypical; it is unlikely that other Iowa communities would have supported an essentially untested technology.

Ames' decision came at the height of the environmental movement, at a time when Americans were becoming acutely aware of natural resource and pollution problems. This philosophy or attitude was very much a factor in the city's choice -- both among city council members and in the community at large. The RDF proposal was seen as a way of preserving agricultural land, avoiding the environmental impacts of another landfill, and conserving natural resources.

Certainly other criteria entered into the council's decision as well. The city council thought that resource recovery would engender less public opposition than a new landfill. They were convinced that the RDF plant would work and that it would be cheaper in the long run. The 1972 GHDR report predicted a 10-year "payback" period; after this point, landfilling would be more costly in present-value terms.[24] The city also had lots of willing technical assistance -- from GHDR and the university. GHDR was anxious to become established in what it saw as a future growth industry, and many faculty at ISU were willing to assist in developing such a major new technology.

The council's choice engendered very little controversy -- among council members or the public. Despite early skepticism by some council members over the new technology, "nobody dragged their feet",[25] and the council was unanimous in supporting the RDF proposal. This consensus can be explained by both the prevailing politics, which supported innovative and environmentally-sound solutions, and the merits of the proposed RDF project.

The public at large had a minimal role in the resource recovery choice. No community organizations were involved in either suggesting or promoting resource recovery. Because solid waste disposal was considered an "essential public service", the council did not need to obtain voter approval on the G.O. bonds which financed the plant.[26] More importantly, the RDF proposal was compatible with community sentiment at that time. Although the city newspaper was critical of the project, questioning its feasibility, most citizens apparently favored or were unaware of the project.[27] In retrospect, some residents wish city officials had spent more time on citizen education prior to their decision. Now, many Ames' citizens are unhappy with the RDF plant's high operating costs. Earlier efforts to involve the public might have produced a broader consensus, and could have sensitized citizens to the possibility of higher-than-predicted costs.

Project financing and siting, two common pitfalls in energy recovery plant development, caused no serious problems in Ames. The city had ample debt capacity at the time, and had set aside funds since 1970 to finance a new disposal facility. Land for the project was available near the power plant, in a primarily commercial area. Some of the few residents near the site did object to the project on grounds of excessive noise, but the city was able to purchase the necessary parcels without resorting to condemnation.

Notes

1. City of Ames, Community Development Department, Community Profile, June 1978, p. 2.

2. Ibid., p. 3.

3. Personal communication: City Clerk, City of Ames.

4. Personal communication: George Welch, Iowa Department of Environmental Quality (Air and Land Division).

5. Code of Iowa, Ch. 455B, Dir. 4, Part 1.

6. Personal communication: Barbara Koerber, member of Ames City Council; and City of Ames, Energy from a Wasted Resource: The Ames Experience, by David Doran, 1978, p. 3.

7. Personal communication: J. R. Castner, former City Manager, City of Ames.

8. Personal communication: Barbara Koerber, Joseph Maxwell, and Dean Huston, members (or ex-members) of Ames City Council.

9. City of Ames, Energy from a Wasted Resource: The Ames Experience, by David Doran, 1978, p. 3 (henceforth "Ames Experience").

10. Ames Experience, <u>op.cit</u>., p. 4.

11. Personal communication: J. R. Castner.

12. <u>Ibid</u>.

13. Personal communication: City Clerk, City of Ames.

14. Ames Daily Tribune, "The Garbage Plant," March 23, 1976, p. 12.

15. <u>Ibid</u>., p. 12.

16. U.S. Environmental Protection Agency, <u>Evaluation of the Ames Solid Waste Recovery System, Part I</u>, by J. C. Even et.al., Iowa State University, and D. E. Fiscus and C. A. Romine, Midwest Research Institute (Cincinnati: Muni. Env. Research Lab.), November 1977, pp. 196-198.

17. <u>Ibid</u>., p. 31.

18. Ames Experience, <u>op.cit</u>., p. 25.

19. Personal communication: Arnold Chantland, Director of Public Works Department, City of Ames.

20. Ames Daily Tribune, "County towns start search for funds," February 1, 1977.

21. Personal communication: Arnold Chantland.

22. Personal communication: Charles Miller, Director of Air and Land Division, Iowa Department of Environmental Quality; and John Parks, member of Ames City Council.

23. Personal communication: Arnold Chantland.

25. Personal communication: Barbara Koerber, member of Ames City Council.

26. Personal communication: Arnold Chantland.

27. Personal communication: Keith Adams, Iowa State University, Ames.

VIII. CONCLUSIONS

This paper set out to accomplish two tasks: to observe how communities view the low-versus-high technology resource recovery issue, and to suggest a process municipalities should use to choose between the two approaches (and among specific resource recovery options). The first matter is empirical; the second prescriptive. This section addresses both in terms of the fours case studies.

The Community Perspective

In none of the four cases did communities directly compare high and low technology approaches to resource recovery. Rather, one approach was compared to the community's present waste disposal method. In the case of El Cerrito and Marblehead, recycling was evaluated in the context of continued landfilling or incineration. North Little Rock and Ames saw energy recovery as an alternative to landfilling. These cases are probably not unique; the author knows of no communities that have viewed low and high technology approaches as competing options.*

* In at least two metropolitan regions -- Portland, Oregon, and Washington, D.C. -- high-technology proposals have been rejected in favor of further study of both low and high-technology options.[1] In neither case, however, were the two approaches seen as comparable substitutes.

Why is this the case? As section III pointed out, low and high-technology approaches have different attributes and solve different problems. They also tend to address different community objectives and criteria for solid waste management. From the case studies, it appears that communities considering low-technology approaches have been primarily concerned with environmental issues (conserving natural resources and energy, and reducing landfilling impacts) and to a lesser extent with economic issues (reducing disposal costs and extending the useful life of the community's landfill). Communities considering high-technology approaches have been primarily concerned with economic and fiscal issues (providing new disposal capacity, reducing disposal costs, and attracting new industry) and to a lesser extent with environmental issues (conserving materials and energy, as in the Ames case).

Aside from these differences, though, communities tend to view the choice between the two approaches differently than those engaged in the appropriate technology debate. As section III noted, the debate has focused on national issues of resource policy. In considering resource recovery options, many municipalities are more concerned with net costs, system reliability, and compliance with environmental regulations than they are with resource policy. While the national debate focuses on two generic approaches to resource recovery, communities must consider specific options -- at specific sites, each with associated costs, risks, and benefits. The municipality's time frame is usually shorter, with priority on meeting short-term disposal needs. Finally, local governments can view solid waste management as an "open" system. A local option, such as hauling MSW to a regional landfill (as Marblehead decided to do in 1975), might not be considered a valid long-term disposal solution from a regional or national perspective.

Municipalities are usually motivated to consider resource recovery for a specific reason (or reasons). These reasons may imply a lot about the options available to the community and how they are valued, as we will see. Common motivations include: little remaining disposal capacity, high disposal costs, stringent state (or other) regulations affecting MSW disposal, public support for resource recovery, and demand for alternative energy.

Disposal capacity may be limited by a landfill near its capacity, as was the case in Ames, or by an incinerator (or dump) that is scheduled to be closed at some future time, as in the case of Marblehead in 1975. If new disposal facilities can be easily acquired, the municipality may feel no need to consider resource recovery. More often, however, developing a new disposal facility means significant initial costs, and political opposition to facility siting. Communities in this situation have strong incentives to consider resource recovery.

High disposal costs -- or costs that are expected to increase rapidly in the future -- also make resource recovery an attractive option, in an economic sense. Disposal costs refer to all post- collection costs, including any transfer or long-distance hauling costs. Expected future costs are often more important than present costs. A community such as Marblehead, facing a high marginal (as well as average) cost of disposal, may find that even small reductions in MSW tonnage can yield lower disposal costs overall.

Stringent state (and other) regulations may reduce remaining capacity at a disposal facility (for example, by restricting a landfill area or requiring an incinerator to close if it cannot meet air quality standards, as in Marblehead). They may also increase disposal costs, by requiring remedial work (such as leachate barriers in existing landfills) or restricting new landfill sites (and increasing haul distances or acquisition costs). In Ames, state regulations hastened the need for a new landfill, which was expected to increase disposal costs from $2.50 to $6.00 per ton.

Public support for resource recovery -- in the form of citizen proposals, support for resource and/or energy conservation, or opposition to existing disposal practices -- is often a primary reason for municipal involvement. In El Cerrito, Marblehead, and (to a lesser extent), Ames citizen support was a major factor in those cities' decisions to study and eventually proceed with resource recovery. Public support is critical for low-technology approaches, given their greater reliance on resident participation.

Either the municipality itself or local industry may be interested in alternative sources of energy, and a high-technology system for energy recovery may be attractive in this context. Alternative sources may be needed to counter expected shortages or supply curtailments (as in North Little Rock) or to obtain less expensive energy. If local industry is the energy user, a community may be presented with a specific resource recovery proposal prior to any municipal study.

Communities may have one or several reasons for wishing to consider resource recovery. Those found in the four case studies are summarized in Table 9.

Suggestions for a Community Choice Process

At the community level, the appropriate technology issue is more complex than its national counterpart. In order to facilitate further discussion, let us first restate the original question, which posed a simple choice between the two approaches, to read: "Does resource recovery make sense for a given community? If so, which type or combination is most appropriate?" Trying to construct a useful choice process is difficult, however, since many important aspects of the resource recovery choice are specific to a community

TABLE 9 MOTIVATION FOR CONSIDERING RESOURCE RECOVERY

Reason	Low Technology				High Technology	
	Marblehead*			El Cerrito	North Little Rock	Ames
	1972	1975 (a)	1975 (b)			
1. Need new disposal capacity		o				o
2. Face high or increasing disposal costs			o		o	o
3. Stringent state (or other) regulations		o				o
4. Local support for resource recovery	o		o	o		o
5. Demand for alternative energy					o	

* Three columns refer to Marblehead's three different choices: (i) a voluntary decision in 1972 to start separate collection, (ii) consideration of energy recovery just prior to having its incinerator closed in 1975, and (iii) a late 1975 decision to upgrade its separate collection program after arranging for regional landfilling.

or resource recovery proposal. Particular options can be combined in various ways (e.g. the separate collection - centralized MSW processing combination noted in section III).

The case studies and their results are not immediately relevant, since they do not illustrate a choice between low and high-technology options. Nonetheless, the cases do contain certain lessons which are applicable to the resource recovery choice. In each case, a community was motivated to consider resource recovery, examined specific options, and selected its preferred choice. The remainder of this section offers specific suggestions concerning the local choice issue. Without defining a choice "process", these suggestions can help a community to (i) determine the feasibility of low and high-technology approaches to resource recovery and (ii) see if that community's solid waste management circumstances and objectives favor one approach over another.

Feasibility of Resource Recovery

Clearly, a municipality must have an interest in resource recovery before examining the feasibility of different technologies. Assuming that this is the case, for one or more of the reasons noted above, the matter of feasibility must be addressed. At this stage, we are concerned with the feasibility of the two approaches, not specific resource recovery options or projects. Below are listed two sets of criteria for evaluating the feasibility of low and high-technology approaches; each is discussed in turn.

The feasibility of the low-technology approach to resource recovery depends on:

(1) MSW Composition

A community considering recycling should analyze its MSW composition to be sure that recyclable materials are present in sufficient quantities to justify materials recovery. On a nation-wide basis, recyclable materials constitute the majority of MSW by weight,[2] but this composition varies considerably on a regional and seasonal basis. In Marblehead and Somerville, Massachusetts, MSW contains a greater-than-average amount of paper and glass, and less ferrous metals.[3] In El Cerrito, a high percentage of aluminum helps make recycling quite profitable.

(2) Availability of materials markets

Ready access to secondary material markets is a prerequisite for any recycling program. Communities should investigate materials markets carefully, locating potential buyers and checking product prices and specifications. Some regions of the country have significantly better secondary materials markets than others -- notably California and the mid-Atlantic states.[4] This is due to several factors. Scrap paper, a principal source of recycling revenues, is often sold for export, so that port regions support a large share of this market. Other materials buyers tend to locate near their markets in major metropolitan areas. Also important is the strength and diversity of those markets. A recycling program, such as El Cerrito's, that can sell its products to several buyers will tend to receive higher, more consistent material revenues than a single-buyer program. In Marblehead, a market for mixed recyclables was critical to the feasibility of that community's minimum-separation recycling program.

(3) Community support and participation

Recycling depends on household separation of recyclable materials and, in some cases, their transportation to drop-off or buy-back center. As such, the willingness of citizens to conduct source separation of household wastes is fundamental to recycling success. A community can create incentives for recycling -- such as lower refuse collection costs or free use of the town's landfill, but even so, a successful recycling program relies heavily on citizen cooperation and interest. In both Marblehead and El Cerrito, a clear majority of residents expressed interest in source separation, and in fact participate in the local recycling program. Predicting participation is difficult. There appears to be only a minor correlation between the rate of community participation in recycling and socio-economic factors, such as age, income, and education.[5] Communities should conduct surveys to determine residents' willingness to participate in source separation, and under what terms.

These are the factors most relevant to low-technology approaches. The feasibility of high-technology resource recovery depends on a somewhat different set of factors:

(1) MSW Energy Value

While the relative abundance of recoverable materials is again of interest, the energy value of MSW is the most important factor for high-technology resource recovery. Energy value, measured in BTU per pound of MSW, depends on the mix of organic and inorganic wastes; EPA estimates the national average to be 5,000 BTU/lb.* Like MSW composition, energy value can vary greatly from community to community and between seasons in a given community. A predictable range of MSW energy value is necessary to a successful energy recovery plant; if this value is too low or too unpredictable, energy recovery may be impractical. In Ames, the consulting engineers estimated energy value at 3,000-6,000 BTU/lb., indicating wide fluctuations.[6] In Marblehead and Somerville, EPA found an average energy value of 4,340 BTU/lb., but this varied between 4,000 and 5,300 BTU/lb.[7] In neither Ames nor North Little Rock was energy value an obstacle to energy recovery.

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* For comparison, coal has an average energy value of 12,600 BTU/lb.[8]

(2) Availability of energy markets

The high-technology approach focuses mainly on energy recovery. Many centralized plants also recover materials, but energy recovery is usually the main feature of the plant and provides the bulk of plant revenues. In Ames, ferrous metal recovery represents only 22% of MSW-derived revenues; at North Little Rock's modular plant, no materials are recovered. Once again, the presence of such markets is crucial to the success of an energy recovery plant. There is often a wide range of markets for recovered energy, depending in part on the energy product. Electric utilities are an important potential market for electricity, and under the right circumstances steam or RDF. In the Ames case, the fact that the city operated its own utility created a ready market for RDF, a hitherto unproven fuel supplement. Local industry or the city itself may provide a market for steam -- for industrial processes or heating purposes. Typically, an energy recovery plant must provide a product that meets the needs of the energy buyer. The North Little Rock plant, while providing a sufficient daily supply of steam, could not meet the peak steam demands of its energy buyer. A community should investigate potential energy markets, identifying potential buyers and checking product specifications and needs.

(3) Sufficient MSW tonnage

Until recently, it was generally agreed that large quantities of MSW -- on the order of 1,500 tons per day --

were required for economically feasible energy recovery. But modular incinerators (with heat recovery), such as the North Little Rock plant, make the high-technology approach possible for communities producing more than 30 TPD -- the equivalent of a population of about 15,000. Smaller towns would probably have to participate in a regional project. The minimum size of an energy recovery plant depends largely on the particular technology chosen: waterwall incinerators and RDF plants are considerably larger, usually in the 600 - 2,000 TPD range. Ames' proposed RDF plant required more MSW tonnage than the municipality produced, leading it to contract with other towns to deliver their wastes to the facility.

(4) Air quality regulations

MSW is by definition a highly variable and heterogenous fuel; its combustion at an energy recovery plant yields a more unpredictable mix of air pollutants than that from fossil fuel combustion. In particular, MSW combustion produces high levels of particulate emissions, as well as lesser amounts of hazardous materials, such as lead and cadmium.[9] The feasibility of energy recovery may depend on the stringency of state (and federal) air quality regulations and their enforcement. Ames' coal-fired utility plant has had considerable difficulty meeting federal air quality standards since it started using RDF as a fuel supplement, and was obliged to install remedial emissions-control equipment. Smaller, modular-incinerator facilities may pose less of a problem; their starved-air incineration process reduces emissions considerably, and they are sometimes too small to be subject to "new source" regulations (as was the case in North Little Rock).

(5) Institutional factors

Under this heading, the community should consider the legal and organizational factors which affect its ability to plan, procure, finance, and (if relevant) operate an energy recovery system. EPA's series of reports on resource recovery plant implementation provides guidance in this respect:

> Questions to be raised here include: what are the laws affecting the process by which the city can procure a recovery system; can the city efficiently operate a recovery plant and market the product itself; can the city assure that wastes will be delivered to the plant; what financing options are available to the city; and what arrangements must be made to meet the requirements of the financial community.[10]

Institutional factors were important in both energy recovery cases. In Ames, contracts with other towns were necessary to assure sufficient MSW tonnage, and the city had to persuade the state legislature to raise the allowable interest rate on municipal bonds before it could obtain financing. In the North Little Rock case, a key state utility commission ruling which assured the modular incinerator of auxiliary fuel contributed to the project's feasibility. The city also had to reform its MSE collection financing system in order to meet state requirements for issuing special revenue bonds.

Some of these factors are predictable and should be anticipated; others arise unexpectedly.

(6) Access to capital

Energy recovery plants are capital intensive, especially large-scale ones. Amortized capital costs for proposed plants range between $10 and 30 per ton (1980 dollars).* The Ames, Iowa, plant serves a population of 65,000 and cost $5.5 million (1975 dollars), or $14,000 per ton of capacity. North Little Rock's modular incinerator cost $1.3 million (1976 dollars), or $13,000 per ton of capacity. For many types of plant procurement, a community must have (and be willing to devote) sufficient resources to finance plant development. Private equity has not been attracted to energy recovery projects, due to the newness of the technology and to their perceived risk. Revenue bonds backed by the project being financed may not attract buyers for the same reason. As was the case in North Little Rock, states may authorize the city to issue special revenue bonds, or otherwise improve the city's access to capital.

Factors Affecting the Choice

Any of the items noted above may pose a serious obstacle to a low or high-technology approach. Given that both approaches are basically feasible, a community's

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* Author's estimate, based on EPA and American Iron and Steel Institute published data.[11]

preference for one or the other will depend on its circumstances and on its solid waste management objectives. The following factors, it should be stressed, refer primarily to the choice between approaches, and less to specific resource recovery options.

Several circumstances affect the low-versus-high technology choice. They include the community's motives for considering resource recovery and various external conditions, such as state policy for resource recovery. Each may cause a community to prefer one approach over the other.

(1) Remaining disposal capacity

Remaining capacity refers both to the remaining lifetime of a community's existing disposal facility and the prospects for replacing that facility in the future. A community with little remaining capacity at its present facility will be forced to make a choice between energy recovery and traditional disposal methods; a low-technology approach alone will not solve its problems. Ames and Marblehead (in 1975) faced this situation; in both cases, the municipalities decided that siting a new landfill was either too costly or politically unworkable, and considered energy recovery options. It may be desirable to select an interim solution in order to provide adequate time to examine resource recovery options; this is what Marblehead did in its 1975 contract with a private hauler. While energy recovery is a better response to limited disposal capacity, recycling may be a useful part of the community's resource recovery strategy.

Conversely, a community with considerable disposal capacity can utilize low-technology strategies to extend the life of its landfill and reduce annual disposal costs. For example, a recycling program that diverted 20% of MSW would extend the community's landfill capacity by 25%; about 3 years if 12 years of capacity remained. In neither Marblehead nor El Cerrito, however, did the low-technology approach have this effect; Marblehead's landfill was virtually full when it began recycling, and El Cerrito is only one of many users of a private landfill in Richmond.

(2) MSW disposal costs

In general, high disposal costs favor the use of both high and low-technology approaches. High tipping fees or anticipated increases motivated Ames, North Little Rock, and Marblehead to consider resource recovery strategies. There may be no incentive for recycling, however, unless the marginal cost of disposal is also high. In Marblehead, a $19 per ton marginal cost was quite sufficient to encourage recycling efforts. Unfortunately, there is no convenient definition of "high" cost; net disposal cost is only one factor in the resource recovery decision.

(3) State regulations affecting MSW disposal

State regulations and their enforcement tend to result in increased disposal costs and reduced disposal capacity, with consequences as described in (1) and (2) above.

(4) Citizen attitudes toward resource recovery

Active community support for low or high-technology approaches may be an important motivation for local officials to investigate one or both approaches. This is particularly true for low-technology approaches, which depend heavily on resident participation, as the El Cerrito and Marblehead cases illustrate.

(5) Demand for alternative energy

A demand for alternative energy -- by the municipality itself or a local industry -- clearly favors energy recovery options. In North Little Rock, the energy recovery proposal by U.S. Recycle and Koppers Co. dominated the city's consideration of resource recovery. Nonetheless, some combination of low and high-technologies may be appropriate, to reduce the non-combustible fraction of incoming MSW.

(6) Other resource recovery projects

A community may already be host to a privately-operated recycling program (as in Marblehead and El Cerrito), or it may have access to high-technology recovery systems in the region -- either planned or already in operation. The existence of a low or high-technology project will, for several reasons, make that approach more attractive to a community. An existing recycling program enhances the prospects for low-technology strategies, serving the function of a pilot project by checking material markets and resident participation, and identifying operational problems. The early recycling program in El Cerrito was valuable in this respect.

Similarly, a nearby energy recovery plant may represent another option to the community: participation in an existing or planned resource recovery project. Marblehead, for example, considered contracting with an existing energy recovery plant (RESCO, in Saugus) or joining one of the planned regional resource recovery projects. This option had the advantage of minimizing the community's planning and implementation costs and avoiding the financing issue. In regions, such as northeast Massachusetts, several private and/or regional energy recovery proposals compete for MSW from essentially the same area. Such a situation is favorable to municipalities in the region, who can select the project that best suits them, and perhaps bargain for more favorable terms. Participation in a regional project has disadvantages too, usually forcing a community to meet various obligations, such as contributing a minimum annual volume of MSW.

(7) Role of state and federal policy

While external to a community's specific circumstances, state and federal policy on resource recovery can nonetheless create important incentives and disincentives for both low and high-technology approaches. By providing technical assistance and planning grants for resource recovery projects, government agencies can to a degree define resource recovery options and determine their relative feasibility. EPA's demonstration grant program has assisted both low and high-technology systems; its 1975 grant to Marblehead improved implementation prospects significantly. California's SWMB grant program enabled El Cerrito to purchase most of the equipment necessary to the expansion and later success of its recycling program. The E.C.ology program brochure emphasizes this point:

> Without CETA grants and State Solid Waste Grants, the chances for most (California) communities to start and retain a recycling program are minimal.[12]

Other state policies and actions have incentive effects too. In Arkansas, a state utility commission ruling assured modular incinerator plants of a continuous supply of auxiliary fuel. State legislation authorizing special revenue bond financing of solid waste disposal facilities enabled North Little Rock to finance its energy recovery plant for a relatively low rate of interest. In Massachusetts, a state policy promoting centralized resource recovery led to the formation of several regional resource recovery proposals, which Marblehead was able to choose from.* State policies in Iowa, on the other hand, served to impede resource recovery. State law set an upper bound on interest rates for municipal bonds; the limit had to be raised before Ames could successfully finance its RDF plant. Iowa's DEQ in fact recommended against the Ames proposal, citing its

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* Although the town chose instead to build a transfer station and utilize a regional landfill.

high cost and risk.

Just as a community's circumstances can affect its choice between resource recovery options, so can the community's objectives with respect to solid waste management. Clearly, each community will have a somewhat different set of objectives, and hence different criteria for evaluating resource recovery options. Nonetheless, we can identify several commonly used criteria, and assume that a given community will weight each criterion appropriately (and may add others). Five criteria for evaluating resource recovery options are most relevant: net cost, reliability, environmental impact, opportunity cost, and time constraints.*

(1) Net cost

The net cost of a resource recovery option refers to the net per-ton cost to the community of MSW processing and disposal. An estimate of net cost should account for future trends, perhaps expressing cost in terms of net present value. It may be necessary to incorporate changes in collection cost; Marblehead's separate collection program reduced refuse collection costs to the community. A measure of net cost should also account for risk and uncertainty, indicating the measure's accuracy and events which could significantly affect cost estimates.

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* Several criteria are derived from a recent study of solid waste disposal options in Rockport, Massachusetts.[13]

The net cost of energy recovery, generally speaking, is more volatile than that of a low-technology approach coupled with, say, landfilling. Energy recovery plant costs are the result of large revenues and gross costs; small changes in either can have large effects on net cost. In both North Little Rock and Ames, net costs of disposal have been twice (or more) those predicted at the time when the community's choice was made. However, in some circumstances, landfill costs may be equally or more volatile, depending on the availability of new sites or the enforcement of state regulations. Marblehead may find its disposal costs rising rapidly in the future if the Amesbury landfill is closed or modified by state regulations, as could well happen. If energy prices and landfill costs increase rapidly, as they seen likely to do, the net cost of energy recovery will decline faster than the net cost of a low-technology strategy.

(2) Reliability

Reliability refers to the dependability of a resource recovery system -- its design, equipment manufacturer, and operator (as relevant). Especially in energy recovery plants, a community is concerned about system flexibility, redundancy, and back-up procedures. In general, the recycling-landfill approach is far more reliable, due to its relative simplicity and lack of inter-dependent or sequential elements. For example, a paper-baler breakdown at El Cerrito's recycling center would only cause a slight decline in project revenues, since unbaled paper brings a lower per-ton price. At the

Ames plant, however, clogged pneumatic tubes transporting the RDF product cause the entire plant to shut down until the tubes are cleared. Careful design can assure that a centralized recovery plant is reasonably reliable, but this also means higher cost. In practice, siting a new landfill or incinerator (a more frequent occurence with a low-technology approach) may also pose a "reliability" problem.

(3) Environmental impact

A resource recovery option should comply with state (and federal) regulations concerning air quality, water quality, and landfilling. It should also be consistent with any local or community policies promoting materials recovery, energy conservation, and so forth.

Both low and high-technology approaches have unavoidable impacts which can be largely mitigated, although often at substantial cost. Recycling implies continued impacts from traditional disposal. For both approaches, the seriousness of the unavoidable impacts is somewhat uncertain; for example, the health effects of MSW emissions are largely unknown.

(4) Opportunity cost

A community is usually concerned with both the opportunity cost and the degree of local control implied by a resource recovery option. How many future actions are foreclosed by the option? The preemptive effect may affect a broad or narrow range of future choices, and may be of short or long duration. Both North Little Rock and Ames issued debt that will be repaid over a 20 year period. Clearly, a flexible resource recovery system has a lower opportunity cost.

The high-technology approach usually has much higher opportunity costs. Plant financing requires debt service payments over 20-30 years, and usually necessitates contracts of equal duration with MSW contributors and/or energy buyers. Energy recovery plants are usually inflexible, in that they cannot easily adapt to changes in MSW volume or composition. Participation in a regional energy recovery project usually means relinquishing considerable local control over solid waste management decisions (such as whether to conduct source separation, where to dispose of MSW, and how much disposal will cost). Low technology approaches, while less binding on a community, can have a *de facto* opportunity cost if the community must make a long-term commitment for a new disposal facility.

Communities wishing to minimize opportunity costs should consider various combinations of MSW disposal and recovery options. For example, in 1975 Marblehead chose to develop a transfer station and haul its MSW to a regional landfill. This meant a 5-year contract with a private hauler, a much shorter commitment than would have been required had the town participated in a regional resource recovery project or developed its own disposal facility. It can be argued that any combination of low-technology resource recovery and conventional disposal which defers a high-technology approach is worth considering. By deferring energy recovery, a community can reap the benefits of technological advances and greater operating experience in the energy recovery field, which will presumably reduce net costs and improve system reliability.

(5) Time constraints

Communities often face time constraints in developing new solid waste disposal capacity; a resource recovery option should be implementable within the necessary time frame. Options with uncertain implementation schedules that depend on events beyond the community's control pose a problem in this respect. High-technology approaches take considerable time to be implemented, and the lead time can vary considerably - between 3 and 9 years. In Ames, the interval between serious consideration of the RDF proposal and project start-up was nearly four years; in North Little Rock, this interval was slightly more than three years. Not surprisingly, smaller plants appear to take less time to procure and develop. The practicality of energy recovery options may depend on interim disposal options to tide a community over.

Choice Process Suggestions

The previous material is relevant mainly to a community's general evaluation of low and high-technology approaches. In order to proceed further, a community must define specific resource recovery options (such as municipally-run separate collection or small-scale modular incineration with heat recovery), specifying potential energy or materials buyers, sites, service area, and so forth. The community's evaluation and choice will invariably hinge on implementation factors, many of which defy generalization; examples of these can be found throughout the four case studies. Consequently, rather than describing a formal choice process, the remaining material reviews the case studies and identifies various lessons which apply to the resource recovery decision.

A point often overlooked in evaluating alternatives to the status quo is that present conditions tend to change; the "status quo" is not static. In comparing resource recovery options -- with each other and with present disposal practices, a community should look for future trends in landfilling costs, state regulations, energy prices, and so forth. Future trends are most relevant to resource recovery options that require long-term commitments. Ames' decision to develop an energy recovery plant was based largely on city officials' expectation of much higher landfill costs in the future. A net present value analysis may be helpful in this respect.

Information is an important commodity in the resource recovery choice process. Good planning information is crucial to an informed decision, especially for high-technology projects which are more sensitive to systems effects. In the Ames case, project consultants over-estimated MSW generation in the RDF plant's service area; as a result, per-ton operating costs were considerably higher (and total revenues were less) than predicted, An early analysis of MSW composition and potential community participation was important in El Cerrito's decision to develop its own separate collection program. While information gathering should be geared to actual data needs, a community should develop necessary information early in the choice process.

In a similar sense, a thoughtful municipal choice process demands ongoing staff attention -- to keep local officials informed and to be sure that the evaluation process reflects community (versus private or plant investor) interests. Ames' special task force, composed of city staff and officials, served this function; so too did the El Cerrito solid waste advisory committee.

There is a tendency in defining and evaluating resource recovery options for a community to seize the first project that comes along. The necessary preoccupation with implementation issues reinforces this tendency, with the result that other, possibly better, options are never explored. This happens in terms of defining resource recovery technologies, available sites, material and/or energy buyers, equipment vendors, and so forth. In North Little Rock, for example, the city compared only one proposal -- the USR-Koppers modular incinerator proposal -- to the landfilling option. Communities should, if at all possible, define their options more broadly and not foreclose choices too soon.

Similarly, communities should be sure that analyses of resource recovery options are impartial, and sensitive to local needs and objectives. In North Little Rock and, to a lesser extent, Ames, feasibility studies of the preferred option were performed by private firms with a direct interest in seeing the option implemented. The usual paradox is present: often, only firms with experience in the design and operation of resource recovery projects are competent to evaluate the proposed option(s). This problem is less apparent for low-technology systems, whose assessment does not demand sophisticated technical skills.

A community should promote public participation in the resource recovery choice process. This is important for both low and high-technology approaches, but for different reasons. Source separation and recycling require extensive household involvement, and early public input is the first step in publicizing and promoting a low-technology approach. High-technology systems are, of course, capital intensive (and/or require long-term commitments), and resource commitments of this size often require public approval of some sort. Formal voter approval was not necessary in either Ames or North Little Rock, but in both cases there was little or no community opposition.

Finally, communities should bear in mind that any resource recovery strategy must be integrated with the existing solid waste management system already in place. In

El Cerrito, the cooperation of the city's franchised collector was considered relevant to the development of its separate collection program. North Little Rock found it necessary to reform city collection practices to provide its energy recovery plant with a dependable supply of MSW. In evaluating resource recovery options, municipalities should examine their compatibility with other MSW management activities -- MSW storage, collection, and disposal.

In the years ahead, resource recovery will assume increasing importance as the costs of traditional solid waste disposal methods increase and as their various impacts become more apparent. Federal and state government can develop policies which create various incentives and disincentives, and thus hasten the trend, but decisions to implement resource recovery will be made at the local level -- either by initiating projects or by participation in regional or private projects. Municipalities will be faced with specific resource recovery options, not generic approaches. The local decision, while responsive to state and federal policy, should be based on local conditions and criteria.

Notes

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GLOSSARY AND ACRONYMS

BTU: British thermal unit, a measure of energy.

Centralized MSW processing: centralized separation and recovery for use or recycling of materials and/or energy contained in mixed MSW.

DEQ: Iowa Department of Environmental Quality.

DPCE: Arkansas Department of Pollution Control and Ecology.

Energy recovery: A resource recovery process in which part or all of MSW is recovered as a fuel, or burned to produce steam for heating or electricity.

EPA: U.S. Environmental Protection Agency.

GHDR: Gibbs, Hill, Durham, and Richardson, Inc., of Omaha, Nebraska.

High-technology: In the context of resource recovery, any centralized facility processing mixed MSW to recover energy and/or materials.

ISU: Iowa State University.

Low-technology: In the context of resource recovery, a process for materials recovery which relies on the source separation of MSW.

Materials recovery: The recovery of various materials from MSW -- using either a high or low-technology approach.

MSW: Municipal solid waste -- regularly collected solid waste from households, institutions, and commercial establishments.

Recycling: Reprocessing of used products into new basic materials, in which the identity and utility of the original product is lost. Usually refers to low-technology systems.

Resource recovery: Processes for recovering useful energy and/or recyclable materials from mixed or separated MSW; includes both high and low-technology approaches.

RPA: Resources Planning Associates, Boston, Massachusetts.

SCA: Service Corporation of America.

Separate collection: Regular collection of waste products that are segregated according to material type.

Source spearation: Household separation of recyclable materials from other MSW prior to recycling.

SWMB: California State Solid Waste Management Board.

TPD: Tons per day (similarly, TPM is tons per month and TPY is tons per year).

USR: U.S. Recycle, a franchised vendor of Consumat equipment.