Municipal Solid Waste

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FOREWORD

As the nation's cities enter the 1980s, they face new problems in managing solid waste. Landfill sites are no longer easy to obtain. As we learn more about the value of certain habitats and the need to prevent air and water pollution, various sites once commonly used for disposal—wetlands and floodplains, for example—must be ruled out. Local residents oppose other proposed new sites because they will bring traffic, noise, odors, and other kinds of environmental degradation to their neighborhoods. Disposal costs are rising. Yet the amount of waste that we generate continues to increase. It was up 10 percent per capita in the last decade.

A number of city managers, planners, and other officials who deal with solid waste are experimenting with new ways to turn urban trash from a liability into an asset. More than 20 cities, some with assistance from the U.S. Environmental Protection Agency (EPA), have built plants designed to convert their trash to energy. The plants range from a small 20 ton-per-day facility in Siloam Springs, Arkansas, to plants in Akron, Ohio, and Saugus, Massachusetts, capable of handling close to 2,000 tons per day. More than 40 cities are requiring residents to separate their garbage into its recyclable components—paper, cans, glass, other wastes—and are separately collecting and selling the reusable portions.

This report describes some of these efforts and discusses the changing economics and regulatory framework of solid waste disposal. These pioneering efforts to recover valuable resources from solid waste—some of them assisted by EPA and the Department of Energy—brought environmental benefits. Many helped solve the mounting problem of municipal waste disposal and also saved the taxpayers money. EPA is encouraging more efforts of this kind through planning grants to several dozen cities.

Originally published as Chapter 4 of *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* and reprinted by EPA, this report offers ideas and information useful to public officials and private citizens concerned about disposing of waste at reasonable cost and about saving landfill space, energy, and materials.

GUS SPETH, Chairman

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MUNICIPAL SOLID WASTE

Before 1970 the question of what to do with a city's waste was hardly ever asked. The answer was obvious: either burn it in an incinerator or take it to a dump.

During this decade conditions have changed. Obtaining land for dumping has become more difficult as existing sites have filled up, nearby residents have opposed new sites, and the commercial or ecological importance of places once considered convenient dump sites—such as wetlands—has been recognized. At the same time, the total amount of waste has been increasing. Municipal waste, which rose at a rate of 5 percent a year from 1960 to 1970, slowed to a rate of about 2 percent a year from 1970 to 1978, but is still on the upswing. In fact, as Figure 4–1 shows, residential and commercial gross discards rose in every year of this decade except 1974 and 1975, both recession years. Total U.S. municipal waste was estimated at 154 million tons for 1978, the equivalent of 1,400 pounds per person.

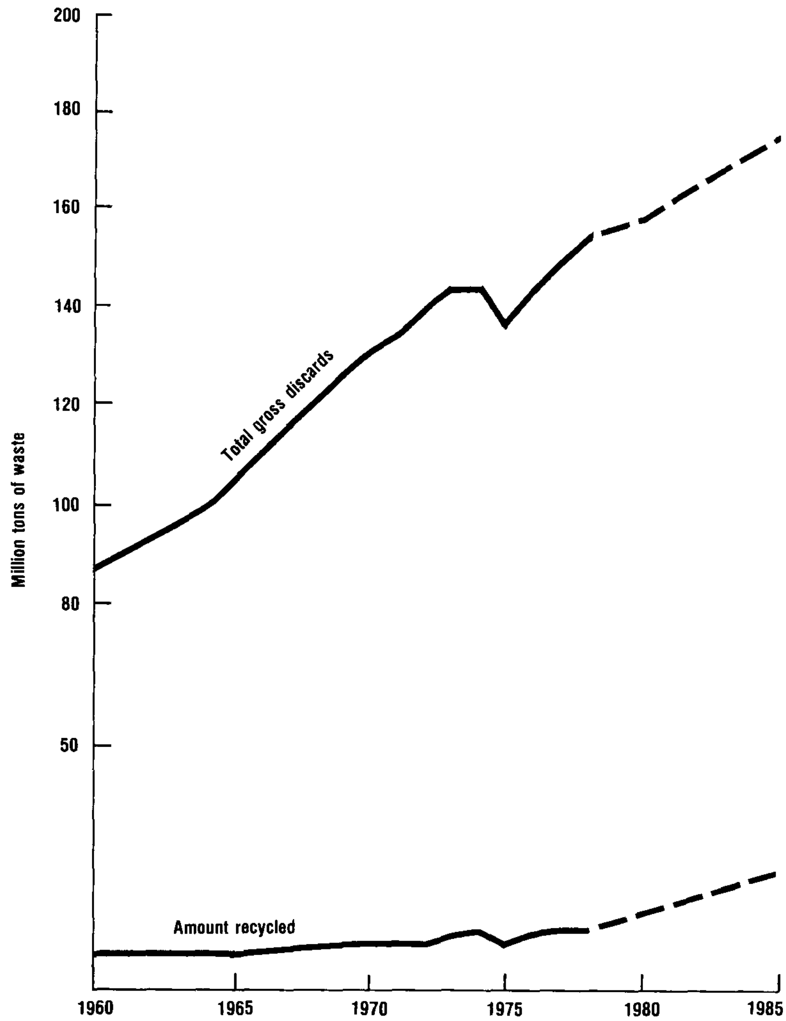
The amount of municipal waste generated per person also increased overall for the decade, declining somewhat during 1974 and 1975, but then rising again to an average level of 3.85 pounds per day in 1978 (see Figure 4–2). The rate of increase per person for the period 1970 to 1978 averaged approximately 1 percent annually. During this period, labor and equipment costs associated with waste disposal also rose.[1]

As the economics and politics of waste disposal have changed, so has environmental awareness. Solid waste disposal is now coming under much more stringent regulation than in the past. The Resource Conservation and Recovery Act,[2] passed by Congress in 1976, set as an objective the complete elimination of open dumps and the upgrading of other waste disposal practices. It offered federal help to states to create waste management plans and to bring waste disposal systems up to federal standards. These changes could easily double the cost of landfilling wastes in many areas.

Squeezed by increasing amounts of waste, disappearing disposal sites, and tightening restrictions on use of the sites, many local government officials and businesses involved in solid waste disposal have begun to consider alternatives to disposing of wastes in sanitary landfills. Municipal trash, after all, contains many potentially useful items.

Figure 4–1

Estimated U.S. Post-Consumer Solid Waste Generated and Recycled, 1960–85[a]



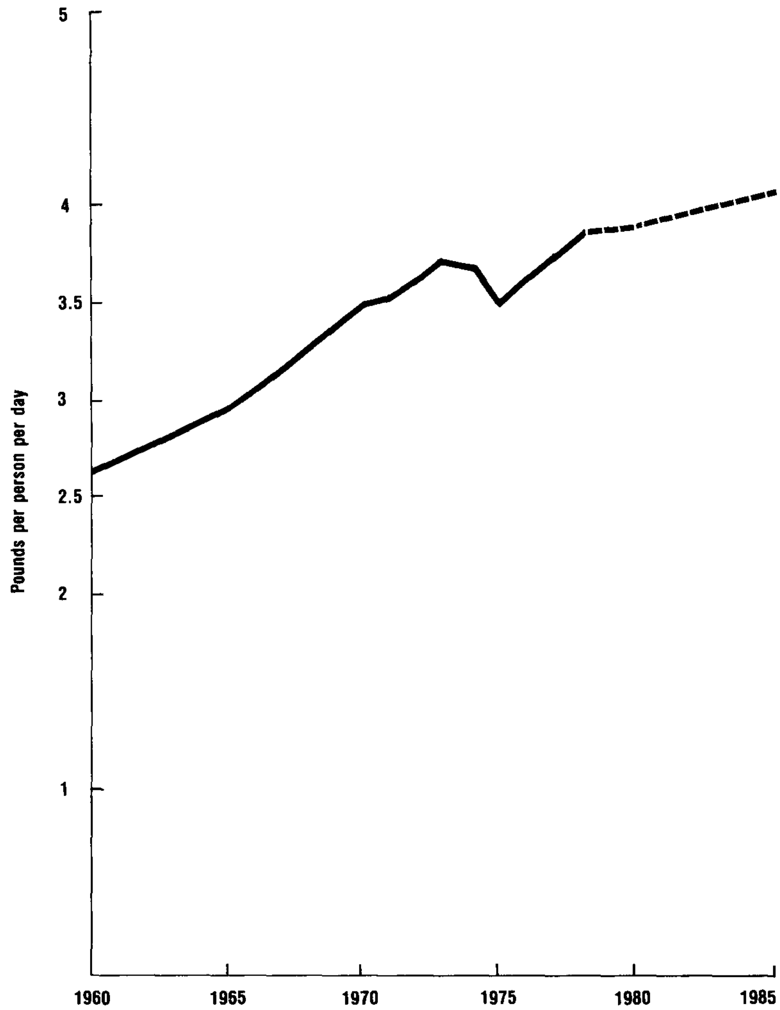
[a]Projections assume no major new federal policies to reduce waste generation

Source: Analysis by Franklin Associates, Ltd for U.S. Environmental Protection Agency, Office of Solid Waste.

Newspapers, aluminum and steel cans, glass bottles, and rubber tires can all be reused, either as is or after reprocessing. Food wastes have potential value as compost. A wide variety of components, including paper, food, and yard wastes, can be burned to make energy—a fact of great importance in a world of rapidly rising energy prices. (The

Figure 4–2

Estimated Average Individual Waste Generation, 1960–85 [a]



[a]Projections assume no major new federal policies to reduce waste generation.

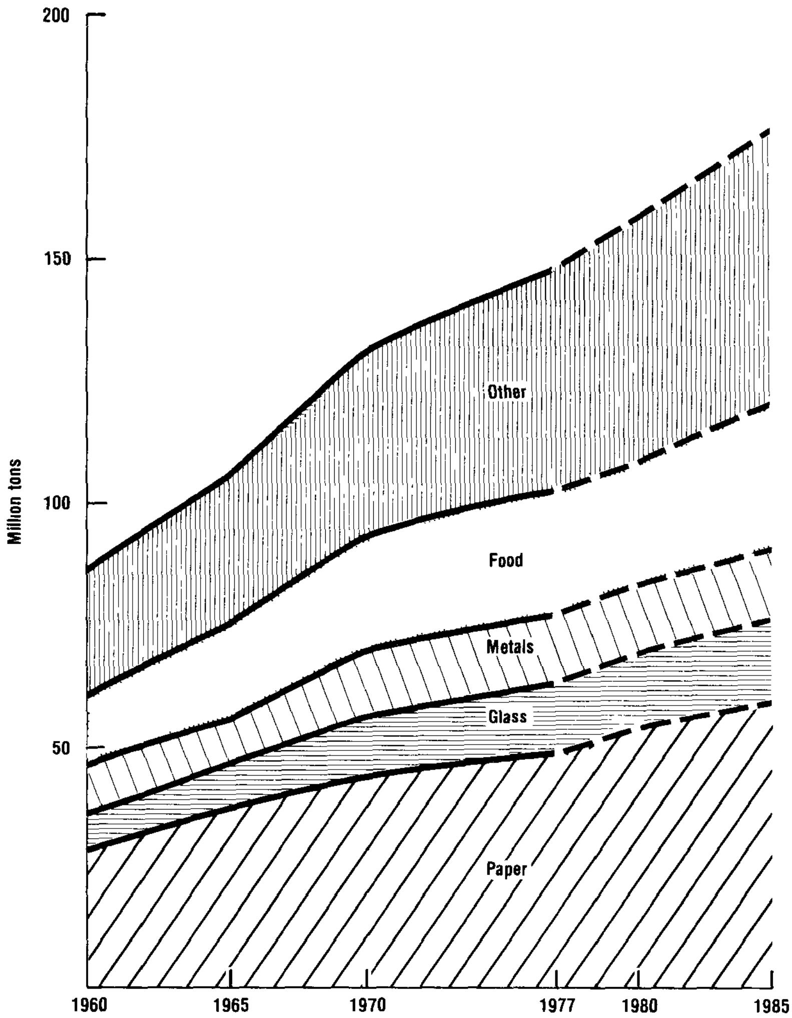
Source. Analysis by Franklin Associates, Ltd. for U.S. Environmental Protection Agency, Office of Solid Waste.

estimated composition of the nation's municipal waste for the period 1960 to 1985 appears in Figure 4–3.)

Two of the cities that showed an early interest in recycling were St. Louis, Mo., and Denver, Colo. In St. Louis, the U.S. Environmental Protection Agency (EPA) and the Union Electric Co., a private utility, began operating a small pilot plant for recovering

Figure 4–3

Estimated[a] Generation of Residential and Commercial Post-Consumer Solid Waste, by Material, 1960–85



[a]Projections assume no major new federal policies to reduce waste generation.

Source Analysis by Franklin Associates, Ltd for U.S Environmental Protection Agency, Office of Solid Waste.

recyclable materials and energy from municipal wastes in 1972.[3] By 1976, the success of the pilot project had convinced Union Electric and city officials that it was time to mount a major resource recovery effort. Union Electric proposed building a trash-to-energy plant that would be more than 30 times larger than the test facility, with the capacity to handle all the solid waste from the city of St. Louis as well as some from surrounding counties— 8,000 tons per day.[4]

Shredding machines would tear the tons of garbage into inch-long pieces. Magnets would extract the iron. Blowers would separate out the lighter, burnable portion (paper, food wastes) from the heavier glass and other nonburnable materials. The burnable fraction would then be fed, together with coal, into Union Electric's boilers. The plant would generate 5 percent of the electricity for Union Electric's service area, which includes most of the eastern half of Missouri as well as parts of Illinois and Iowa.[5]

At about the same time, the Director of Public Works of the suburban community of Northglenn, Colo., near Denver, proposed quite a different approach, based on household separation of wastes and biological decomposition processes. Residents would be asked to sort their garbage into glass, cans, newspapers, and organic wastes (food, grass clippings, etc.). The organic material, together with manure from farms in the area, would then be fed into anaerobic digesters where bacteria would convert the wastes into natural gas (methane) and a sludge. The sludge, and possibly the newspapers, would be fed to earthworms, and the earthworm castings marketed as potting soil.[6]

The proposals developed for these two cities exemplify the two basic alternatives for recycling solid waste: source separation, which is based on sorting of trash in the home or business and appropriate reuse of its various components; and centralized resource recovery, which usually involves burning trash at a central facility for its energy value and may also include separation of some components for recycling.

Each approach has its advocates. Source-separation enthusiasts argue that their method is highly energy-efficient because people rather than machines separate components; that it is easy to implement; and that centralized systems are impractical and unreliable because their massive size and technological complexity make them prone to breakdowns and failures. Centralized-system proponents argue that it is source separation that is impractical and unreliable, depending as it does on cooperation from the general public, and that central systems can provide a significant new source of energy. Some people have also argued that the two approaches are incompatible, alleging that institution of a centralized plant would preclude neighborhood recycling efforts or efforts to reduce the total amount of garbage generated. The economics of the central facility, it is claimed, depends on having large amounts of garbage to process.

Happily, evidence is accumulating that the two approaches are not incompatible except, perhaps, in their extreme applications. A 100-percent-effective bottle, can, paper, and compost recycling program might be incompatible with an extremely high-technology facility designed to separate glass, steel, and aluminum trash and make methane or artificial oil from the residue, because the central plant would lack the necessary raw materials. However, as a practical matter, neither a 100-percent-effective recycling program nor a high technology trash-to-gas resource recovery plant has yet been

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shown to be a realistic option. No example of either one exists anywhere in the country today, despite numerous attempts. As we shall see, neither the St. Louis nor the Northglenn projects cited above actually proceeded as planned, in part because they were too ambitious. On the other hand, reasonably effective recycling programs are possible and are compatible with most of the simpler resource recovery systems. Indeed, for a variety of reasons discussed below, they should enhance or complement each other's effectiveness.

BACKGROUND: FACTORS AFFECTING RESOURCE RECOVERY

POTENTIAL FOR RESOURCE RECOVERY

Recovery of energy and materials from municipal solid waste is not a new idea. European countries began recovering energy from urban wastes after World War II, when it became apparent in many cities that garbage would have to be incinerated to conserve landfill space. By 1977, Denmark was converting 60 percent of its wastes to energy, Switzerland 40 percent, and the Netherlands and Sweden each 30 percent.[7]

The United States, by contrast, converted less than 1 percent of its municipal wastes to energy in 1977. Even optimistic projections show that figure rising to just 10 percent by the late 1980s.[8] In 1977, another 7 percent of the nation's municipal solid waste was being recovered for its material value by recycling centers and other source separation programs.[9] Estimated rates of resource recovery for the period 1960 to 1977 are shown in Table 4–1, together with projections for 1985, assuming a continuation of present trends.

The potential for "mining the trash" for materials and energy is very large. The composition of municipal trash, on a percentage basis, is indicated in Table 4–2. The amount of paper and glass in municipal waste is equal to more than two-thirds of the annual national consumption of these materials.[10] Likewise, the amount of aluminum in wastes is more than one-fifth of national consumption.[11] The Department of Energy (DOE) estimates that 200 million tons of municipal solid waste, the amount now projected for 1990,[12] plus another 14 million tons of sewage solids, represent a total recoverable Btu content of 2 quads.[13] (A quad is one quadrillion British thermal units, or Btus; total U.S. energy use in 1978 was approximately 78 quads.) Recovery of metals and glass in waste would save an additional quad because it takes less energy to recycle these materials than to process them from virgin ores. According to DOE, waste-to-energy technologies that are already available could recover about two-thirds of the potentially recoverable energy resources in wastes.[14]

ECONOMICS OF WASTE DISPOSAL

Until very recently, the cost of land disposal was low enough and land for this purpose plentiful enough that local governments had

Table 4–1

Estimates and Projections of Recovery of Residential and Commercial Post-Consumer Solid Waste, Selected Materials, 1969–85

(in thousands of tons, as-generated wet weight)

Material	1960	1970	1977	1985
Ferrous metals				
Source separation	—	—	35	50
Magnetic separation [a]	50	150	200	200
Mixed-waste processing	—	—	50	400
Total	50	150	285	650
Aluminum				
Source separation	—	10	140	225
Mixed-waste processing	—	—	—	5
Total	—	10	140	230
Paper				
Source separation	5,575	7,115	10,180	12,150
Glass				
Source separation	100	160	500	865
Mixed-waste processing	—	—	—	5
Total	100	160	500	870
Rubber				
Source separation	330	255	160	170
Total Materials Recovery				
Source separation	6,005	7,540	11,015	13,460
Magnetic separation [a]	50	150	200	200
Mixed-waste processing	—	—	50	410
Total	6,055	7,690	11,265	14,070
Energy recovery from combustibles	—	—	750	9,400
Total recovery	6,055	7,690	12,015	23,470
Total gross discards	87,000	131,000	148,000	175,000
Percent recovered	7	6	8	13
Percent source separated	7	6	7	8

[a] Includes systems magnetically separating ferrous scrap, but doing no other resource recovery.

Source: Franklin Associates, Ltd., "Post-Consumer Solid Waste and Resource Recovery Baseline," prepared for the Resource Conservation Committee (Washington, D.C., April 6, 1979), p. 21.

little incentive to recover energy or useful products from solid waste. In 1978, municipal solid waste in the United States was being sent for disposal to 18,500 sites covering a total of 500,000 acres.[15]

In recent years, however, public opposition to new disposal sites has become a major hindrance to sanitary landfill. A 1978 study of 23 cities reported "moderate" or "severe" public opposition to new disposal sites in two-thirds of the localities contacted.[16]

Public concern, coupled with rising labor, equipment, energy, and environmental control costs, has caused cost increases for waste disposal in many areas to become acute. By 1978, the average cost of solid waste collection and disposal was estimated at more than $25 per capita, or about $43 per ton.[17] The cost of land disposal alone

Table 4–2

Estimated Composition of Residential and Commercial Post-Consumer Solid Waste, 1977

(as-generated wet weight in millions of tons and percents)

Materials	Millions of Tons	Percent of Total
Paper	49.5	33.5
Glass	14.7	9.9
Metals	13.6	9.2
Ferrous	(11.8)	(8.0)
Aluminum	(1.4)	(0.9)
Other nonferrous	(0.4)	(0.3)
Plastics	5.3	3.6
Rubber & leather	3.9	2.6
Textiles	3.0	2.0
Wood	4.7	3.2
Total nonfood products	94.7	64.0
Total nonfood products	94.7	64.0
Food waste	25.2	17.0
Yard waste	25.9	17.5
Miscellaneous inorganics	2.2	1.5
Total generation	148.0	100.0

Source: Franklin Associates, Ltd., "Post-Consumer Solid Waste and Resource Recovery Baseline," prepared for the Resource Conservation Committee (Washngton, D.C., April 6, 1979), p. 11.

(excluding collection costs), according to a 1974 survey, the most recent data available, averaged $4.62 per ton nationally, ranging from less than $1 per ton to $19.60 per ton.[18] It is estimated that inflation had raised these costs to $5.39 per ton, on the average, by 1978.[19]

IMPACT OF NEW ENVIRONMENTAL CONTROL REGULATIONS

One of the most important factors now affecting local government decisions on solid waste is new environmental control regulations. The Council of Environmental Quality (CEQ) estimates that compliance with existing and proposed environmental standards for municipal solid waste disposal will increase annual disposal costs by about $700 million annually, or about $4.50 per ton on a national average. The average cost of disposing of a ton of waste at a sanitary landfill will thus almost double. A majority of the increase can be attributed to proposed federal criteria for sanitary landfills although a substantial portion is still due to existing state standards with which localities have yet to comply.

These cost increases will occur gradually between now and the mid-1980s, as the planning and enforcement mechanisms set in motion by the 1976 Resource Conservation and Recovery Act go into effect. The Act requires states to set up solid waste management plans in order to receive certain kinds of federal aid. It also prohibits open dumping except under a timetable or compliance schedule established under an approved state plan. EPA was assigned the task of developing guidelines in both these areas. The agency issued guidelines for evaluating the acceptability of state plans in July 1979.[20] EPA has also been working on precise criteria for states to use in determining which disposal facilities are acceptable and which should be classified as open dumps. After much debate, classification criteria were proposed in February 1978.[21] They were scheduled to become final in September 1979.[22]

The criteria to be used in identifying "open dumps," known as the "Criteria for Classification of Solid Waste Disposal Facilities," will be far-reaching in their effect. They were proposed under both the Resource Conservation and Recovery Act (RCRA) [23] and the Clean Water Act of 1977 [24] because of similar objectives outlined in both laws.[25] They define acceptable and unacceptable disposal facilities in terms of effects on surface and ground water, air quality, and public safety, as well as in terms of use of a cover material. Facilities that allow open burning or facilities sited in wetlands, floodplains, habitats of endangered species, or recharge zones for principal sources of local drinking water are generally defined as unacceptable under these regulations and will have to be phased out.[26]

In addition, the RCRA also required EPA to develop guidelines for environmentally sound management of solid wastes for states to use as standards. A portion of these guidelines, those pertaining to landfill disposal practices and procedures, were proposed in March

Under the Resource Conservation and Recovery Act, open dumps will have to be phased out. Photographer: Milton Baron.

1979.[27] Final issuance is planned for January 1980.[28] They specify practices to be used to prevent ground water pollution, for example, and to prevent explosions and fires from gas generated by natural decomposition processes.[29]

As of March 1979, all states had taken the first step toward participation in the federal program, namely that of designating a particular state agency to develop a state solid waste disposal plan.[30] The states are now expected to identify, in phases, environmentally unacceptable dumps and to upgrade or phase them out within 5 years from the date of identification.

Many localities are aware of the content of these guidelines and are coming to grips with the fact that as a result they will probably be paying more for landfilling and, in some cases, may simply have no environmentally acceptable landfill site. In the latter case, resource recovery may be a necessity because incineration, the only other alternative, is generally more expensive. However, even if an environmentally sound landfill site is available, resource recovery may prove preferable from an economic point of view. There are two basic approaches to resource recovery: source separation for recovery of materials and centralized waste processing for recovery of energy.

SOURCE SEPARATION

EXISTING PROGRAMS

Source separation programs take a number of forms. Cities collect newspapers, for example, and occasionally glass and cans. Private dealers collect high-quality office paper waste and computer cards. Companies sponsor programs for aluminum can collection, and community groups man drop-off centers for paper, glass, and cans. In 1978, 40 cities had some kind of separate collection program for the full gamut of recyclables, and another 196 collected newspapers. More than 3,000 independent voluntary community recycling centers were in operation, concentrated in California and the Northeast.[31] EPA has estimated that more than 500 offices have paper recycling programs.[32]

EPA gave source separation programs direct encouragement in 1976 when it issued guidelines requiring all federal offices with 100 or more employees to set aside waste paper for recycling.[33] The same guidelines required federal facilities housing 500 or more families, such as military bases, to recycle newspapers. In March 1979, 175,000 federal employees working in 135 facilities were participating in the program and another 100,000 workers were expected to be covered by the end of the year.[34] About 15 state governments were carrying out office source separation programs for waste paper recovery as of May 1978.[35]

At present, paper products—office paper, newsprint, cardboard, etc.—are the materials that are recycled most. Paper accounts for

Many government and private offices separate paper from other wastes for recycling. Photographer: *Daniel Brody.*

90 percent, by weight, of the materials recovered through source separation.[36] Approximately 20 percent, by weight, of all discarded paper products are recycled.[37]

Recently, the aluminum industry has stepped up its efforts to recover more aluminum because recycling requires only about one-twentieth of the energy needed to produce aluminum from virgin sources.[38] One out of four aluminum cans is now recycled, and it is estimated that 10 percent of all post-consumer aluminum waste is recovered.[39]

The opposite trend is evident in the glass industry. As recently as 1950, 99 percent of all soft drink and 70 percent of beer containers were returnable bottles.[40] Soft drink bottles averaged 40 trips before being discarded. Today, only 25 percent of soft drink and beer bottles are returnable.[41] Altogether, only 3 percent of the glass in municipal trash is recovered through source separation programs.[42] The rate of recovery for iron is even worse: only 2 percent of all iron-bearing municipal waste is reclaimed through source separation or any other recovery technology.[43]

EPA has estimated that a maximum feasible source separation effort nationwide could result in the recycling of about 25 percent, by weight, of total gross discards.[44] Based on projected gross discards of 175 million tons by 1985, a national source separation effort could yield 40 to 45 million tons of paper, metal, glass, and rubber for recycling. However, as discussed below, some towns have been able to cut their wastes by as much as 50 percent, by weight, through recycling.[45]

ADVANTAGES

The main advantage of source separation is that it yields high-quality waste products that can command a relatively high price in the secondary materials market. It is the only proven method for recovering recyclable newspaper, office paper, corrugated cardboard, color-sorted glass, plastics, and rubber from municipal solid waste, and it is still the best method of recovering aluminum.[46]

Another advantage of source separation is the relative ease with which a program can be started, especially compared with centralized waste processing. Source separation requires minimal capital investment, in many cases less than $50,000 (see Table 4–3). The basic costs are for a warehouse to collect sorted wastes, and, in some cases, for purchase or modification of collection vehicles, as opposed to construction of a large factory complex involving complicated shredding machinery, conveyors, and boilers. Source separation systems may be as large or small as desired. Another advantage is that they consume little energy, other than human, in operation. They may thus be the only practical choice for communities that want a resource recovery system but are too small or remote to build or adequately supply a centralized processing plant.

Table 4–3

Capital Costs for Seven Municipal Source Separation Programs

Municipality	Population Served	Year Built	Capital Cost, Source Separation Facilities (in dollars)
Somerville, Mass.	90,000	1975	$41,000
Marblehead, Mass.	23,000	1975	40,000
Nottingham, N.H.	1,200	1973–75	42,600 [a]
University of New Hampshire Regional Center	49,100	1974	104,000
Swanzey, N.H.	4,900	1975	39,700
Plymouth, N.H.	3,200	1976	201,000 [a]
Meredith, N.H.	3,800	1976	100,200 [a]

[a] Includes some costs related to site preparation and construction of enclosure for incinerator.

Source: U.S. Environmental Protection Agency, 4th Annual Report to Congress, *Resource Recovery and Waste Reduction* (Washington, D.C., August 1, 1977), p. 34; and Tichenor and Jansen, *Recycling as an Approach to Solid Waste Management in New Hampshire* (Durham, N.H.: University of New Hampshire, June 1978).

These very attractive features of source separation programs have led not just municipalities, but also many public-spirited citizen groups, to establish recycling centers across the country. Unfortunately, many such projects have failed, for the simple reason that the costs of running the program, however low, are still more than can be consistently covered by revenues in the rapidly fluctuating secondary materials market. Source separation still cannot be counted on to be a moneymaker. Such programs are attractive to municipalities at this time because they provide a less costly way of getting rid of some waste than trucking it to, and burying it in, a landfill site. Even so, to make a source separation program work, municipalities must solve two potential problems: insuring adequate public participation and finding secure markets.

PUBLIC PARTICIPATION RATES

A key obstacle to instituting a municipal source separation program is uncertainty as to its effectiveness. Source separation programs depend heavily on public cooperation for success. Under the right circumstances, public participation rates can be very high. For example, in the small town of Nottingham, N.H., (population 1,200) a source separation program was instituted in 1974 by town ordinance after environmental regulations required closing of the town dump. A study made 3 years later showed that townspeople were recycling 97 percent of the glass, 93 percent of the cans and other metal, and 85 percent of the newspaper (by weight) in their garbage.[47] This meant that the total amount of waste that the town had to incinerate and landfill was cut in half.[48]

The success of this program has been attributed in part both to the manner of its beginning and to the continuing information and education efforts during its operation. The plan was not "imposed from above" by town officials, but rather was adopted, after much public discussion, by a community vote. Compartmentalized waste containers were offered free to anyone wanting them, and more than half the households did. The town sent at least one mailing per year explaining to residents how the system worked and describing its accomplishments.[49]

Source separation programs have been less successful when they are a voluntary adjunct to the main refuse disposal system, rather than an integrated part of it, required by ordinance. EPA reports that voluntary recycling centers on the average reduce the total amount of waste going to disposal in the community by only 1 percent,[50] although some do much better. For example, almost 15 percent of the wastes in Berkeley, Calif., are taken to voluntary community recycling centers.[51]

Socioeconomic factors may also play a role in levels of participation, although very little data exist on this subject, and what evidence there is is far from conclusive. Beginning in 1976, EPA sponsored experimental source separation programs in two Massachusetts communities: Marblehead, a relatively affluent suburb, and Somerville, a blue-collar, densely populated urban community. The towns were motivated to try the programs for similar reasons: high disposal costs—$18.95 per ton and $14.75 per ton, respectively—paid to landfill operators to get rid of their wastes.[52] If the total volume of waste could be reduced and a portion of it sold for reuse, the savings would be considerable.

Both towns passed local ordinances requiring source separation, and both obtained favorable contracts for the sale of recovered materials. Marblehead residents were asked to separate wastes into four categories, Somerville into three, and recyclable wastes were

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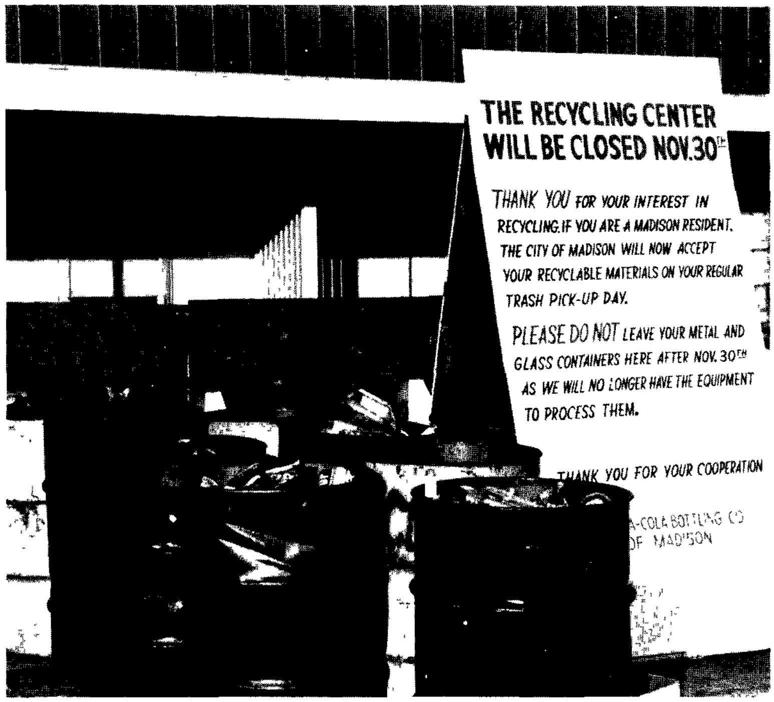


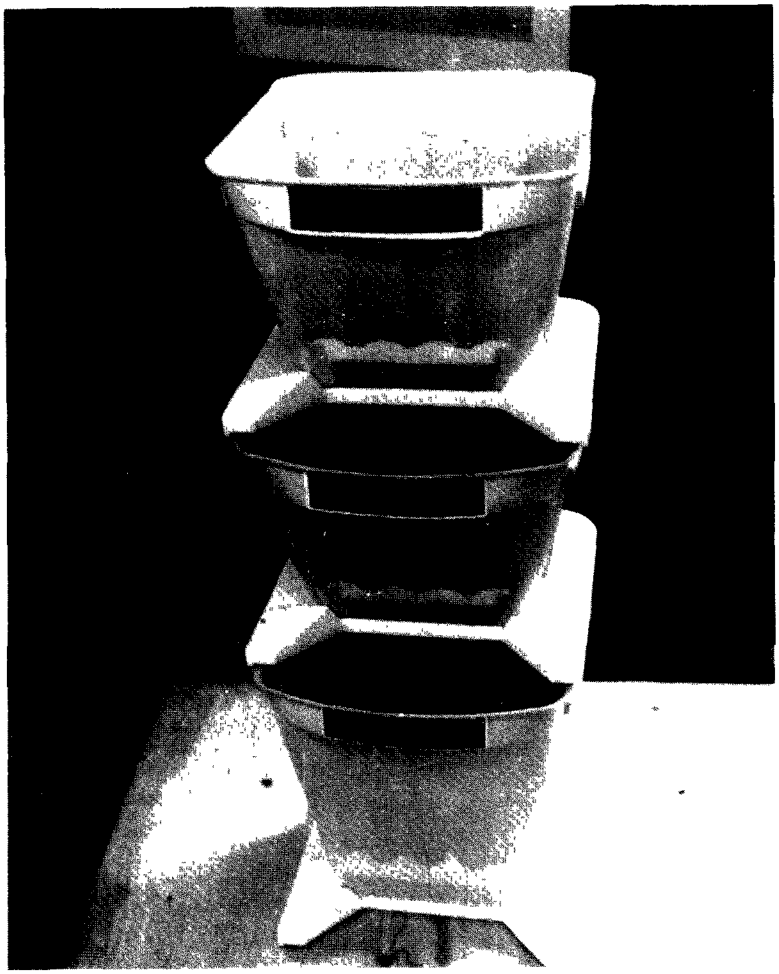
Integration of source separation into a city's main refuse disposal system generally results in higher participation rates. Photographer: Daniel Brody.

picked up weekly in both towns by compartmentalized garbage trucks.[53]

The results in the two towns differed significantly. In Marblehead, with an estimated 75 to 80 percent of households participating,[54] the town reduced its total amount of solid waste by 23 to 33 percent during the first 9 months of the program.[55] Somerville, with somewhat lower participation, reduced its solid wastes by 7 to 10 percent.[56] During this period, Marblehead's net savings, counting money not spent on landfilling as well as revenues from materials sales, were approximately $3,000 per month. Even at its lower participation rate, Somerville's net savings in some months ran as high as $1,700, but overall the town approximately broke even for the 9-month period.[57]

The Somerville program was discontinued within the year. According to EPA, its demise was due partly to political problems between the mayor and the sanitation union that produced strikes and disrupted the project [58] and partly to several severe snowstorms that so taxed city manpower that wastes could not be collected separately. Both factors may have led Somerville residents to lose faith in the project. However, the Marblehead program, now in its fourth year of operation, continues to achieve a 25 percent reduction of wastes.[59]

The results of this test might seem to suggest that source separation programs do better in areas populated by relatively well edu-



Compartmentalized waste containers make household separation of wastes easier.

cated, high-income citizens. However, the experience of the town of Nottingham, N.H., a rural area with relatively low average income and education levels, contradicts this conclusion. Many other factors—from degree of public involvement in the decision to effectiveness of publicity efforts—may be important to a program's success.[60]

COST AND MARKET PROBLEMS

Besides possible difficulties with participation rates, source separation programs also face problems in keeping down costs and obtaining markets for their recycled materials. Municipal source separation programs are seldom profitmaking enterprises on the basis of the materials recovered alone. The cost of collecting, sorting, and baling the recyclables generally exceeds the revenues from their sale. Source separation is an economically viable proposition for most towns that have instituted it because it is a cheaper way of getting rid of wastes than operating a sanitary landfill or town incinerator. The costs of collection and sorting are thus balanced by revenues from sales of materials plus savings from not having to landfill these materials.

Cost factors for the town of Marblehead, which recovered about 200 tons of waste per month, are shown in Table 4–4. The table shows that, for most months, the cost of operating the source separation program ("incremental collection costs"), including capital, labor, and collection costs, after revenues from sale of recyclables are taken into account, is less than $5 per ton of recycled waste. Because Marblehead would have had to pay nearly $19 a ton to have those wastes landfilled, the source separation program was competitive with the alternative disposal method.[61] A regional source separation program serving the University of New Hampshire and several surrounding towns incurred similar costs: approximately $7 per ton of waste processed, after revenues were counted.[62] With the average cost of disposing of a ton of waste in a landfill expected to rise from around $5.50 to about $10 per ton as environmental standards tighten, source separation—even if it cannot pay for itself—should become an economically attractive disposal solution in more and more places.

Table 4–4

Marblehead Program Economics, January-September 1976

(in dollars)

Month	Incremental Collection Costs [a]	Revenues From Sales	Diverted Disposal Savings	Net Savings
January (12-31)	2,930	1,870	2,990	1,930
February	3,570	2,560	3,390	2,380
March	4,450	3,790	3,680	3,020
April	4,470	3,500	3,640	2,670
May	3,850	3,400	3,390	2,940
June	4,240	3,730	3,850	3,340
July	4,040	3,280	3,350	2,590
August	4,240	4,340	3,850	3,950
September	4,050	3,360	3,580	2,890

[a] Includes labor costs as well as operation, maintenance, and capital amortization for the compartmentalized trucks and all other equipment added as a result of the source separation program.

Source: U.S. Environmental Protection Agency, Fourth Report to Congress, *Resource Recovery and Waste Reduction* (Washington, D.C.: U.S. Government Printing Office, August 1, 1977), p. 35.

The major operating costs of a source separation program are generally collection of the separated wastes, and operation of the reycling center. Collection may be made either by separate trucks (in which case extra workers may have to be hired to make the rounds) or by normal garbage collection, with modified trucks. The latter option is generally cheaper, but problems can develop because progress over a route is slower, or because one truck compartment fills up faster than another.[63] Collection problems can be complicated by local scavengers who sometimes take newspapers put out for municipal pickup. Several communities have had to pass anti-scavenger ordinances.

A greater source of difficulty to many programs is obtaining adequate markets for materials collected. Prices for recycled materials are subject to wide and sudden swings. It is, therefore, critical to the success of any recycling program to develop contractual arrangements for purchase of its recycled materials. Cities that pass recycling ordinances and fully integrate source separation into their waste disposal system do seem to be able to find contractors willing to guarantee them a floor price for their recyclables, generally with an escalator clause tied to spot market prices. In return, the contractor is assured a stable supply of materials delivered in a known, reliable form. Marblehead's guaranteed floor prices in 1976, for example, were $5 per ton for paper, $12 per ton for glass, and $10 per ton for cans.[64]

LONG-TERM PROSPECTS FOR MARKETS

Obviously, however, these prices are very low. At this point the likelihood of their increasing, or of U.S. industries absorbing significantly larger quantities of recyclables, is highly uncertain. Currently, most U.S. industries are set up to make their products from virgin raw materials. In the paper industry, the percentage (though not the actual tonnage) of paper products made from recycled fiber actually decreased since World War II, from 30 percent of the total in 1950 to about 22 percent in 1977.[65] According to an analysis by EPA, most paper producers favor using virgin pulp, and waste paper prices have risen dramatically only in periods when, for one reason or another, virgin pulp was in short supply.[66]

Increased paper recycling is technically and economically feasible. Only about 12 percent nationally of all newsprint is made from recycled newspapers,[67] yet one company operates three mills that make newsprint from nothing but recycled fiber. The company, Garden State Paper, supplies newsprint to the *New York Times* and *Washington Post*, among others, and was scheduled to open a new facility in Georgia in 1979. The company has shown that the recycling process can save energy and generate less air and water pollution than conventional newsprint plants.[68] Nevertheless, it appears that for the present, the amount of paper being recycled is limited not by insufficient supply, but by lack of paper industry demand.[69]

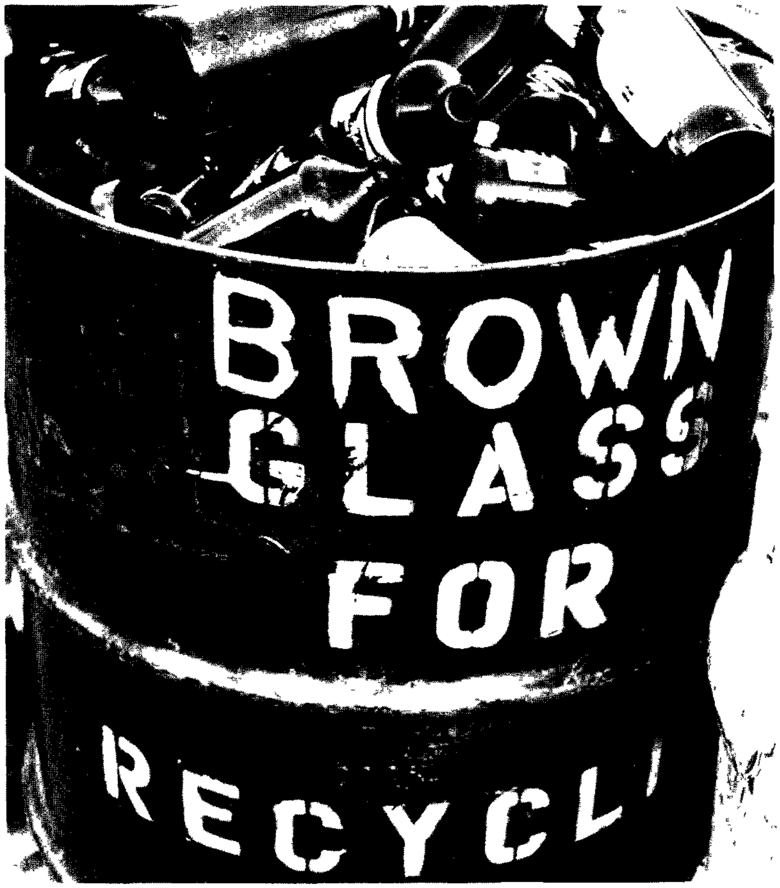
Much the same situation appears to hold true in the iron and steel industry. Less than 10 percent of all steel produced in this country is currently made from scrap steel that has gone through a cycle of use,[70] and almost all of this amount represents industrial rather than consumer waste.[71] A study conducted for the Institute of Scrap Iron and Steel indicates that at present rates of scrap use, there is a 14-

Labor costs are often a significant component of the total cost of a source separation program. Photographer: Daniel Brody.

The market for recycled iron is not strong. There is a 14-year backlog of scrap at junkyards across the country. Photographer: Daniel Brody.

year backlog of scrap iron available for recycling at junkyards and other locations around the country.[72] Steelmaking technology is such that some furnaces could accept more scrap. But using scrap adds uncertainties and potential problems to the steelmaking process in the form of possible contamination with dirt, plastics, aluminum, and other metal impurities that steelmakers would just as soon avoid.[73]

In the aluminum industry, the long-term outlook for markets for recycled materials is more encouraging. The reason is simply and clearly the energy crisis. Although it takes two to four times as much energy to make steel from virgin materials as from recycled materials,[74] it takes at least 20 times as much energy to make new aluminum as to recycle it.[75] As a consequence, the aluminum industry has been paying up to $400 a ton for aluminum cans,[76] as opposed to the $20 per ton generally offered for steel cans.[77] There are no backlogs of aluminum cans for recycling, and it appears that the industry will be willing to purchase as much aluminum as source separation systems can supply.



The market for glass may strengthen. One company has pioneered new techniques in making recycled glass. Photographer Daniel Brody.

The market in glass is nowhere near as strong, but may strengthen. At present, only 3 percent of glass production uses recycled raw materials.[78] However, one company, Glass Container Corp., has pioneered new techniques in making recycled glass and operates regularly using 50 to 60 percent consumer "wastes."[79]

For source separation to grow as a waste disposal method in the United States, long-term markets will have to be found for the systems' products. It is presently not certain whether those markets will exist in the paper, steel, or glass industries. To some extent, this is a chicken-and-egg problem. Industry spokesmen commonly cite lack of reliable sources of supply as one of the reasons for setting up their processes to use virgin rather than recycled raw materials. An analysis by the U.S. Congress' Office of Technology Assessment asserts that, at present, neither the paper nor glass industry is technically equipped to absorb the full amount of these materials potentially recoverable from municipal solid waste.[80]

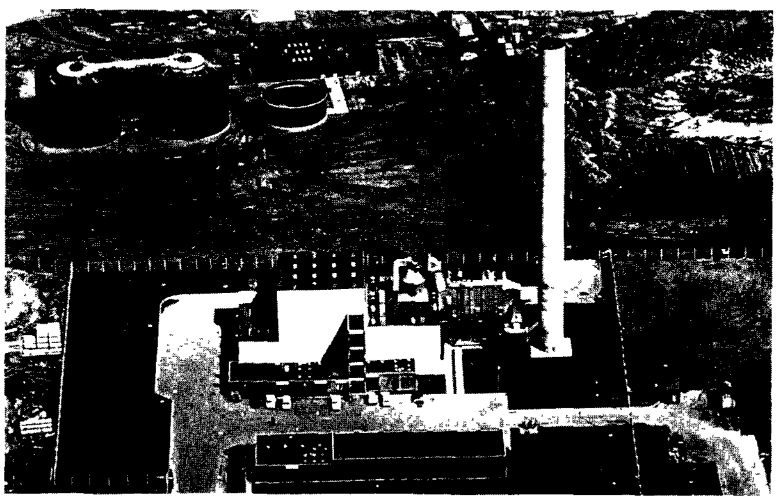
CENTRALIZED WASTE PROCESSING

CURRENT STATUS

In a central resource recovery scheme, household and commercial wastes are taken to a waste processing facility, rather than a commercial incinerator, landfill site, or recycling center. At the processing plant, the waste is generally burned and the heat energy used to make steam, which may in turn be put to a variety of uses, from space heating to industrial processes to generation of electricity. Steel cans and possibly other materials may also be recovered from the waste, either before or after incineration.

Interest in this technology began in Western Europe in the 1950s and 1960s as an adjunct to efforts to reduce waste volume via incineration. A number of these countries now feed from one-third to one-half their municipal waste through such plants.[81] The United States, with its cheaper energy prices and greater availability of land for dumping, has been slower to take advantage of the technology. Only three centralized waste processing facilities, two in New York state and one at a U.S. Naval Station in Virginia, were built in this country before 1970.[82] But interest has grown. As Table 4–5 indicates, the General Accounting Office was able to identify 20 trash-to-energy plants in operation and another 10 under construction at the end of 1977.[83] Advanced planning had been completed for 30 more, and preliminary planning had begun on another 70 facilities.[84]

As noted earlier, the 20 operating facilities process only about 1 percent of the nation's municipal solid waste.[85] If they were operating at full capacity, however, and if all 40 plants under construction or in advanced planning were complete and operating at full capacity, they could be extracting energy from about 10 percent of the



Refuse-burning district heating plant in Horsens, Sweden. Some European countries convert over a third of their municipal solid waste to energy.

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country's waste, or 18 million tons per year.[86] If all 70 plants now in the preliminary planning stage were also built, this figure could be doubled, and the nation could be processing close to 20 percent of its municipal waste.[87]

ADVANTAGES

The advantages of energy and material recovery are clear. First, the weight and volume of wastes to be landfilled is drastically reduced. Though there is some variation depending on how well non-burning materials such as glass and cans are removed, the amount left over after processing is no more than 10 percent by volume, and 25 percent by weight of the original.[88] This residue is sanitized and is largely inert.

The second important benefit of operating such facilities is the energy they can recover. Not all municipal solid waste is, from a practical point of view, available for energy recovery. EPA estimates that perhaps 75 percent of all municipal waste is generated in areas with sufficient population density that the cost of transporting wastes to a central processing facility would not be prohibitive.[89] The agency calculated in 1973 that the maximum possible energy yield from this trash was about 900 trillion Btus, or the equivalent of 424,000 barrels of oil per day. That amount is equal to about a quarter of the 1979 flow of the Alaska pipeline and is enough energy to meet the home and office lighting needs of the entire nation.[90] Total gross discards have risen by 10 percent since EPA made the estimate; the amount of energy potentially available from trash should have risen proportionally.

A third possible benefit of centralized resource recovery is its potential for producing iron, steel, aluminum, glass, and even paper from waste for recycling. Iron-bearing items, including cans, broken appliances, nails, pails, and drums, are easily removed from garbage by magnets. The technology for iron recovery is not new; it has been used for years at landfills, junkyards, and elsewhere.[91] However, as noted earlier, the current market for iron is not good.

The market for aluminum is better, but the technology for recovery in processing plants is more complex and less advanced. In the case of glass, both markets and recovery technology are poor. Various ingenious schemes involving blowers, electrical charges, and air bubbles in water have been tried for separating aluminum and glass from wastes.[92] A few such systems have been incorporated in some of the plants now operating or under construction, including those in Bridgeport, Conn.; Ames, Iowa; and Milwaukee, Wis.[93]

Both glass and aluminum recovery systems have consistently suffered from technical deficiencies—chiefly, a low recovery rate and a recovered product containing significant amounts of impurities and contaminants.[94] The Office of Technology Assessment reports efficiencies of 50 to 70 percent (see Table 4–6). In several cases, owners of installed systems have not used them because they cannot find a market for their product.

Table 4–5

Summary of Urban Waste-to-Energy Projects in the United States, in Operation and Under Construction, 1977

Project Location	Process Type	Capacity (TPD) [a]	Energy Form Produced	Other Resources Recovered	Starting Date	Market for Energy Form	Cost (million dollars)	Owner/Operator
Systems in Operation (20)								
Ames, Iowa	RDF [d]	400	RDF	Paper, Fe, and Al [b]	9/75	Ames Municipal Power Plant	6.3	City of Ames
Baltimore, Md.	Pyrolysis	1,000	Gas to steam	Fe, Glass Agr.[c]	6/75	Baltimore Gas and Electric Co.	25.0	City of Baltimore
Baltimore County, Md.	RDF [d]	400 to 1,200	RDF	Fe, Al, glass	4/76	TBD [e]	10.0	50% Baltimore County, 50% State of Md./Teledyne
Blytheville, Ark.	MCU [f]	50	Steam	None	11/75	Metal plating industry	0.8	City of Blytheville
Braintree, Mass.	RWI/WWI [g]	240	Steam	Fe	9/70	Weymouth Art and Leather Co., and Sigma Industries	3.0	City of Braintree
Chicago, Ill. (NW)	WWI	1,600	Steam	Fe	Spring 1972	Industrial park	30.0	City of Chicago
East Bridgewater, Mass.	RDF	1,200	RDF	Fe	8/76	Utility plant	14.0	East Bridgewater Associates/Combustion Equipment Assn.
El Cajon, Calif. (San Diego County)	Pyrolysis	200	Oil	Fe, Al, glass	12/77	San Diego Gas and Electric Co.	14.5	San Diego County

Groveton, N.H.	MCU	30	Steam	None	10/75	Diamond International Paper Co.	0.3	Diamond International
Harrisburg, Pa.	WWI	720	Steam	Fe	10/72	Pennsylvania Power and Light	2.8	City of Harrisburg
Lane County, Oreg. (Eugene)	RDF	500	RDF	Fe	12/77	Eugene Water and Electric and Univ. of Oregon	3.5	Allis Chalmers Corp. Western Waste Corp.
Milwaukee, Wis.	RDF	1,600	RDF	Paper, Fe, Al, glass agr.	5/77	Wisconsin Electric Power Co.	18.0	American Can Co.
Nashville, Tenn.	WWI	720	Steam	None	7/74	Building complex	26.5	Nashville Thermal Transfer Corp.
Norfolk, Va.	WWI	360	Steam	None	6/67	U.S. Navy Base	4.3	U.S. Navy Public Works
North Little Rock, Ark.	MCU	100	Steam	None	9/77	Koppers Co.	1.5	City of North Little Rock
Palos Verdes, Calif.	Methane recovery	1.1 MMCF/D	Methane gas	None	6/75	So. Calif. Gas Co.	1.5	Reserve Synthetic Fuel Co.
Portsmouth, Va.	WWI	160	Steam	Fe, Al	8/77	U.S. Navy Base	4.5	U.S. Navy
Saugus, Mass.	WWI	1,200	Steam	Fe	10/75	General Electric Co.	38.3	RESCO (Joint venture of De Matteo Construction Co. and Wheelabrator-Frye, Inc.)
Siloam Springs, Ark.	MCU	20	Steam	None	9/75	Canning plant	0.4	Town of Siloam Springs
Tacoma, Wash.	RDF	500	Steam	Fe	12/77	TBD	3.0	City of Tacoma

See footnotes at end of table.

Table 4–5 (continued)

Systems Under Construction (10)								
Project Location	Process Type	Capacity (TPD)[a]	Energy Form Produced	Other Resources Recovered	Starting Date	Market for Energy Form	Cost (million dollars)	Owner/Operator
Akron, Ohio	RDF	1,000	Steam	Fe, non-Fe	12/79	B. F. Goodrich Co., Univ. of Akron	46.0	City of Akron/ Teledyne
Albany, N.Y.	RDF	1,200	RDF	Fe	5/79	N.Y. State Office of General Services	11.0	City of Albany and N.Y. State
Bridgeport, Conn.	RDF	1,800	Powdered RDF	Fe, Al, glass	3/78	United Illuminating	53.0	Occidental Petroleum Corp. and Combustion Equipment Assn.
Chicago, Ill. (Crawford)	RDF	1,000	RDF	Fe, non-Fe	3/78	Commonwealth Edison	19.0	Commonwealth Edison
Hempstead, N.Y.	RDF	2,000	Steam	Fe, Al, color-sorted glass	5/78	Long Island Lighting Co.	81.0	Hempstead Resources Recovery Corp. (Div. Black Clawson/Parsons and Whittamore, Inc.)
Jacksonville, Fla.	MCU	50	Steam	Fe	3/79	U.S. Navy Base	2.0	Scientific Energy Engineering
Monroe County, N.Y.	RDF	2,000	RDF	Fe, non-Fe, mixed glass	Late 1978	Rochester Gas and Electric Co.	50.4	Monroe County/ Raytheon
Mountain View, Calif.	Methane recovery	1 MMCF/D	Methane gas	Fe, paper, glass	7/78	Pacific Gas and Electric	0.7	Pacific Gas and Electric

Redwood City, Calif.	Pyrolysis	100	Gas to Steam	Fe		5/78	Pacific Gas and Electric	1.0	Redwood City/Bay-side System Authority
Western Lake Superior District (N.E. Minn.)	RDF	400	RDF	Fe		12/78	Negotiating with Duluth Transit Co.	60.0	Western Lake Superior Sanitary District

[a] Tons per day.
[b] Fe=Ferrous metals; Al=Aluminum.
[c] Glass agr.=glass aggregate.
[d] Refuse-derived fuel.
[e] To be determined.
[f] Modular combustion unit.
[g] RWI=refractory wall incineration; WWI=waterwall incineration.

Source: General Accounting Office, *Conversion of Urban Waste to Energy: Developing and Introducing Alternate Fuels from Municipal Solid Waste* (Washington, D.C.: U.S. Government Printing Office, February 28, 1979), p. II–2; and Council on Environmental Quality.

Table 4–6

Material Recovery Efficiencies at Centralized Waste Processing Facilities

Material/Technology	Estimated Achievable Efficiency of Recovery Technology (in percent)
Ferrous/magnetic	90–97
Paper/wet slurry	50
Aluminum/magnet	65
Glass/froth flotation	65–70
Glass/optical sorting	50

Source: U.S. Congress, Office of Technology and Assessment, *Materials and Energy from Waste*, final draft (Washington, D.C.: U.S. Government Printing Office, June 1978), pp. 6–11.

At one test facility, the potential for recovering paper from wastes for industrial use has been demonstrated. At the EPA-sponsored facility in Franklin, Ohio, garbage was turned into a wet slurry, and paper fibers recovered from it, for use in making felt roofing shingles.[95] However, the very small output of this test facility (it processed only about 25 tons of waste a day) eventually led the shingle plant to terminate its purchasing arrangement, and in March 1979 the Franklin plant closed.[96]

Despite technical problems with glass and aluminum recovery, centralized waste processing systems seem to be eminently worthwhile methods of obtaining energy and conserving landfill space What, then, is preventing cities, utilities, and private trash disposal companies from adopting them widely and rapidly? There is no single answer, but rather a broad range of potential problems, some technological, some institutional, and some economic, that can stymie progress.

TECHNOLOGICAL BARRIERS

Technological barriers are probably the least serious obstacle to wider resource recovery at this time. Problems can be minimized by employing proven, relatively simple trash-to-energy systems now in use in both Europe and the United States. The "workhorse" of trash-to-energy is the waterwall incinerator, and 7 of the 20 operating U.S. facilities are of this type.[97] The sides of the incinerator are lined with pipes for water to pass through. When waste is being burned in the incinerator, the exhaust gases heat the water in the pipes. The hot water is used to make steam, which can then be used to heat homes or offices, generate electricity, or run industrial processes. A 1,200-ton-per-day waterwall incinerator plant in Saugus, Mass., began operation in 1976 and processes the wastes of a dozen Massachusetts communities. The plant sells steam heated to 845° F to General Electric for all three uses listed above.[98]

A second reliable technology for recovering energy from wastes is the modular incinerator. These "packaged" units are small, factory-made incinerators equipped with waste heat boilers. The boilers capture the heat from the incinerator's exhaust gases, which may then be used for the same purposes as outlined above. However, modular units are not as efficient at recovering heat as the waterwall incinerators.

The main advantages of these units are their small size and relatively low cost. This makes them suitable for small-scale and small-town use. The smallest of the waterwall facilities is a 175-ton-per-day plant operating at the U.S. Navy base at Portsmouth, Va.; however, economic concerns usually dictate waterwall plants in the 1,000-ton-per-day range. The larger size facility requires the wastes of at least half a million people to run at full capacity. However, modular incinerators processing as little as 20 to 40 tons per day have been built in such places as Siloam Springs, Ark., Groveton, N.H., the John Deere plant in Dubuque, Iowa, and at the Pentagon.[99] Four of the country's 20 municipal trash-to-energy facilities are of this type, and perhaps several dozen more such units are being employed in factories and various institutions.[100]

A third proven technology for extracting energy from garbage is to convert a major portion of the trash to a fuel that can be burned not only in incinerators but in standard utility and industrial boilers as well. This fuel has been dubbed refuse-derived fuel, or RDF.

Both waterwall and modular incinerators can handle unprocessed wastes. Garbage is simply dumped in the incinerator and burned. The leftover ash is landfilled. However, to improve efficiency, allow production of hotter steam, and permit extraction of recyclables, some American builders and operators of such systems have felt it desirable to process wastes before feeding them into waterwall incinerators. The technology for this process is fairly reliable, and involves reducing all garbage to small pieces so that nonburnable materials such as glass and metal can be removed before incineration. The size of the pieces is reduced by various processes including shredding, milling, flailing, trommeling, and screening. As of the end of 1978, no such facilities were in operation, but five were under construction.[101]

Such processed wastes can also be burned in electric utility boilers. The pioneer in this field was the EPA-sponsored facility which supplied wastes to Union Electric in St. Louis, Mo. It operated on an experimental basis for 4 years. Six of the 20 operating facilities now use this technology.[102] At the St. Louis-type plants, waste is first shredded. It then passes through blowers that separate the light materials—generally easy-to-burn materials like pieces of leaves, plastic containers, paper, and food—from the heavier materials, such as hard-to-burn items like bottles and cans. The lighter fraction becomes the RDF. At St. Louis, it was burned, together with coal, in Union Electric's boilers. The heavier portion, after recovery of iron-bearing wastes, was landfilled.[103]

A variant of this technology is production of "wet RDF." Originally tested at the Franklin plant in Ohio as a means of recovering paper fiber, it involves reducing all wastes to a wet pulpy mass. This mush is then fed into a cyclone and spun around. Centrifugal force separates the lighter from the heavier materials.[104] The lighter fraction is then partially dried and burned in specially designed boilers to produce energy.

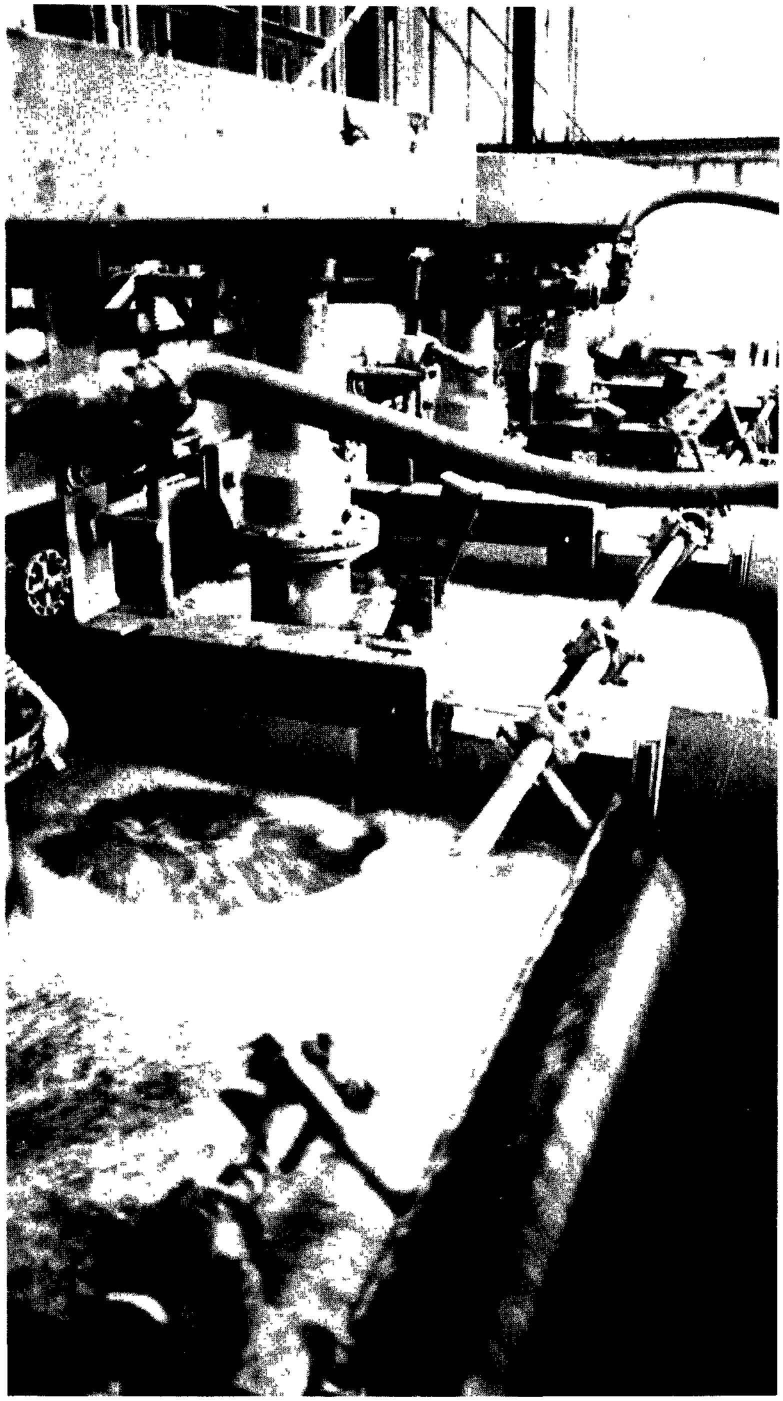
A plant that produces dry RDF, rather than one that burns waste for steam, has the advantage of making a transportable energy product that can be burned in a pre-existing energy plant. However, because dry RDF is highly flammable and subject to spontaneous combustion, it generally must be burned in the immediate vicinity of the trash-to-energy facility. This also minimizes transportation costs.

If one of these relatively well-developed technologies is not employed, serious technical difficulties are far more likely to arise. As noted earlier, systems to extract glass and aluminum from trash are desirable because they make valuable materials available for recycling, but they are hampered by technical problems. Even more serious technical problems have developed with plants designed to turn garbage into oil or gas. If these fuels could be produced successfully, they would, of course, be even more useful and versatile than dry RDF.

The city of Baltimore, with federal help, was the first to attempt to build a commercial-scale trash-to-gas plant using a technology called pyrolysis. In 1972, Baltimore contracted with Monsanto Enviro-Chem Systems, Inc., to build a 1,000-ton-per-day pyrolysis facility at a cost of $16 million. The gas produced was to be burned to make steam, which Baltimore Gas and Electric would purchase for heating and cooling large buildings in the downtown area.[105] The immediate impetus for the plant was the fact that the city's landfill capacity was virtually exhausted.[106] The federal government, through an EPA grant, contributed $7 million toward the cost.[107]

The plant, scheduled to go into full operation in 1975, has experienced an enormous number of difficulties, and 4 years later was still undergoing modifications projected to total over $4 million.[108] In principle, the plant was supposed to operate by passing wastes through a shredder and then feeding them into a large kiln, where at temperatures of 2000° F the organic material in the garbage would break down into the burnable gas.[109]

It appears that everything has broken down but the garbage. A Congressional Research Service report noted the following problems: the conveyor systems failed to function properly; the lining of the kiln broke up and fell out; a fan controlling the movement of the gases suffered uncorrectable vibration problems; the gas burner was half as big as needed; and the waste hopper did not work as designed, to a point where on at least one occasion solidified garbage had to be blasted out with dynamite.[110] The worst problem was the failure of the air pollution control system, which finally required the purchase of a new electrostatic precipitator at a cost of $1.2 million.[111]



Experimental flotation cells for extracting glass from wastes. Photographer: Perry Bagalman.

Despite its problems, the plant had, by early 1978, processed 70,000 tons of waste in the course of its intermittent operation. It had also generated 250 million pounds of steam that sold for $750,000.[112] According to EPA, the plant, as of May 1979, had completed modifications and was just beginning new test operations.[113]

Another attempt at a pyrolysis plant was that undertaken by San Diego County and Occidental Petroleum, with EPA assistance. The plan was for a 200-ton-per-day plant to convert waste to a form of oil through a "flash" pyrolysis process. The plant, completed in 1976, was designed to shred wastes to dust-like fineness and then heat them to 900° F in less than 2 seconds in a vertical shaft.[114]

Shakedown operations, begun in December 1977, ran into numerous mechanical problems.[115] As of mid-1979 the plant's future was uncertain. This plant was designed to be a test facility and, according to the Congressional Research Service (CRS), requires sophisticated personnel to run it. The CRS feels that a facility of at least 1,000-ton-per-day capacity, costing about $50 million, would be required for it to be economical.[116]

Another drawback of these complex processing systems, beyond the technical difficulties, is that the net energy recovered decreases as the amount of processing increases, because of the additional energy requirements. As Table 4–7 indicates, solid refuse-derived

Table 4–7

Comparison of Energy Recovery Efficiencies for Selected Solid Waste Energy Recovery Processes

(percent of higher heat value contained in input solid waste)

Process	Net Energy in Fuel Produced [a]	Net Energy Available as Steam [b]
Fluff RDF	[c] 70	[c] 49
Dust RDF	80	63
Wet RDF	76	48
Waterwall combustion furnace	—	59
Modular incinerator	—	[c] 25–50
Purox gasifier	64	58
Monsanto gasifier	78	42
Torrax gasifier	[c] 84	[c] 58
Occidental Petroleum Co. pyrolysis	26	23
Biological gasification [d]	[c] 33	[c] 29

[a] *This is the higher heating value of the fuel product less the heat value of the* energy used to operate the system (in the case of electric power consumption it was assumed that the electricity was produced on site using the system's fuel product), expressed as a percent of the heat value of the solid waste.

[b] In order to compare all the processes on an equal basis, the net energy available as steam was calculated using the boiler efficiency for each fuel product.

[c] Updated figure drawn from U.S. Congress, Office of Technology Assessment, *Materials and Energy from Waste,* final draft (Washington, D.C. June 1978), pp. 6-12.

[d] Includes energy recovered from sewage sludge.

Source: U.S. Environmental Protection Agency Publication SW-157.2, 1976. All calculations based on solid waste input at 5,000 Btu per pound (higher heating value) with some inorganic materials removed.

fuel that is produced by mechanical means is more energy-efficient than liquids and gas from pyrolysis. But the gas or liquid produced would be expected to sell for a higher price and, therefore, might be economically justified if the technical problems could be worked out.[117]

POLLUTION AND WORKERS SAFETY AND HEALTH PROBLEMS

A final area of technological uncertainty for all trash-to-energy plants relates to potential pollution and occupational safety and health problems. To date, operating facilities appear able to meet current state and EPA standards for particulates and for sulfur dioxide and nitrogen oxide emissions, although at some sites this has been at considerable expense and after much effort. Trash-burning plants also have certain very appealing environmental characteristics when compared with other energy facilities. They produce no radioactive wastes. Nor do they emit large quantities of sulfur dioxide, since the sulfur content of municipal waste is between 0.1 and 0.2 percent, compared with the troublesome 2.5 to 3.5 percent sulfur content of most power plant coals.[118] Nevertheless, trash-to-energy plants do emit measurable quantities of fine particulates, certain potentially hazardous organic compounds, viruses and bacteria, and toxic elements such as cadmium, lead, and mercury. The latter toxic substances occurred in higher concentrations in the refuse-derived fuel than in the coal at the St. Louis demonstration plant.[119] Leaching of toxic heavy metals such as arsenic and cadmium from residues and ash that are landfilled may also prove to be a problem.[120] Health hazards, such as harmful dusts and vapors, infectious disease or viruses, and excessive machine noise, may also occur inside the facilities. Noise levels of up to 108 dBu were recorded inside the St. Louis facility.[121] Furthermore, as of early 1979, existing facilities had experienced over 100 explosions and a number of fires. Most of the explosions caused serious damage to buildings and equipment, injuries to employees, and at least one death.[122] Much more needs to be known both about the potential hazards to health inside such plants and about the levels at which hazardous substances are emitted from waste processing facilities before the extent of the pollution hazards can be accurately assessed.

MARKET PROBLEMS

Technical difficulties constitute only one obstacle to wider use of centralized resource recovery. Despite our current energy crunch, a second important problem is finding appropriate markets for the steam or fuel produced. One reason for this, according to an analysis by the Office of Technology Assessment, is that a reasonable size for a centralized resource recovery facility, in terms of the amount of waste generated by a moderate-sized city, is an extremely awkward size in terms of finding markets for potential energy products.[123] It appears that an "average" size for a new waterwall incinerator is in the neighborhood of a 1,000-ton-per-day capacity. Such a facility can process the wastes of about 600,000 people.[124] The United States has approximately 70 metropolitan areas of this size or larger.[125] The economics of building and operating such a plant seem to work out well.[126]

A plant of this type and size could be used to produce electricity. However, the 37 megawatts of power it could generate would satisfy the needs of only 3 percent of 600,000 people. Many electric utilities see this as too small a contribution to justify the effort and cost of adopting a new technology. On the other hand, the energy output from a 1,000-ton-per-day plant is much too large for most alternative customers for the steam or hot water. A plant of this size, for example, could serve the heating and cooling needs of 5 million square feet of office space. The Pentagon, one of the world's largest office buildings, has 6.5 million square feet; the U.S. Capitol has only 0.75 million square feet.[127]

A municipality that wants to build a centralized recovery facility thus faces several choices, none of which is completely satisfactory: build much smaller units with lower energy efficiency and the proliferation of siting and logistics problems; experiment with one of the less technically reliable methods of producing solid, liquid, or gaseous fuels; find industrial customers whose needs match the energy production of a larger plant; or line up a series of customers for the steam. One city that adopted the last course is Nashville, Tenn. The experience of that city, which was ultinately successful, illustrates still another area of problems for centralized resource recovery that can only be described by the vague term "institutional."

INSTITUTIONAL BARRIERS

American political and business institutions are structurally ill-adapted to centralized resource recovery. In most cities wastes are collected by the municipality, although some types of waste, e.g., commercial, and some portions, e.g., from unincorporated suburbs, may be collected by private haulers. The makers of recovery systems are, of course, private, while the most likely buyers of the recovered energy—electric utilities—are private concerns heavily regulated by government agencies unrelated to the cities.

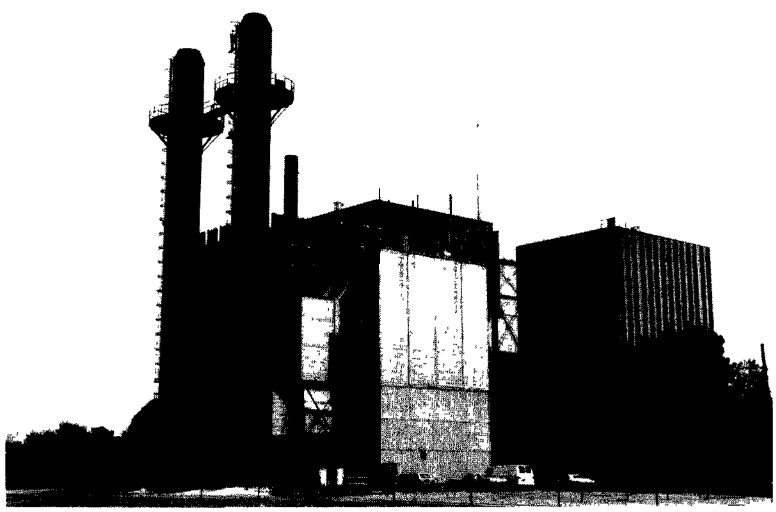
Getting all the relevant institutions to cooperate successfully on a major resource recovery project is a formidable task. It can be difficult, for example, to round up enough wastes from various disposers to make a plant economically viable. Usually, some entity must be found or created to operate the facility. The engineering firms that construct the plants usually want to sell them and go on to build more plants. The firms that formerly disposed of wastes—haulers and landfill operators—have no expertise in operating a large, high-technology energy plant. City sanitation departments likewise are ill-suited for such a complex business and engineering venture.

Furthermore, in the interests of preventing misspending of public funds, city and state charters sometimes prohibit these entities from entering into longer than 1-year contracts for buying or selling of goods and services, making it extremely difficult to plan or to involve private businesses in such facilities.[128]

Finally, the utilities, which might logically be the best market for the energy produced and are prime candidates for owning and operating recovery facilities, appear loath to get involved. Many of the reasons relate to the way in which they are regulated. Many utilities are allowed to pass fuel price increases directly on to consumers through "fuel adjustment clauses." Such clauses reduce the incentive to use cheaper fuels. Utilities are also required by law to provide reliable service, something that discourages them from experimenting with technologies that have not been proven beyond all possible shadow of doubt, especially when the technology can make only a modest contribution to a utility's total output.

The city of Nashville dealt with a number of these institutional problems in an unusual and interesting way. As part of a downtown renewal program, Nashville decided in the late 1960s to create a district heating and cooling system for public and private buildings in the central city area. The city solved the "who should do it" problem by creating a not-for-profit corporation called Nashville Thermal Transfer Corp. to build and operate the system. The city then decided to fuel the plant with wastes, thereby solving another city problem. After due study, Nashville Thermal became a refuse disposal organization as well as a heating and cooling utility.[129]

Nashville Thermal eventually built a 720-ton-per-day waterwall incinerator facility designed to handle only a portion of the city's



The city of Nashville, Tenn., solved several problems at once when it created the Nashville Thermal Transfer Corp., an independent, not-for-profit corporation, to build and operate this trash-burning district heating and cooling plant.

wastes.[130] The plant began operating in 1974 and was subsequently upgraded to a 1,060-ton-per-day capacity.[131] The system serves 30 buildings [132] and processes a quarter of Nashville's wastes. Its relatively modest size obviated a number of potential pitfalls. For example, the system has had sufficient amounts of waste to process, in contrast to several others, including those in Ames, Iowa, and Saugus, Mass., where waste volume did not meet projections.[133] In addition, seasonal fluctuations in volume of waste could be accommodated by varying the amount of waste delivered to the landfill.[134]

By creating an independent not-for-profit corporation to process wastes and distribute steam, Nashville avoided many of the institutional problems involved in trying to pull numerous disposal entities, an entrenched bureaucracy, and conservative utilities together for an experimental venture. Nevertheless, the project did suffer as a result of another institutional difficulty: the need for government entities to let contracts at the lowest possible cost. The Nashville plant experienced numerous technical problems in starting up, including such a serious malfunction of air pollution controls that a whole new system had to be added. Such problems did not occur at the Saugus plant, which is similar in design. An EPA assessment attributes the far poorer performance of the Nashville plant to cutting corners in the design of the project. A consultant's report states: "The critical problem was one not unique to waste processing facilities, but inherent in the low-bid requirements of government purchasing . . . . The lesson to be learned from Nashville is that a bargain in industrial equipment is a rarity." [135] Fortunately, it has proved possible to make the needed changes, and the plant now appears to be functioning reasonably reliably and within emission limitations.[136]

ECONOMIC BARRIERS

Related to the issue of "who is responsible for what" at a centralized resource recovery facility is the question of "who pays for what." Such facilities must be economically viable. At present, despite the economic pressures of higher energy and landfill costs, their profitability is still marginal.

Solely on the basis of the energy they produce, complex trash-to-energy facilities definitely are not yet economically competitive. Energy can still be produced more cheaply using conventional fuels burned in conventional boilers. Resource recovery facilities are able to break even or turn a profit only because the revenue they receive from sale of steam or fuels is supplemented by the amount the municipality pays them for getting rid of the wastes, known as a "tipping fee," plus any revenues from recovered materials.

The total cost of a centralized resource recovery facility consists of two components: capital costs and operating costs. Capital costs for such plants are high enough to strain the resources of many municipalities (see Table 4–5). The 2,000-ton-per-day Hempstead, N.Y., plant—the most expensive built to date—cost $81 million. A more typical figure for a 1,000-ton-per-day facility that produces an RDF fuel, but does not involve electricity generation equipment, is $25 million.

Table 4–8 presents the annual capital and operating costs, expressed in terms of cost-per-ton of capacity, for the Saugus, Mass., and Ames, Iowa, plants and estimates of projected costs for three other plants. The total annualized costs of the five plants range from approximately $15 to $23 per ton of refuse processed. A 1978 theoretical analysis of possible resource recovery options for the greater Kansas City area projects similar costs—in the neighborhood of $20 to $25 per ton—for the most cost-effective options for that area (see Table 4–9).

This, then, is the amount that must be recovered by a combination of energy sales, material sales, and tipping fees. The amount that can be charged in each category will vary greatly from place to place. A locality that is paying $20 per ton to landfill its wastes will obviously be willing to pay a much higher tipping fee than one that is paying $1 a ton for landfilling. Likewise, a recovery plant could probably charge more for steam in the Northeast, where energy costs are high, than in the Southwest, where fossil fuels are available more cheaply. The Kansas City study cited above estimated possible revenues from sale of steam in that locale of $18 per ton of waste processed. For the most cost-effective options, that amount would almost cover the cost of building and operating plants, and the operators could break even charging a tipping fee of only about $3 per ton. Such a result may not be too far off the mark. In Nashville, the city makes a lump sum contribution to the operation of the plant to make up the deficit not covered by revenues from sale of steam. That annual contribution—approximately $1.3 million in each of the last 3 years—is the equivalent of a tipping fee of approximately $8 per ton.[137] As shown in Table 4–10, actual tipping fees at four other plants currently in operation range from $8 to $15 per ton, a level competitive with the cost of landfilling in many areas.

COMPATIBILITY OF SOURCE SEPARATION AND CENTRALIZED RESOURCE RECOVERY SYSTEMS

Can source separation and centralized waste recovery coexist? On the face of it, it might appear that they are mutually exclusive. After all, if all the bottles, cans, glass, and paper are removed from waste before it is collected, then it would seem that centralized facilities will have little of value to recover or burn for energy. Some even argue that the economics of recovery plants is now so borderline that they could not tolerate even a small source separation effort. A bottle and can recycling program that was 50 to 90 percent effective might eliminate any revenues from materials recovery. A newspaper recycling program might lower the Btu content of the wastes to such a degree that the energy efficiency of the plant would be severely

Table 4–8

Summary of Annualized Costs of Selected Waste-to-Energy Processes

Project	Date of Capital Costs	Type of Process	MSW Capacity[a] (ton/day)	Investment (million dollars)	Annualized Capital Cost (dollars/ton)	Operating Cost (dollars/ton)	Total Annualized Cost (dollars/ton)
Saugus, Mass.	1975	Waterwall incinerator	1200	$37.5	$8.69	$9.16	$17.85
Ames, Iowa	1973	RDF	400	6.3	11.11	11.58	22.69
Milwaukee, Wisc. (projected)	1974	RDF	1600	11.7	7.09	9.75	16.84
Lorton, Va. (projected)	1974	RDF	750	6.9	3.39	15.18	18.57
	1974	RDF	1500	11.7	2.88	13.52	16.40
Edgemoor Delmarva, Del. (projected)	1974	RDF/Utility boiler	475	6.0	6.28	8.39	14.67

RDF = Refuse Denied Fuel

[a] Design capacity

Source. Gordian Associates, Inc., *Overcoming Institutional Barriers to Solid Waste Utilization as an Energy Source,* Prepared for U.S. Department of Energy, Division of Synthetic Fuels (Washington, D.C., November 1977), p. vi; and updated data supplied by DOE, August 1979.

Table 4–9

Projected Costs and Revenues for Energy Recovery Systems for the Kansas City Area, 1978

(in dollars per ton processed)

Type of System	Annual Cost [a]			Revenues	Net Cost
	Ownership	Operating and Maintenance	Total		
Modular Combustion Units [b]					
25 tons/day	$17.50	$23.41	$40.91	$18.00[c]	$22.91
50 tons/day	15.48	15.08	30.56	18.00[c]	12.56
100 tons/day	12.38	11.93	24.31	18.00[c]	6.31
200 tons/day	10.85	10.14	20.99	18.00[c]	2.99
Waterwall Combustion Unit [d]					
200 tons/day	16.27	12.68	28.95	18.00[c]	10.94
500 tons/day	14.34	8.75	23.09	18.00[c]	5.09
1500 tons/day	13.25	7.15	20.40	18.00[c]	2.40
Refuse-Derived Fuel System [e]					
500 tons/day	12.09	10.78	22.87	10.02[f]	12.85
1000 tons/day	10.78	9.33	20.11	10.02[f]	10.09

[a] Annual costs include interest on land, amortization of equipment, insurance, and operating and maintenance costs.

[b] Plants are assumed to operate at 95 percent of rated capacity, 5 days a week, 50 weeks a year.

[c] The plants are assumed to sell steam at $3 per thousand pounds in competition with fuel oil.

[d] Plants are assumed to operate at 78 percent of rated capacity, 7 days a week, 50 weeks per year. Capital investment was calculated at $43,370 per ton at 200 tons/day capacity; $38,157 per ton for 500 tons/day; and $35,187 per ton for 1500 tons/day.

[e] The system is assumed to operate at 85 percent of rated capacity, 6 days per week, 50 weeks per year. Capital investment includes modification of an existing boiler, and was calculated to be $32,102 per ton at 500 TPD capacity and $26,819 per ton at 1000 TPD capacity.

[f] The plants are assumed to sell RDF at $8.00 per ton. Ferrous and aluminum scrap are assumed recovered and sold.

Source: Black and Veatch and Franklin Associates, Ltd., "Detailed Technical and Economic Analysis of Selected Resource Recovery Systems," for the Mid-America Regional Council, 1978, Tables 1, 3, and 4.

Table 4–10

Tipping Fees at Selected Resource Recovery Facilities

Location	Normal capacity (TPD)	Technology	Tipping Fee (dollars/ton)	Date
Braintree, Mass.	240	Waterwall	8.00	Feb. 1979
Harrisburg, Pa.	720	Waterwall	12.60	July 1977
Milwaukee, Wis.	1,600	RDF	11.64	March 1979
Saugus, Mass.	1,500	Waterwall	14.58	March 1979

Source: Franklin Associates, Ltd., "Post-Consumer Solid Waste and Resource Recovery Baseline," Prepared for the Resource Conservation Committee (Washington, D.C., April 6, 1979), p. 55.

impaired. Finally, a source separation program that reduced the total volume of wastes by 25 to 50 percent might reduce the recovery plant's tipping fees to a point where it was no longer economically viable.

These problems of potential incompatibility are actually less serious than they appear. As explained above, the technology for extraction of recyclables, except for iron, is in its infancy for central resource recovery plants. At most such plants operating today, materials recovery contributes a very small amount to overall revenues.[138] Many plants burn wholly unprocessed wastes and do not recover any materials at all. Thus a bottle or can recycling program would generally not interfere, per se, with a centralized facility's economic position.

The question of whether the removal of paper and other recyclables from waste in a source separation program would seriously reduce the energy value of municipal wastes is a more open one. However, recent EPA data suggest that the impact would be minimal and, depending on the type of source separation program, might even be positive.

The reason for this is that recyclables in general, and newspapers in particular, actually constitute only a small portion of the burnable substances in refuse. Approximately 75 percent of all waste can be burned.[139] This includes everything from banana peels and plastic bags to old shoes and broken chairs. In general, newspapers, books, and magazines average only about 9 percent of municipal wastes.[140] According to EPA calculations, even an extremely effective newspaper recycling program would reduce the solid waste stream by no more than 7 percent, by weight, and the Btu value of the waste would decline by only 3.5 percent (see Table 4–11). If beverage container legislation significantly reduced the amount of bottles and cans in waste, the Btu value per pound of waste would actually *increase* by about 6 percent.

The third argument—that source separation could reduce tipping fee revenues at a centralized facility below the breakeven point—is more compelling. However, it holds true only under certain circumstances. It applies only when source separation is introduced after a centralized plant has been built, when the centralized plant in question is processing all of a region's waste, and when it has no access to additional wastes, either because transportation costs for such wastes would be too high or because political jurisdictional problems would be too great. In such a situation, the introduction of a source separation program would reduce the amount of wastes going to the centralized facility and thus its revenues from tipping fees (which are charged on a per-ton basis).

A plant that handled only a portion of a city's wastes would not, however, experience this problem. In the event that local source separation was instituted, or a national program of beverage container deposits or some other waste reduction measure took effect, such a plant could maintain the volume of wastes processed (and thus revenues) by increasing the proportion of the city's wastes it handled.

Table 4–11

Impact of Source Separation Options on Btu Content of Municipal Trash

Type of Source Separation Program	Average Btus per Pound of Trash	Percent Change
No source separation	4,600	—
High level, all wastes [a] (25% reduction in total waste stream)	4,660	+1.3
Low level, all wastes [a] (10% reduction in total waste stream)	4,510	−2.0
High level, newspaper (7% reduction in total waste stream)	4,440	−3.5
Low level, newspaper (3–4% reduction in total waste stream)	4,550	−1.1
Glass and cans (beverage container legislation)	4,890	+6.3

[a] All wastes defined as glass, cans, newspaper, office paper, and corrugated cardboard.

Source: U.S. Environmental Protection Agency, Office of Solid Waste, unpublished study, 1979.

Many people in fact now think that the best approach in developing a centralized recovery facility is to design the system to work in tandem with source separation at the outset. This would take advantage of the strengths of both systems: materials recovery from the source separation program and energy recovery from the centralized facility. If the source separation program did not materialize or proved less effective than hoped, it would mean a somewhat heavier load on the backup landfill site. However, EPA has pointed out that many other factors can also affect the amount of waste available to a plant, including seasonal fluctuations, jurisdictional problems, and the fact that many localities have only the roughest idea of how much waste they actually generate.[141] In general, EPA believes that it is better to plan conservatively and perhaps underbuild, than to build a centralized resource recovery facility that might eventually prove too large for the needs of the locality and, therefore, be uneconomical.

FEDERAL ACTIVITIES

Beginning with the Solid Waste Disposal Act of 1965 [142] and continuing with the Resource Recovery Act of 1970 [143] and the Resource Conservation and Recovery Act of 1976,[144] Congress has asked the federal government to attempt to do something about the nation's solid waste problems. These laws directed EPA to develop and to encourage use of better systems for disposing of solid waste, particularly where health hazards are involved. In addition, DOE has responsibilities for research, development, and demonstration of the energy potential of solid wastes.

The 1976 law created the Resource Conservation Committee, a special interagency Cabinet-level group,* for the purpose of examining various possible "incentives and disincentives to foster resource conservation."[145] The committee selected for study 10 existing or possible federal policies that could affect waste generation and recovery. The findings and recommendations of the committee, presented in its July 1979 final report, *Choices for Conservation*,[146] are discussed in the following section.

ECONOMIC INCENTIVES FOR WASTE REDUCTION AND RECYCLING

Beverage Container Deposits

Given the national interest in and political prominence of the issue, the Resource Conservation Committee gave special consideration to a mandatory national system of deposits and refunds for beverage containers. Deposits would reduce waste by encouraging recycling of bottles and cans.

Staff studies summarized in the committee's final report[147] indicated that such legislation would:

- Reduce litter volume by 35 percent eliminating 15 to 20 percent of the number of individual litter items;
- Reduce the amount of solid waste by up to 2 million tons per year, or 0.5 to 1.5 percent;
- Realize an annual savings in lower disposal costs of $25 to $50 million annually;
- Save 250,000 to 380,000 tons of aluminum (5 to 10 percent of annual production), reducing bauxite imports by a potential 1.6 million tons;
- Reduce steel consumption by about 1.5 million tons (1 to 2 percent of annual production);
- Reduce total atmospheric emissions caused by bottle and can production by 0.75 billion to 1.2 billion pounds;
- Reduce waterborne wastes from container production by 140 to 210 million pounds;
- Save 70 to 130 trillion Btus, equivalent to 33,000 to 61,000 barrels of oil per day, or 0.1 percent of total national energy consumption;
- Reduce the retail price of beverages an average of 0.5 to 1.5 cents per container, saving consumers a total of $0.66 billion to $1.76 billion annually;

*The members of the Committee were: Douglas Costle, Administrator, EPA, Chairman; Juanita Kreps, Secretary of Commerce; Cecil D. Andrus, Secretary of the Interior; F. Ray Marshall, Secretary of Labor; W. Michael Blumenthal, Secretary of Treasury; Charles Warren, Chairman, Council on Environmental Quality; Eliot Cutler, Office of Management and Budget; Lawrence J. White, Council of Economic Advisors; Alvin Alm, Department of Energy.

- Cause an unquantifiable amount of inconvenience to beverage consumers who presently purchase beverages in nonrefillable containers and discard the containers when empty;
- Eliminate between 4,900 and 10,400 jobs in the glass container production industry and between 14,200 and 22,000 jobs in the metal can production industry over a 5-year period; and
- Create between 80,000 and 100,000 new jobs in the beverage distribution and retail sectors.

In the committee's final report, four of the nine agency and department heads who were members of the Resource Conservation Committee recommended national beverage container legislation. Two officials wanted to wait to see the effect of such laws in the states—Maine, Michigan, Connecticut, Iowa, and Delaware—that have recently adopted them, before taking a position. (Only Oregon and Vermont have had beverage container deposit laws for several years.) One member of the committee took no position, and two were opposed.

The committee also recommended that if beverage container legislation were adopted, it should apply to all sealed beer and soft drink containers, regardless of material used, except cartons and carriers; that the deposit should be for a minimum of 5 cents, with possible increases scaled to the Consumer Price Index; and that the deposit should begin at the distribution-wholesaler level.

Other Deposit Systems

A waste management concept similar to beverage container deposits is that of a system of deposits or bounties for durable or hazardous goods. Under this arrangement, a consumer would pay a deposit when buying a refrigerator or auto battery, for example, which would be returned when the item was turned in at a disposal depot. The system would be valuable in encouraging proper disposal of hazardous substances, such as the chemicals in the car battery. However, its impact on total volume of municipal solid waste would probably be limited, because these items would still have to be disposed of. The Resource Conservation Committee decided that it did not have sufficient information to evaluate this concept and recommended further research.[148]

National Litter Tax

A concept that is often put forth as an alternative to beverage container and other deposit systems is that of a litter tax, that is, a special tax on frequently littered items such as beer cans. Such a tax could be earmarked to clean up litter and might provide an incentive against littering. The committee unanimously recommended against such legislation at the national level, however, for a number of reasons. First, such a tax would penalize those who do not litter as well as those who do. Second, to act as an incentive against littering, it would have to discourage buying the product altogether. To do

The Resource Conservation Committee rejected the concept of a litter tax on the grounds that it would create no incentives for individuals to clean up or reduce wastes. By contrast, beverage container deposits would do both. Photographer: Tom Raymond.

this would require an extremely large tax, perhaps 20 to 40 percent of the sales price. Such a structuring was considered both infeasible and undesirable. Lastly, the tax would create no incentive for individuals to clean up or reduce wastes. By contrast, beverage container deposits would do both.[149]

Solid Waste Disposal Charge

Congress specifically asked the Resource Conservation Committee to investigate and issue a report on the concept of levying solid waste management charges on consumer products; that is, a federal weight or unit-based tax on products and packaging that would be charged to the producer of the item and would be tied to the cost of disposing of the item. To take a hypothetical example, the manufacturer of a pair of shoes might be charged 2 cents per pair, reflecting the cost of disposing of those shoes and the shoebox in which they are sold in a municipal landfill. Revenues from the tax would be distributed to local governments. Recycled materials used in products would be exempt from the tax.

The aim of this scheme is to create a financial incentive for manufacturers to avoid excess packaging and use recycled materials, and for consumers to do likewise, assuming that the tax will be passed along. However, the committee found less merit in this concept than in several others. No committee members voted to recommend a national disposal charge, largely because the effects of such a tax are simply too difficult to predict. The committee members were not convinced that the size of the incentives would be sufficient in practice to discourage excess packaging or to encourage use of recyclables. Yet such a tax would raise shelf prices of consumer goods.[150]

Local User Fee

The committee was more interested in a slightly different concept with a similar goal—the "local user fee"—but felt it lacked sufficient information to fully endorse the concept. Under this system, a municipality charges a household for waste pickup according to volume or weight of trash collected, i.e., by the bag, rather than financing garbage collection out of general or property tax revenues. The more waste, the higher the fee. Such systems are already used by some private waste collectors. In theory at least, it should be possible to set the fees so that consumers have an incentive to choose less wasteful products. It should also encourage households to recycle newspapers, bottles, and cans and to compost, thus reducing waste. However, it might encourage households to engage in illegal or "midnight" dumping of wastes in undesirable locations.

The committee acknowledged that little empirical data exist on how such fees actually affect householders' habits and stated that "the present state of knowledge makes it premature to create positive incentives for local governments to adopt user fees." It suggested further research and proposed that, in the meantime, the federal government should provide information to local governments on this technique.[151]

Product Design Regulations

Another potential method of reducing wastes and encouraging recycling is through direct intervention in the design of products. The government could require manufacturers to use more durable or simply fewer materials in the products they produce, or recycled or easily recyclable raw materials. The federal government could, for example, require that all newsprint contain a certain minimum percentage of recycled fibers. Or it could ban products like bimetallic (part aluminum, part steel, part other metals) cans that are difficult to recycle and interfere with the efficient operation of source separation programs.

The Resource Recovery Committee rejected the notion of direct regulation, because its impact is unpredictable and because it would be immensely difficult to administer and enforce. A newsprint rule, for example, might simply result in the diversion of recycled paper from some other use, like production of cellulose insulation, rather than actually causing a net increase in paper recycling. Detailed definitions as to what exactly is or is not recycled, would be necessary: for example, whether to count newsprint wastes produced at the paper mill or printing shops, as well as newsprint actually purchased and used by readers of the nation's dailies.

The committee did recommend further study, however, of potential regulation of materials that cause special hazards in disposal and those that significantly impede resource recovery operations (like bimetallic cans).[152]

Tax Policies

The Resource Recovery Committee also considered whether certain government policies might be hindering recycling. In particular, it considered whether recycled raw materials are at a competitive disadvantage, either because certain tax subsidies for virgin materials are not offered for recycled materials, or because freight rates are set at levels that discriminate against recycled materials in favor of virgin ones.

The committee's staff analysis confirmed the existence of a number of special tax advantages for virgin resource development. These policies were originally instituted on the grounds that stimulating resource development would contribute to economic growth and make the nation more self-sufficient. They include percentage depletion allowances for certain minerals and treatment of annual royalty income from iron ore and coal mining and income from sales as capital gains. These and several other provisions of the tax code are considered subsidies in that they depart from normal methods of taxing business income, to the industry's benefit. According to the committee's analysis, these subsidies amount yearly to $375 million for nonfuel minerals production and $275 million to $550 million for timber growing.[153] The committee stopped short of recommending abolition of the subsidies, however, recommending instead further study by other government entities considering tax reform.

Freight Rate Discrimination

The Institute of Scrap Iron and Steel and many others have long maintained that the rail freight rates established by the Interstate Commerce Commission (ICC) discriminate in favor of virgin raw materials at the expense of recycled materials. National policy on this issue was firmly enunciated in 1976, when Congress included a provision in the Railroad Revitalization and Regulatory Reform Act requiring the ICC to investigate its current rate structure and revise any rates found to be discriminatory.[154]

The Interstate Commerce Commission lowered freight rates for recycled paper and several other materials in certain parts of the country in 1979, after 2 years of investigation over whether its rates discriminated against recycled commodities.

In 1977, the ICC, using certain narrow definitions of the term, affirmed that its rate structure did not "discriminate" against recycled materials.[155] The ruling was appealed by two secondary material industry trade associations, the Departments of Energy and Justice, and EPA. In August 1978, the U.S. Court of Appeals for the District of Columbia ordered the ICC to examine its rates again using a broader definition of discrimination.[156] The ICC reopened its investigation and in April 1979 announced that it had found that, in fact, several commodities did suffer rate discrimination relative to competing virgin materials. It ordered secondary material rates to be reduced on scrap iron and steel in the South and West, on aluminum scrap in the East and South, on copper scrap in the West, on lead and zinc scrap in the South, and on waste paper in the West and South.[157]

At the same time that the ICC was conducting its latest investigation, the Resource Conservation Committee staff made its own analysis of ICC data. It also concluded that freight rates discriminate against important secondary materials, but felt that the most serious discrimination was against waste paper and glass. It calculated that rate reductions of 38 percent for waste paper, 34 percent for glass, 1 to 29 percent for iron scrap, and 9 percent for waste aluminum might be in order.[158] Most of the committee members concurred in a recommendation that the Administration file a brief with the ICC presenting their findings and expressing its interest in achieving compliance with the Railroad Revitalization and Reform Act of 1976.

MATERIALS RECYCLING

Whatever the success of any economc incentives in reducing wastes, large amounts of waste will continue to be discarded. Municipalities will still face the same choices in dealing with their wastes: landfilling, incineration, materials recovery, and/or energy recovery.

EPA has taken certain direct steps toward stimulating materials recovery, with mixed success. It has issued guidelines for institution of beverage container deposits at federal facilities and is developing guidelines to increase federal purchasing of recycled products.

Beverage Container Deposits at Federal Facilities

Under authority granted it by the Resource Recovery Act of 1970, EPA issued guidelines in 1976 requiring a refundable 5-cent deposit on all beer and soft drink containers sold at federal facilities, except in cases where costs would be excessive.[159]

Federal agencies have been slow to implement these guidelines, despite a recent Executive order (October 1978) spelling out the responsibility of federal facilities to comply with federal environmental laws.[160] As of March 1979, only 14 of 52 agencies reported that they were implementing the guidelines agencywide.[161] More than half reported that their facilities were under the jurisdiction of the General Services Administration (GSA), which as of May 1979 had decided not to implement the guidelines on a broad scale. GSA made this decision on the basis of test projects at 12 sites which, it reported, had difficulty finding markets for collected containers and caused inconvenience to vendors.[162]

The Department of Defense also conducted a test of the guidelines at 10 military bases for a 1-year period ending June 1978. One of its findings was that where it was convenient, post residents would attempt to evade the deposits by buying beer and soft drinks off the post, causing a decline in beverage sales of 13 to 56 percent at the 10 installations. On the basis of that result, the Department of Defense declined to implement beverage container deposits at any of its installations. Nevertheless, the actual return rates for the containers purchased were quite good, ranging between 68 and 93 percent at the 10 bases.[163]

Federal Procurement of Recycled Materials

As noted earlier, municipal recycling efforts currently suffer greatly from the instability and inadequacy of industrial demand for recycled materials. One way the government could increase that demand would be for the government itself to buy products made from recycled materials. Such a policy would have many benefits beyond simply furthering municipal recycling programs: conserving natural resources; reducing dependence on foreign raw material supplies; reducing pollution; and conserving energy.

The Resource Conservation and Recovery Act required EPA to set guidelines for federal agencies "to procure items composed of the highest percentage of recovered materials practicable." [164] Although the agencies were supposed to be carrying out this policy by October 1978, EPA had issued no guidelines by that date. The agency is scheduled to propose its first guidelines in this area—regarding use of fly ash in concrete and cement—in February 1980.

EPA attributes some of its slowness in issuing these guidelines to the fact that it was initially faced with 45,000 different federal product and material specifications to review and evaluate. The agency has now decided to concentrate on a few products where use of recycled materials could be significant. EPA is due to issue additional guidelines—for federal purchase of recycled paper and of parkland soil conditioner that incorporates sewage sludge—later in 1980. Guidelines for procurement of construction products that use recycled paper, of glass, and of rubber are scheduled to be proposed in 1981.[165] EPA points out that even if procuring agencies were ready to comply, industries producing recycled products would not yet be prepared to supply all the products the government needs.[166]

ENERGY RECOVERY PROGRAMS

As explained above, a number of technical, institutional, and economic obstacles inhibit increased energy recovery through centralized waste processing facilities.

Research and Development

Both EPA and DOE have research and development programs whose goal is to overcome technical barriers to waste processing. EPA's program, begun by the Bureau of Solid Waste Management at the U.S. Department of Health, Education, and Welfare (HEW), dates back to 1967. Since EPA's creation in 1970, the agency has spent about $5 million a year on trash-to-energy technology and has sponsored six major demonstration plants.[167] EPA's involvement in the field, budgeted at $4.25 million for fiscal year 1978 and $2.5 million for fiscal year 1979 and scheduled to go lower in 1980, is now decreasing.[168] For the future, EPA expects to limit itself to assessments of environmental impact of trash-burning facilities and development of better air pollution control methods. DOE's program began in 1976 under its predecessor agency, the Energy Research and Development Administration. It is funding demonstrations of less-developed trash conversion technologies, mainly pyrolysis and anaerobic digestion. DOE's expenditures were about $11 million in this field in fiscal year 1978 and are budgeted at $8.5 million for fiscal year 1979.[169]

In a February 1979 report examining the federal waste-to-energy program, the General Accounting Office charged the program with being "fragmented, uncoordinated, inadequately funded, uncertain in its priorities, and lacking in detailed overall strategy." [170] GAO believed that DOE and EPA were failing to coordinate their programs adequately, despite an interagency agreement worked out in 1976 to do so. It pointed out, for example, that research and development contracts were not being reviewed for possible duplication.[171]

It is especially vital that adequate lines of communication between the two agencies be established and used in the coming year. Such communication is necessary to insure that, as EPA phases out its involvement in technology development, DOE takes advantage of the experience and lessons that EPA has gained. DOE currently sponsors a number of projects in pyrolysis. This technology has the potential for helping to supplement the nation's oil supplies; however, EPA has found that technically it is very difficult to make pyrolysis projects work. It is also important that DOE adequately pursue technologies that EPA found promising. EPA feels that development of "briquets" of refuse-derived fuel, for example, could be an extremely fruitful avenue of research.[172]

Planning Assistance

As discussed earlier, too often the barriers to building and operating a waste processing facility are not so much technological as institutional. In the past, EPA provided some assistance to communities in how to go about the complex task of planning and organizing such a facility, with panels consisting of EPA staff members, outside consultants, and state and local officials with expertise in engineering, finance, and management. Between January and October 1978, 245 requests for assistance had been filled under this program.[173] The budget for the panels program was $3.75 million in fiscal year 1978 and is expected to be about $4.5 million in fiscal year 1979.[174] However, EPA has indicated that, for the future, the panels will increasingly be used to deal with hazardous wastes and solid waste problems other than resource recovery.[175]

In 1979, Congress allocated $15 million under President Carter's urban program to assist cities in initiating resource recovery projects. Grants can be used for investigating markets, assessing technologies, doing feasibility studies, analyzing local issues, and negotiating contracts. EPA selected 68 communities to receive awards under this program in 1979. It hopes to continue the program for 2 more years.[176]

EPA plans to issue guidelines for federal purchase of recycled rubber in 1981. Meanwhile, tires continue to accumulate in dumps and landfills across the country. Less than 4 percent of the rubber disgarded in municipal waste was recycled in 1977.

DOE also has a technical assistance program that provided $2 million in planning grants in fiscal year 1978.[177]

Finally, some of the funds EPA is providing to states for the overall planning of their waste management strategies under RCRA may be used for planning of resource recovery. These funds totaled $14.2 billion in fiscal year 1978 and are budgeted for $15.2 million in fiscal year 1979.[178]

Capital Cost Assistance

A waste processing facility capable of handling 1,000 tons of refuse a day can cost $25 million to $50 million to plan and build. Coming up with such a large sum is not easy, especially when, because of the newness of the field, many financial institutions regard such plants as high-risk ventures.[179]

Government can assist communities in this area through loan guarantees, tax exemptions for municipal industrial development or pollution control bonds, other tax benefits for facilities, or outright construction grants. To date, many of the larger waste processing facilities have, in fact, been financed by issuance of tax-exempt municipal bonds.[180]

Another tax benefit now available to builders of waste processing plants is an investment tax credit. The Energy Tax Act of 1978 allows businesses to take an additional 10 percent investment tax credit for installing alternative energy systems, including recycling equipment.[181] According to DOE, such credits are expected to reduce the cost of producing energy from municipal solid waste by 5 to 19 percent.[182]

A third possible form of federal aid is loan guarantees. Although the Energy Conservation and Production Act of 1976 [183] authorized such guarantees up to $2 billion, none has been made. GAO has criticized DOE for failing to request any appropriations under this program, which expires at the end of fiscal year 1979. The DOE Energy Act of 1978 also authorized certain kinds of loan guarantees, although the Congress declined to appropriate money for this purpose for fiscal year 1979.[184]

OUTLOOK FOR THE FUTURE

Municipalities facing high disposal costs or the lack of an environmentally acceptable landfill site may want to institute a source separation program or build a centralized waste processing facility, or both. Each system has advantages and disadvantages that may suit it for one area and not another (see Table 4–12).

Instituting a program of household separation and recycling of wastes will cost a city a certain amount (up to $7 per ton of waste processed, exclusive of collection costs). However, it will probably cost less than building and operating a centralized facility ($3 to $15 per ton) and almost certainly less than building and operating

Table 4–12

Comparison of Source Separation and Centralized Waste Processing as Methods of Municipal Waste Disposal

	Source Separation	Centralized Waste Processing
Typical size of processing facility	10 tpd	1000 tpd
Typical capital investment (dollars)	low (50,000)	high (25,000,000)
Net cost per ton processed (after revenues)	$0–7	$3–15
Reduction in waste stream (percent)	10 to 50	75 and up
Products recovered	glass, paper, iron, aluminum	energy, iron
Environmental impact	negligible	some air pollution and worker health hazards

tpd=tons per day

an incinerator ($25 to $35 per ton).[185] Source separation can be instituted in a city of any size. However, the fact that public cooperation is essential means that source separation may be begun more easily in small towns and rural areas, where citizens can be closely involved in the decisionmaking process.

There are two basic disadvantages of source separation relative to centralized waste processing. First, source separation generally reduces wastes by 10 to 50 percent (by weight), compared with 75 percent or more at a centralized facility. Second, separation yields materials, which may be most useful to a more-or-less distant industry, rather than energy, which is useful locally. However, although a centralized waste processing facility can help meet a locality's energy needs, it requires a large initial investment. It is also a relatively costly disposal method, may cause air pollution problems, and may not produce energy in an optimally useful form. The best markets for energy-from-trash seem to be industrial facilities or district heating systems that can make use of steam. Because the economics of centralized waste-processing plants usually dictates a capacity of at least several hundred tons per day, such facilities appear best suited to urban areas where wastes from 100,000 or more people are available. However, some smaller towns are experimenting successfully with small modular units.

A number of cities are already experimenting with both kinds of systems. A modest, step-by-step approach seems to be working best in most places. The relatively elaborate source separation program considered in 1976 by the city of Northglenn, Colo., never got off the ground. City officials found they were simply too busy dealing with other problems, including construction of a $31 million sewage treatment plant, to get a new $200,000 waste system involving anaerobic digesters and earthworm colonies underway at the same time.[186]

The city elected instead to institute a limited source separation effort in 1977, involving separate collection of newspapers, which are sold, and grass clippings, which are composted on city land. The city still hopes to institute the more advanced program eventually, recycling and selling bottles and cans, and using bacteria and earthworms to process grass, other organic wastes, newspapers, and manure from a local dairy into useful soil.[187]

A plan for a very large trash-to-energy plant, which Union Electric of St. Louis first proposed in 1976, also ran into difficulties and delays. First, because of the great quantities of waste involved (had it been built, the facility would have been four times larger than any plant operating today), the plant required four transfer stations at different locations. The planners were able to acquire the sites for three of them, but local residents vehemently protested the fourth. Shortly thereafter, a state referendum denied all utilities the right to pass interest costs involved in building new plants along to their customers until the projects are actually producing electricity. In 1977, Union Electric announced that it would not go forward with the St. Louis project, and a much more modest venture is now planned.[188] The Bi-state Development Agency—an independent authority that runs the local bus system—is considering a 1,000-ton-per-day facility, which will supply steam to a local industry, rather than the originally planned 8,000-ton-per-day plant.[189]

The experience of these cities points up the need to proceed incrementally in projects of this type. Other lessons also may be drawn as well. The prerequisites for success of a source separation program seem to be:

- Obtaining long-term contracts that dictate floor prices for purchase of recyclable materials;
- Having those whose cooperation is essential to the project, i.e., householders and refuse collectors, solidly behind the project before initiating it; and
- Integrating the source separation program fully into the regular town waste disposal system with household separation mandated by ordinance.

The prerequisites for success of a centralized waste processing facility appear to be:

- Using one of the simpler, proven technologies;
- Locating a user for the energy produced; and
- Designing a facility to process only a portion of the jurisdiction's waste.

The latter measure not only avoids waste shortfalls, but leaves the door open to instituting complementary waste reduction or source separation schemes.

GAO has pointed out that the speed with which we expand our resource recovery efforts over the next 5 to 10 years depends upon a number of factors including the ability of cities to work out institutional problems, the degree to which industry will provide markets for recovered energy and materials, and the degree to which cities can solve capital and financing problems. Cities may have a strong incentive to solve these problems, however, as it becomes increasingly difficult to find land that is sufficiently remote and undesirable and that the public is willing to let be allocated to waste disposal; and as it becomes increasingly expensive to discard the wastes in an environmentally sound fashion. The cost of sanitary landfilling, last estimated at $1 to $20 per ton, is expected to rise by $3 to $12 a ton, depending on the size of the site, environmental factors, and previous practice, as new federal and state standards go into effect.[190] At these higher rates, source separation and resource recovery will undoubtedly become a competitive disposal option in many more cities. EPA's $15 million planning grant program under President Carter's urban assistance program may aid a number of cities in taking new initiatives to recover valuable resources from city waste.

REFERENCES

1. Resource Conservation Committee, "A Cost Analysis of the Solid Waste Management Industry," Staff Background Paper No. 11 (draft, Washington, D.C., December 1978), p. 15–16.
2. 42 U.S.C. § 6901 (1976).
3. U.S. Environmental Protection Agency, Office of Solid Waste, *Fourth Report to Congress: Resource Recovery and Waste Reduction* (Washington, D.C., August 1977), p. 78.
4. Information provided by Union Electric Co., August 29, 1979.
5. *Ibid.*
6. Richard P. Lundahl, "A Public Official Evaluates Resource Recovery Systems," *Environmental Action Bulletin*, February 19, 1977.
7. U.S. Environmental Protection Agency, Office of Solid Waste, "Solid Waste Facts" (Washington, D.C., May 1978), p. 10.
8. Franklin Associates, Ltd., "Post-Consumer Solid Waste and Resource Recovery Baseline," prepared for the Resource Conservation Committee (Washington, D C., April 6, 1979), p. 19
9. *Id.* at 21 and 33.
10. U.S. Congress, Office of Technology Assessment, "Materials and Energy from Waste" (final draft, Washington, D.C., June 1978), pp. 2–5 and 2–8.
11. *Id.* at 2–8.
12. Franklin Associates, Ltd., "Post-Consumer Solid Waste" *supra* note 8, at 1.
13. U.S. Department of Energy, Urban Waste Technology Commercialization Task Force, "Urban Waste Commercialization Strategy I, II, and III" (draft, Washington, D.C., July 19, 1978), p. 1.
14. *Ibid.*
15. U.S. Environmental Protection Agency, "Solid Waste Facts," *supra* note 7, at 1.
16. SCS Engineers, "Availability of Land for Solid Waste Disposal," prepared for the American Paper Institute (Washington, D.C , August 1978), p. 1.
17. Resource Conservation Committee, *supra* note 1, at 1
18. *Id.* at 10.
19. *Id.* at 15–16.
20. 44 Fed. Reg. 45066–086 (1979).
21. 43 Fed. Reg. 4942–4955 (1978).

22. Communication from the U.S. Environmental Protection Agency, August 1979.
23. 42 U.S.C. § 6901 (1976).
24. 33 U.S.C. § 1251 (1977).
25. U.S. Environmental Protection Agency, Office of Solid Waste, *Annual Report to the President and Congress Fiscal Year 1978: EPA Activities Under the Resource Conservation and Recovery Act of 1976* (Washington, D.C., March 21, 1979), p. 4–4.
26. 43 Fed. Reg. 4492–4955 (1978).
27. 44 Fed. Reg. 18138–18148 (1979).
28. U.S. Environmental Protection Agency, *supra* note 22.
29. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 4–5.
30. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 3–4 and 3–5.
31. Information provided by Penelope Hansen, U.S. Environmental Protection Agency, Office of Solid Waste, April 23, 1979.
32. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra,* note 3, at 38.
33. 41 Fed. Reg. 16950 (1976).
34. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 23, at 5–9.
35. U.S. Environmental Protection Agency, "Solid Waste Facts," *supra* note 7, at 12.
36. *Id.* at 10.
37. *Id.* at 11.
38. Z.A. Munir, E. Fuss, and L. Ivers, *An Analysis of the Recycling of Metals,* prepared for Division of Conservation Research and Technology, U.S. Energy Research and Development Administration (final report, Washington, D.C., January 1, 1978), p. 264.
39. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 11, 14, 21.
40. U.S. Comptroller General, U.S. General Accounting Office, "Potential Effects of Mandatory Deposits on Beverage Containers" (Washington, D.C., December 1977), pp. 5 and 6.
41. Mark Trautwein, Environmental Study Conference, "Beverage Container Deposits: What a Difference a Nickel Makes," *Fact Sheet* (Washington, D.C., April 18, 1978), p. 2.
42. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 11, 21.
43. *Ibid.*
44. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 7.
45. *Id*, at 37.
46. U.S. Congress, "Materials and Energy from Waste," *supra* note 10, at 5–4.
47. Richard Tichenor, "Compliance in a Mandatory Source Separation Recycling System," *Compost Science/Land Utilization,* July 1978, p. 23.
48. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 37.
49. Richard Tichenor, *supra* note 47.
50. Penelope Hansen, "Resource Recovery Through Multi-Material Source Separation," *U.S. Environmental Protection Agency, Resource Recovery Update* (Washington, D.C., October 1976), p. 1.
51. *Ibid.*
52. *Id.* at 3.
53. *Ibid.*
54. *Id.* at 2.
55. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 36.

56. *Id.* at 37.
57. *Id.* at 35, 36.
58. Information provided by Penelope Hansen, U.S. Environmental Protection Agency, Office of Solid Waste, April 23, 1979.
59. *Ibid.*
60. Richard Tichenor, *supra* note 47, at 20–23.
61. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 35.
62. R.L. Tichenor and E.F. Jansen, "Recycling as an Approach to Solid Waste Management in New Hampshire" (Durham: University of New Hampshire, June 1978), p. 17.
63. Penelope Hansen, U.S. Environmental Protection Agency, "Residential Paper Recovery: A Municipal Supplementation Guide" (second printing, Washington, D.C., February 1979), p. 7–8.
64. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 35.
65. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 14.
66. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, *Third Report to Congress: Resource Recovery and Waste Reduction* (Washington, D.C., 1975), p. 50.
67. ICF, Inc., "Estimates of Substitution and Supply Elasticities for Post-Consumer Waste Materials," prepared for the U S. Environmental Protection Agency (draft report, Washington, D.C., 1978), p. 8.
68. The Environmental Industry Council, "Top Waste Management Award Is Won by Newspaper Recycler," press release, Washington, D.C., February 28, 1979.
69. U.S. Environmental Protection Agency, *Third Report to Congress, supra* note 66, at 50.
70. Z.A. Munir, *et al., supra* note 38, at 75.
71. *Ibid.;* and ICF, Inc , "Estimates," *supra* note 67, at 14.
72. Robert R. Nathan Associates, Inc., *Iron and Steel Scrap: Its Accumulation and Availability Updated to December 31, 1977,* prepared for Metal Scrap Research and Education Foundation (Washington, D.C.: Metal Scrap Research and Education Foundation, 1978), pp. 3 and 4.
73. U.S. Environmental Protection Agency, *Third Report to Congress, supra* note 66, at 56–57.
74. Z.A. Munir *et al., supra* note 38, at 267
75. *Id.* at 264.
76. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 14.
77. U.S. Department of Defense and U.S. Environmental Protection Agency Joint Executive Task Force, Solid Waste Management, and Franklin Associates, Ltd., *Report to the Secretary of Defense on Department of Defense Test of Environmental Protection Agency Solid Waste Management Guidelines for Beverage Containers* (Washington, D C., March 1979), p. 4–18.
78. ICF, Inc., "Estimates," *supra* note 67, at 11.
79. Environmental Industry Council, "Connecticut Firm is Cited for Glass Recycling Gains," press release, Washington, D C., February 28, 1979.
80. U.S. Congress, "Materials and Energy from Waste," *supra* note 10, at 4–10, 4–11, 4–15.
81. U.S. Environmental Protection Agency, "Solid Waste Facts," *supra* note 7, at 10.
82. David B. Sussman, Office of Solid Waste, U.S. Environmental Protection Agency, "Resource Recovery Facilities in the United States" (Washington, D.C., November 1978), p. 3–4.
83. U.S. Comptroller General, U.S. General Accounting Office, *Report to the Congress: Conversion of Urban Waste to Energy: Developing*

and Introducing Alternate Fuels from Municipal Solid Waste (Washington, D.C., February 28, 1979), p. ii.

84. *Ibid.*
85. Franklin Associates, Ltd , "Post-Consumer Solid Waste," *supra* note 8, at 19.
86 U.S. General Accounting Office, *supra* note 83, at 3–21.
87. *Ibid.*
88. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 45.
89. U.S. Environmental Protection Agency, *Third Report to Congress, supra* note 66, at 33.
90. *Ibid.*
91. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 14.
92. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 53–54.
93. David B. Sussman, *supra* note 82, at 5–6
94. U.S. Congress, "Materials and Energy from Waste," *supra* note 10, at 6–11.
95. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 78.
96. Information provided by Bernard Icholtz, former Franklin, Ohio, City Manager, August 29, 1979.
97. David B. Sussman, *supra* note 82.
98. *Id.* at 3.
99. *Ibid.*
100. *Ibid.*
101. *Ibid.*
102. U.S. General Accounting Office, *supra* note 83, at Appendix II, p II–1–II–9.
103. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 78.
104. *Id.* at 56.
105. U.S. General Accounting Office, *Conversion of Urban Waste, supra* note 83, at 2–9.
106. *Id.* at 2–10.
107. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 80.
108. U.S. General Accounting Office, *Conversion of Urban Waste, supra* note 83, at 2–10.
109. David B. Sussman, *supra* note 82, at 1–2.
110. Mark E. Anthony Reisch, Congressional Research Service, "The Status of Resource Recovery: A Report of Site Visits," prepared for the Subcommittee on the Environment and the Atmosphere of the Committee on Science and Technology, U.S. House of Representatives (Washington, D C., April 1978), pp. 13, 14.
111. U.S. General Accounting Office, *Conversion of Urban Waste, supra* note 83, at 2–10.
112. David B. Sussman, *supra* note 82, at 2.
113. Information provided by David B. Sussman, U.S. Environmental Protection Agency, Office of Solid Waste, May 15, 1979.
114. David B. Sussman, *supra* note 82, at 2.
115. U.S. General Accounting Office, *supra* note 83 at 2–12.
116. Congressional Research Service, "The Status of Resource Recovery," *supra* note 110, at 14.
117. U.S. Environmental Protection Agency, *Fourth Report to Congress, supra* note 3, at 59.
118. E. Milton Wilson, *et al.,* The Ralph M. Parsons Company, *Engineering and Economic Analysis of Waste to Energy Systems,* prepared for the

U.S. Environmental Protection Agency (Cincinnati, Ohio, May 1978), p. A–13.

119. K.P. Ananth, L.J. Shannon, and M.P. Schrag, Midwest Research Institute, *Environmental Assessment of Waste to Energy Process: Source Assessment Document,* prepared for U.S. Environmental Protection Agency (Cincinnati, Ohio, August 1977), p. 2–3.
120. D.E. Fiscus *et al.,* Midwest Research Institute, *St. Louis Demonstration Project Final Report: Refuse Processing Plant Equipment, Facilities and Environmental Evaluations,* prepared for U.S. Environmental Protection Agency, EPA–600/2–77–155a (Cincinnati, Ohio, September 1977), pp. 2, 91–100.
121. *Id.* at 108.
122. Communication from the U.S. Department of the Interior, August 1979.
123. U.S. Congress, "Materials and Energy from Waste," *supra* note 10, at 6–22, 6–23.
124. *Id.* at 6–24.
125. *Ibid.*
126. Information provided by Joseph Boren, Connecticut Resource Recovery Association, April 16, 1979.
127. U.S. Congress, "Materials and Energy from Waste, *supra* note 10, at 6–22.
128. *Id.* at 8–13.
129. E. Milton Wilson *et al., supra* note 118, at 58–59.
130. U.S. General Accounting Office, *supra* note 83, at II–3.
131. Information provided by Nashville Thermal Transfer Corporation, August 28, 1979.
132. E. Milton Wilson *et al., supra* note 118, at 48, 53.
133. Franklin Associates, Ltd., "Post-Consumer Solid Waste," *supra* note 8, at 28.
134. E. Milton Wilson *et al., supra* note 118, at 58–59.
135. *Id.* at 45 and 46.
136. David B. Sussman, *supra* note 82, at 4.
137. Information supplied by Nashville Thermal Transfer Corporation, August 28, 1979.
138. Information provided by Joseph Boren, Connecticut Resource Recovery Association, April 16, 1979.
139. U.S. General Accounting Office, "Conversion of Urban Waste," *supra* note 83, at 3–1.
140. Data supplied by the U.S. Environmental Protection Agency, Office of Solid Waste, and by Franklin Associates, Ltd., reported in Resource Conservation Committee, *Status Report on Solid Waste Disposal Charge Analysis* (Washington, D.C., July 1978), p. 7.
141. Information provided by Penelope Hansen, U.S. Environmental Protection Agency, April 23, 1979.
142. 42 U.S.C. § 3251 (1965).
143. Pub. L. No. 91–512, 84 Stat. 1227.
144. 42 U.S.C. § 6901 (1976).
145. Resource Conservation and Recovery Act, 42 U.S.C. § 6962 (1976).
146. Resource Conservation Committee, "Choices for Conservation," Final Report to the President and Congress (Washington, D.C., July 1979).
147. *Id.* at 101–117.
148. *Id.* at 118–122.
149. *Id.* at 123–128.
150. *Id.* at 136–144.
151. *Id.* at 131–135.
152. *Id.* at 93–98.
153. *Id.* at 56.
154. Pub. L. No. 94–210 § 204, 90 Stat. 40 (1976).
155. Ex Parte No. 319, Investigation of Freight Rates for the Transportation of Recycled Materials.

156. 585 F.2d 522 (D.C. Cir. 1978).
157. Resource Conservation Committee, "Choices for Conservation," *supra* note 146, at 83.
158. *Id.* at 87.
159. 40 C.F.R. § 244 (1977).
160. Executive Order 12088, October 1978.
161. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 5–10.
162. Communication from the U.S. General Services Administration, July 13, 1979.
163. U.S. Department of Defense and U.S. Environmental Protection Agency, *Report to the Secretary of Defense, supra* note 77, at 4–28.
164. Resource Conservation and Recovery Act, 42 U.S.C. § 6901 (1976).
165. Information supplied by U.S. Environmental Protection Agency, Office of Solid Waste, August 1979.
166. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 5–26.
167. U.S. General Accounting Office, "Conversion of Urban Waste," *supra* note 83, at 5–4.
168. Information supplied by David Berg, U.S. Environmental Protection Agency, Office of Research and Development, May 22, 1979.
169. U.S. General Accounting Office, "Conversion of Urban Waste," *supra* note 83, at 5–5.
170. *Id.* at 6–3.
171. *Id.* at 5–7.
172. David Berg, *supra* note 168.
173. U.S. Environmental Protection Agency, *supra* note 165.
174. *Ibid.*
175. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 3–9.
176. U.S. Environmental Protection Agency, *supra* note 165.
177. Information supplied by U.S. Department of Energy, Urban Waste and Municipal Systems Branch, September 1979.
178. U.S. Environmental Protection Agency, *1978 Annual Report, supra* note 25, at 2–11, 3–13.
179. U.S. General Accounting Office, *supra* note 83, at 4–7.
180. *Ibid.*
181. The Energy Tax Act of 1978, Pub. L. 95–618.
182. Urban Waste Technology Commercialization Task Force, *supra* note 13, at 9.
183. 42 U.S.C. § 6881(g)(1) (1976).
184. U.S. General Accounting Office, *supra* note 83, at 4–9.
185. Franklin Associates, Ltd., *Resource Recovery Plant Costs: Semi-Suspension Incinerators and Small Modular Incinerators with Materials Recovery,* prepared for the U.S. Environmental Protection Agency (Washington, D.C., May 1978).
186. Information provided by Richard Lundahl, Director of Public Works, Northglenn County, July 1979.
187. *Ibid.*
188. Information provided by Robert Holloway, U.S. Environmental Protection Agency, April 1979.
189. *Ibid.*
190. James F. Hudson and Michael R. Alford, Urban Systems Research and Engineering, Inc., "Projections of Solid Waste Management Costs, Paper No. 10 in Support of the Resource Conservation Committee," prepared for the President's Council on Environmental Quality (draft, Cambridge, Mass., 1978), p. 16.

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